Life Cycle Assessment of HydroElite Vidi 3G-5.20 by Hydroware AB

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MILJÖGIRAFF

Table of Contents

Table of Contents 2
1 Introduction 6
1.1 Reading guide to the report 6
1.2 General description of the product and its context 6
1.3 The sustainability challenge 8
2 Life Cycle Assessment (LCA) 10
2.1 LCA Methodology background 10
2.2 Environmental product declaration 11
3 Goal and Scope 13
3.1 The aim of the study 13
3.2 Standards and frameworks 13
3.3 Scope of the Study 13
3.4 LCA Software 18
4 Life cycle inventory (LCI) 19
4.1 Product specification 19
4.2 Product content declaration 20
4.3 Assumptions 21
4.4 Raw material (A1) 22
4.5 Transport to site (A2) 25
4.6 Manufacturing (A3) 25
4.7 Transport to installation (A4) 25
4.8 Installation (A5) 26
4.9 Usage (B1-B7) 26
4.10 End-of-Life (C1-C4) 28
4.11 Benefits from material recycling or energy recovery (D module) 29
4.12 Calculation of reference flows per RSL (25 years) 31
4.13 Calculation of reference flows per tkm 31
5 Result of Life cycle impact assessment (LCIA) 33
5.1 Environmental Footprint Midpoint 33
5.2 Environmental Footprint Endpoint 36
5.3 Climate impact (GWP) - IPCC GWP 2021 100 38
5.4 Use of resources and energy CED 1.11 40
5.5 Waste production and output flows 41
5.6 Biogenic carbon content 43
6 Interpretation 44
6.1 Key aspects of results 44
6.2 Sensitivity and scenario analysis 44
6.3 Data quality assessment 48
7 Conclusions and recommendations 49
7.1 Recommendation on how to mitigate the hot spots 49
7.2 How to communicate the results 50
7.3 How to reduce uncertainties 50
7.4 Internal follow-up procedures 50
8 Bibliography 51
9 Appendix list 53

Ordered by: *Hydroware AB*
Hydroware develops, manufactures, and sells high-tech drive and control systems for hydraulic elevators. Through a strong focus on energy and resource efficiency together with the elevator's travel comfort, we are a leader in hydraulic elevators. We manufacture robust elevators with open systems that can be modernized with the philosophy that an elevator should have the same lifespan as the property.

Hydroware is an international company with offices around the world. The head office is located in Alvesta (Sweden), and this is also where the development and production of Hydroware's products take place.

Issued by: Miljögiraff AB
Miljögiraff is an environmental consultant specialising in Life Cycle Assessment and Ecodesign. We believe that a combination of analysis and creativity is necessary to meet today's challenges. Therefore, we provide Life Cycle Assessment to evaluate environmental aspects and design methods to develop sustainable solutions.

We create measurability in environmental work based on a life cycle perspective on ecological 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

CO_2 eq – Carbon dioxide equivalents
EPD – Environmental Product Declaration
GWP – Global Warming Potential
ISO – International Organization for Standardisation
IPCC – Intergovernmental Panel on Climate Change
LCA – Life Cycle Assessment
LCI – Life Cycle Inventory Analysis
LCIA – Life Cycle Impact Assessment
PCR - Product Category Rules
RER – The European region
RoW – Rest of the world
GLO – Global
APOS – Allocation at the point of substitution (system model in ecoinvent)
Cut-off – Allocation cut off by classification (system model in ecoinvent)

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 to 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

Abstract

Hydroware AB is a Swedish manufacturer of high-tech drive and control systems for hydraulic elevators for use in public and private settings. The study's goal was to find metrics for the environmental impact of the lift HydroElite Vidi 3G-5.20 from a life cycle perspective. The report describes the results in a transparent and reproducible way according to the standard. The results are interpreted, followed by recommendations for mitigating the environmental impact. The purpose was product development and environmental communication in the form of an Environmental Product Declaration (EPD), and the intended audience of this report is thus both internal and external.

Miljögiraff has made a cradle-to-grave attributional LCA of the HydroElite Vidi 3G-5.20 lift, which is installed in low-rise residential or commercial buildings. The lift comes in different sizes (2-16 floors), and for this report, an average 2-floor version was modelled, which weighs ca 1110 kg (including packaging). The LCA has been made according to the product category rules for construction products (PCR 2019:14) and the sub-PCR for lifts (c-008) in the international EPD system. Results are presented per functional unit ("transportation of a load over a distance, expressed as one tonne transported vertically over one kilometre, (i.e. 1 tonne*kilometre or tkm)") as well as over the Reference Service Life of 25 years (the lift's technical lifetime is 75 years, including two modernisations).

The environmental impacts have been calculated at midpoint and endpoint according to the environmental footprint 3.0 and IPCC methodologies, respectively (see detailed results in section 5). The HydroElite Vidi lift causes 200 kg CO2-eq of climate impacts per tkm of transportation performance. Expressed per reference service life of 25 years, the climate impacts are instead 16 868 kg CO2-eq. These and other impacts would be considerably larger if the lift did not undergo modernisation. Since it did, part of the environmental impacts have already been mitigated, and minimising the replacement of materials and components could reduce impacts further.

From a life cycle perspective, the environmental impact of the HydroElite Vidi lift can mainly be attributed to the production of materials and components (module A1), the production of replacement materials and components for modernisation (module B5) as well as electricity consumption in the use phase (module B6), which depends on the usage category of the lift. This is true for a lift in usage category 1 (the most common category for Hydroware's lifts), but for the higher usage categories, almost all of the impact comes from the use phase.

The use-phase electricity consumption was calculated to be 15,4 MWh of electricity consumed over the reference service life of 25 years (for the most common usage category, UC1). For the highest usage category, the amount was instead 346 MWh). The majority of this comes from stand-by energy use (for higher usage categories, the share of stand-by power is significantly less). Since the electricity represented a large share of all environmental impact, regardless of usage category, the model of the product system is sensitive to the source of energy in the use phase. If the lift is driven by only wind power instead, the total climate impact per functional unit is reduced by ca 60%.

Miljögiraff suggests that Hydroware can reduce environmental impacts, for instance, by ecodesign for using less material in the product or when modernizing the product and/or using more recycled materials. Furthermore, the electricity consumption in use phase can be mitigated by improved energy efficiency, particularly of the standby-energy consumption, or by influencing customers to use clean energy to power their lift.

1 Introduction

This report presents the total environmental footprint for the HydroElite Vidi lift produced by Hydroware AB from a life cycle perspective using the ISO 14040 standard approach.

The LCA approach harmonises with the Product Environmental Footprint Category Rules published on 12 February 2019. The methodology used follows the General program instructions for the International EPD System (EPD International, 2019), PCR 2019:14 version 1.11 and c-PCR-008 (EPD International, 2021a). These are in line with the international standards for LCA that apply to this context: EN15804:2012+A2:2019 (CEN, 2019), ISO 14025 (ISO, 2006a), ISO 14040 (ISO, 2006b), and 14044 (ISO, 2006c).

The purpose of using the LCA method is to understand the environmental impact from a holistic perspective, which enables the most effective opportunities to mitigate adverse effects and avoid burden shifting from one part of the lifecycle to another. A secondary purpose of the report is to act as a foundation for the publication of an EPD, to be used for external marketing purposes.

1.1 Reading guide to the report

Readers of this report can choose different parts to read, depending on their time availability:

- 5 minutes
    - Section 7 gives the briefest summary of the most relevant conclusions and recommendations.
- 10 minutes
    - Section 7, and section 6 gives some more nuance/depth, including interpretation and sensitivity analysis that underpins the conclusions
- 20 minutes
    - Section 7, section 6 and section 5 presents detailed results and flowcharts/diagrams for the different impact categories
- >30 minutes
    - For in-depth detail and transparent documentation on the modelling of each part of the life cycle, see section 4 (“Life Cycle Inventory”)
    - For information about methodology, scope and functional unit, see sections 2 (“Life Cycle Assessment”) and section 3 (“Goal and Scope”)

1.2 General description of the product and its context

The HydroElite Vidi lift is a hydraulic lift, which is a space-efficient solution that is quiet since the sound does not propagate further in the building. This means that a hydraulic lift is advantageously well suited for all existing properties where a lift need has arisen. Hydroware delivers all parts for new lifts to ensure that the buyer only needs to have contact with one supplier.

HydroElite Vidi 3G-5.20 is a top model from Hydroware. It is an integrated drive and control system for hydraulic lifts and equipped with Hydroware’s unique valve system which makes it possible for the lift to go with direct to floor travel, completely without creeping. The valve also does not need to bypass the oil at full speed upwards. HydroElite VIDI is equipped with an efficient air-cooled IE2 motor and frequency control. The rated speed is gradually reduced when the load exceeds 25 percent of the rated load, which greatly reduces the power requirement.

Hydroware's lifts are based on an open and modular system which allows components to be replaced to extend the life of the lift and keep down the price of lift maintenance. Fully functioning parts and the lift frame never need to be replaced. In this way, the owner of the lift is not forced to buy a completely new lift again after 20-25 years.

1.3 The sustainability challenge

The industrial and natural systems depend on a stable Earth system. Steffen et al. (Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, 2015) describe nine processes that determine the resilience and stability of the Earth system, such as climate change, water use, and land use. Crossing these boundaries increases the risk of abrupt and irreversible environmental change, while staying within the boundaries represents a safe operating space for a sustainable society, see Figure 1.

In LCA, the effect of a product system on the environment and on human health is quantified. These quantifications are divided into different impact categories that represent different types of environmental impact. Note that the division into categories in LCA is done according to a somewhat different logic compared to the planetary boundaries, see Appendix 2.

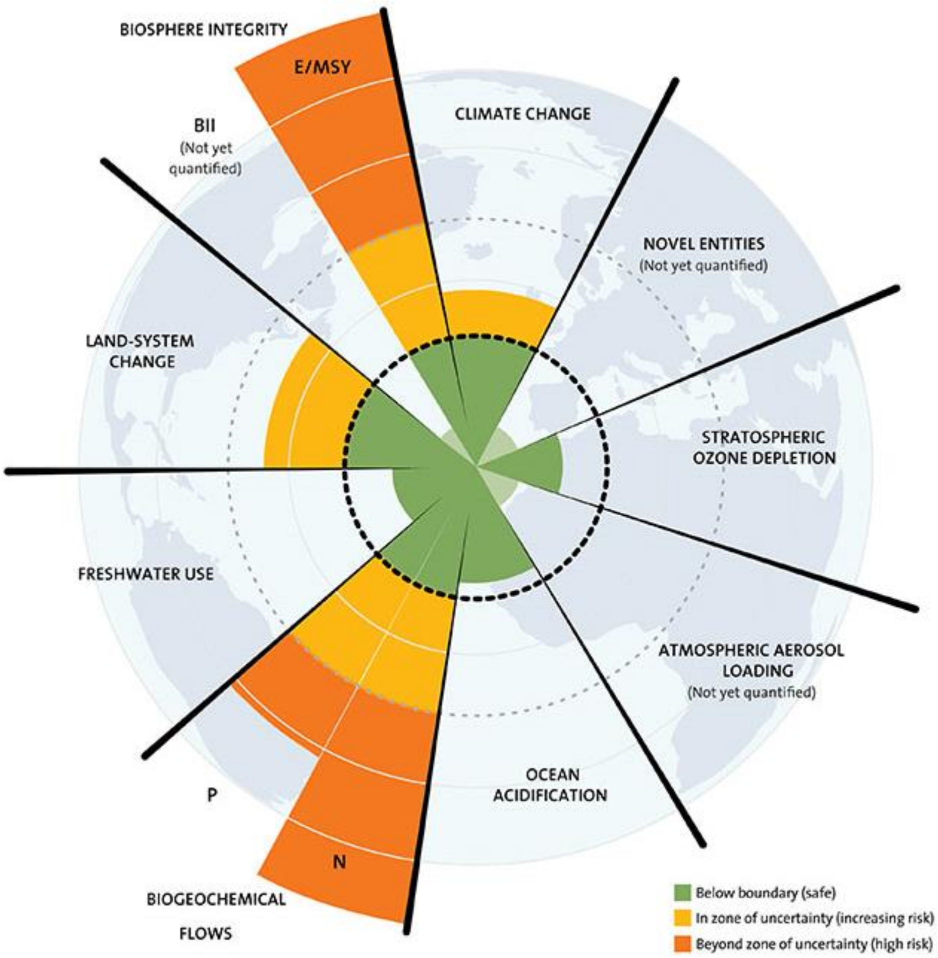

Figure 1: Show the state of the planetary boundaries, where the green area represents a safe operating space. From J. Lokrantz/Azote based on Steffen et al. 2015.

One of the most important environmental impacts is climate change. IPCC (IPCC, 2021) shows that the available space for mitigating radical climate change is ever-shrinking, necessitating decisive action in all parts of society. Figure 2 shows the projected temperature changes due to greenhouse gas emissions in the coming century, in 5 different scenarios where only the most ambitious one results in a temperature increase within 2°C. Keeping the temperature rise below 1.5 ° C is the ambition stipulated by the Paris Agreement 2016.

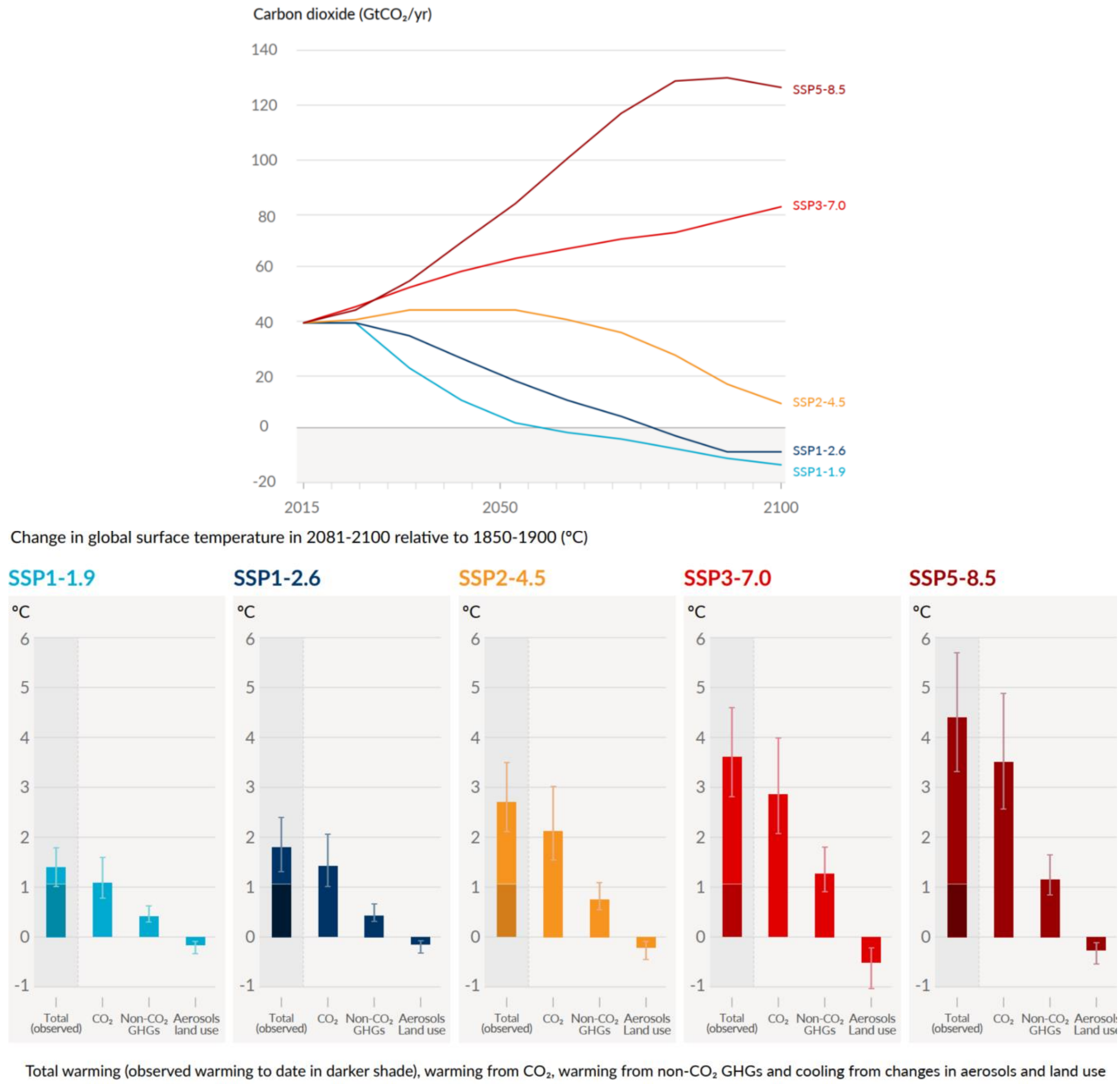

Figure 2: Future annual emissions of CO_2 (top) and contribution to global surface temperature increase from different emissions, with a dominant role of CO_2 emissions (bottom) across five illustrative scenarios (Image from IPCC (IPCC, 2021))

2 Life Cycle Assessment (LCA)

2.1 LCA Methodology background

The importance of understanding the potential environmental impact in connection with the manufacture and use of products is constantly increasing. LCA is the accepted and scientific method that exists to create this understanding. LCA forms a basis for the development of strategy, management and communication of environmental issues related to products.

The purpose of LCA is to provide a basis that describes the environmental impact in such a way that it provides conditions for change and measures in the analysed life cycle that can contribute to a more sustainable development. LCA provides a comprehensive basis for environmental impact as all incoming and outgoing flows of environmental significance during a product's life cycle are measured. (see Figure 3).

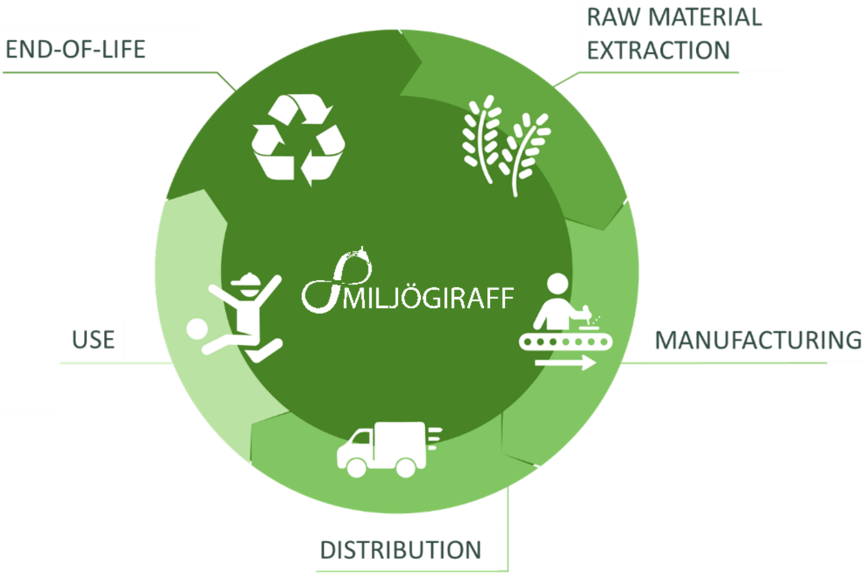

Figure 3: The Life Cycle concept, starting from raw material extraction, manufacturing, and distribution, followed by use and end-of-life.

Practitioners can only achieve the broad scope of analysing the entire life cycle of a product using a holistic approach at the expense of simplifying some aspects. Thus, the following limitations must be taken into account as summarised by Guinée et al. (Guinée et al., 2002):

- Localised aspects are typically not addressed, and LCA is not a local risk assessment tool
- LCA is typically a steady-state approach rather than a dynamic approach
- LCA does not include market mechanisms or secondary effects on technological development
- Processes are considered linear, both in the economy and the environment, meaning that impact increases linearly with increased production.
- LCA involves several technical assumptions and value choices that are not purely science-based
- LCA focuses on environmental aspects and excludes social, economic, and other characteristics

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 (see Figure 4.).

Figure 4: ISO standard combined with reliable data from ecoinvent and the LCA software SimaPro.

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., 2004). 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.

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

2.2 Environmental product declaration

An Environmental Product Declaration (EPD) is defined by (ISO) 14025 as a Type III declaration that "quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function."

EPDs are primarily intended to facilitate business-to-business communication, although they may also be of benefit to consumers who are environmentally focused when choosing goods or services.

As shown in Figure 5 several standard documents are used when creating an EPD.

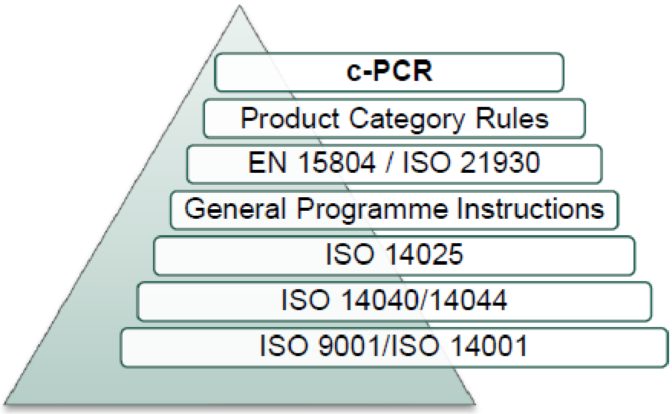

Figure 5, shows the hierarchy of standards used to create and EPD according to the International EPD system.

2.2.1 General Program Instructions (GPI)

General Program Instructions constitutes the General Programme Instructions (GPI) of the International EPD® System. It forms the basis of the overall administration and operation of a programme for Type III environmental declarations according to ISO 14025.

2.2.2 Product Category Rules (PCR)

Product Category Rules (PCRs) provide guidance that enables fair comparison among products of the same category. PCRs include the description of the product category, the goal of the LCA, functional units, system boundaries, cut-off criteria, allocation rules, impact categories, information on the use phase, units, calculation procedures, requirements for data quality, and other information. The goal of PCRs is to help develop EPDs for products that are comparable to others within a product category. ISO 14025 establishes the procedure for developing PCRs and the required content of a PCR, as well as requirements for comparability.

3 Goal and Scope

3.1 The aim of the study

The study's goal was to quantify the environmental impact of the lift HydroElite Vidi, from a life cycle perspective. The report describes the results in a transparent and reproducible way according to the standard. The LCA has been made according to the product category rules for construction products (PCR 2019:14) and the sub-PCR for lifts (c-008) in the international EPD system. The results are interpreted, followed by recommendations for mitigating the environmental impact.

The purpose was product development and environmental communication in the form of an Environmental Product Declaration (EPD).

The intended audience of this report is both internal and external.

3.2 Standards and frameworks

The standards and frameworks that has been followed in this LCA are presented in Table 1.

Table 1: Standards and framework conformance.

Standards conformance
ISO 14040 and 14044 (ISO, 2006b)
General program instructions for the International EPD System (EPD International, 2019)
PCR 2019:14 version 1.11 (EPD International, 2021a)
c-PCR 008 for lifts

3.3 Scope of the Study

The scope of an LCA specify the functions (performance characteristics) of the system being studied.

3.3.1 Name and Function of the Product/System

The system studied was the life cycle of the HydroElite Vidi lift (from cradle to grave) and its function is to transport load between the floors of a building. The lift comes in different sizes (2-16 floors), and for this report, an average 2-floor version was modelled, which weighs ca 1110 kg (including packaging).

3.3.2 The Functional Unit and reference flow

The LCA results shall be presented per functional unit (f.u.) and the f.u. 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 normalised.

The function of a lift is the transportation of persons and/or freight. For this study, in accordance with the PCR, the functional unit was thus defined to be the transportation of a load over a distance, expressed as one tonne transported vertically over one kilometre, (i.e. 1 tonne*kilometre or tkm).

The model as presented in section 4 represents the production, use and waste management for one lift during its technical lifetime of 75 years. The results in section 5 are then presented per f.u., for the most common lift usage category (UC1, see section 4.13). Additionally, results are presented over a Reference Service Life of 25 years, for all usage categories (UC1-UC6).

3.3.3 System Boundary

This study goes from cradle to grave, and includes the D-module as well. That means that all processes needed for raw material extraction, manufacturing, transport, usage, and end-of-life are included in the study, as well as a calculation of the benefits from recycling. Figure 6 shows an overview of the model.

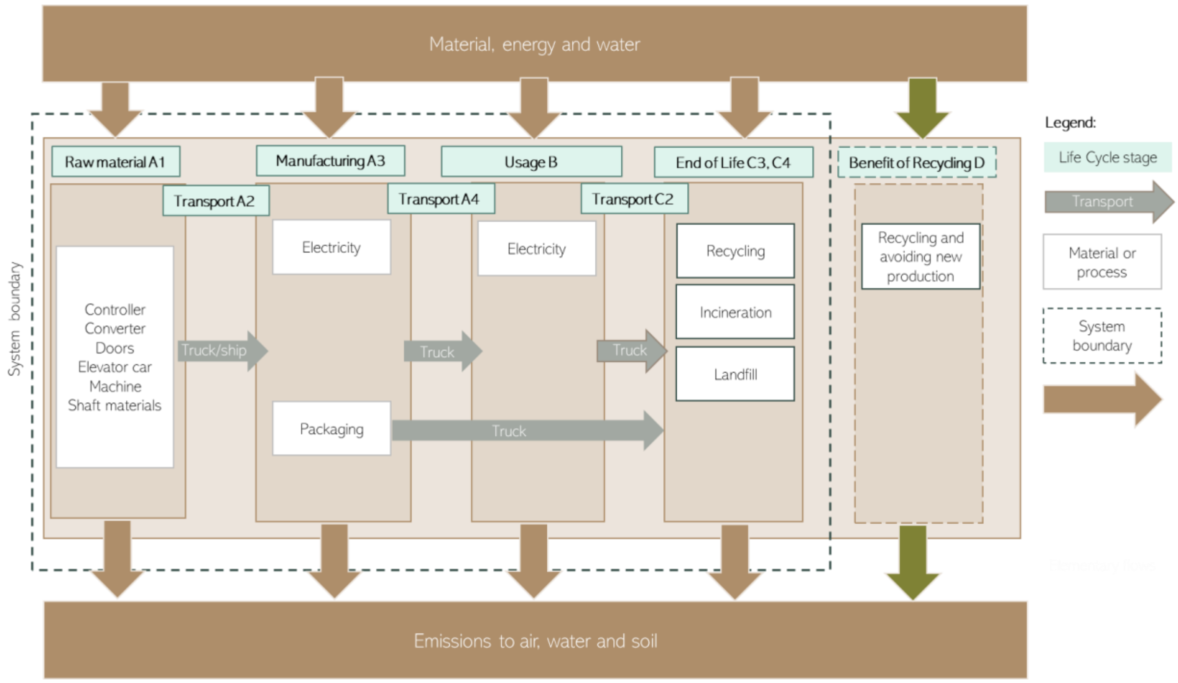

Figure 6: System boundaries for the model of the product system.

3.3.4 Excluded parts and "cut-off"

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

Mass relevance - If the flow was less than 1% of the cumulative mass of all the inputs and outputs of the LCI model.
Energy relevance - If the flow was less than 1% of the cumulative energy of all the inputs and outputs of the LCI model.
Environmental relevance - If the flow met the above criteria for exclusion yet was thought to have a potentially significant environmental impact. The environmental relevance was evaluated with experience and relevant external research on similar products. If an excluded material significantly contributed 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.

In addition to cut-off of material- and energy flows, also life cycle stages can be excluded if they are deemed to be of low relevance or do not cause any negative environmental effects.

In this study, production of capital goods for manufacturing (machines and facilities) are cut off, as is energy use for installation.

3.3.5 Allocation procedure

The method chosen for the allocation is the cut-off method. The cut-off method assigns the loads caused by a product to only that product.

Allocation of waste is described in ISO 14044 section 4.3.4.3.3 (ISO, 2006c) and uses the method Allocation cut-off by classification per EPD guidelines (EPD International, 2021b).

In this report, no allocation in specific data was done.

3.3.6 Method of Life Cycle Impact Assessment (LCIA)

The methods used to calculate the relevant environmental effect categories in this study are summarised in Table 2 and Table 6. The LCIA-method is explained in more details in Appendix 2.

Table 2: Impact categories, indicators and methods used in the study. The chosen indicators follow the standard for Construction products EN 15804:2012+A2:2019.

Impact category	Abbreviation	Category indicator	Method
Climate Change-total	GWP total	kg CO_2 equivalents	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate Change-fossil	GWP fossil	kg CO_2 equivalents	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate Change-biogenic[1]	GWP biogenic	kg CO_2 equivalents	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate Change-land use and land use change	GWP luluc	kg CO_2 equivalents	Baseline model of 100 years of the IPCC based on IPCC 2013
Ozone-depleting gases	ODP20	CFC 11-equivalents	Steady-state ODPs, WMO 2014
Acidification potential (fate not included)')	AP	mol H+ eq	Accumulated Exceedance, Seppälä et al. 2006, Posch et al., 2008
Eutrophication aquatic freshwater	EP	kg P equivalents / kg	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication aquatic marine	EP	kg N equivalents / kg	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication aquatic terrestrial	EP	mol N equivalents / kg	Accumulated Exceedance, Seppälä et al. 2006, Posch et al.
Photochemical ozone creation potential	POCP	kg NMVOC eq./ kg	LOTOS-EUROS, Van Zelm et al., 2008, as applied in ReCiPe

[1] Removals of biogenic CO2 into biomass (with the exclusion of biomass of native forests) and transfers from previous product systems shall be characterised in the LCIA as –1 kg CO2 eq./kg CO2 when entering the product system. Emissions of biogenic CO2 from biomass and transfers of biomass into subsequent product systems (with the exclusion of biomass of native forests) shall be characterized as +1 kg CO2 eq./kg CO2 of biogenic carbon, see EN ISO 14067:2018, 6.5.2. (Swedish Standard Institute, 2020)

Abiotic resource depletion, elements	ADPe	kg Sb eq / kg	CML 2002, Guinée et al., 2002, and van Oers et al. 2002.
Abiotic resource depletion, fossil fuels	ADPf	MJ	CML 2002, Guinée et al., 2002, and van Oers et al. 2002.
Water Depletion	WD	m3	Available WAter REmaining (AWARE) Boulay et al., 2018

Table 3: Additional environmental impact indicators and methods used in the study. SS-EN 15804:2012+A2:2019 (E).

Impact category	Indicator	Unit	Method
Particulate Matter emissions	Potential incidence of disease due to PM emissions (PM)	Disease incidence	SETAC-UNEP, Fantke et al. 2016
Ionising radiation, human health	Potential Human exposure efficiency relative to U235 (IRP)	kBq U235 eq.	Human health effect model as developed by Dreicer et al. 1995 update by Frischknecht et al., 2000
Eco-toxicity (freshwater)	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	CTUe	USEtox 2.1. model (Rosenbaum et al, 2008)
Human toxicity, cancer effects	Potential Comparative Toxic Unit for humans (HTP-c)	CTUh	USEtox 2.1. model (Rosenbaum et al, 2008)
Human toxicity, non-cancer effects	Potential Comparative Toxic Unit for humans (HTP-nc)	CTUh	USEtox 2.1. model (Rosenbaum et al, 2008)
Land-use related impacts/Soil quality	Potential soil quality index (SQP)	dimensionless	Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)

Table 4: Information on biogenic content.

Biogenic carbon content (1 kg = 44/12 kg CO2)	Unit per FU or DC
Biogenic carbon content in the product	Kg C
Biogenic carbon content in the accompanying packaging	Kg C

Unit conversion for LCIA results.

Some methods report the LCIA results in different units then EF 3.0. Below some common unit conversions can be seen:

Acidification: 1.31 to report kg SO2,eq as mol H +,eq
Eutrophication: 0.33 to report kg PO_4^{-3},eq. Kg P,eq

Photochemical Ozone Creation Potential: 1.69 to report kg C2H4,eq as kg NMVOC,eq

Table 5: Resource use to be declared in the study.

Resource	Unit
Use of renewable primary energy excluding primary energy resources used as raw material (PERE)	MJ
Use of renewable primary energy resources used as raw material (PERM)	MJ
Total use of renewable primary energy (PERT)	MJ
Use of non-renewable primary energy excluding primary energy resources used as raw material (PENRE)	MJ
Use of non-renewable primary energy resources used as raw material (PENRM)	MJ
Total use of non-renewable primary energy (PENRT)	MJ
Use of recycled or recycled materials (secondary materials)	Kg
Use of renewable secondary fuels	MJ
Use of non-renewable secondary fuels	MJ
Net use of freshwater	m3

Table 6: Waste materials to be declared in the study.

Rest materials	Unit
Hazardous waste	kg
Non-hazardous waste	kg
Radioactive waste, disposed/stored	kg
Outputs, secondary materials and exported energy	
Material for reuse	kg
Recycling material	kg
Material for energy recovery	kg
Exported energy	MJ

3.3.7 Data requirements (DQR)

The following requirements are used for all the central LCI data. The more peripheral aspects may deviate from the DQI based on the rule for "cut off".

- Geographical coverage: **The processes included in the data set are well representative for the geography stated in the "location" indicated in the metadata**
- Technology representativeness: **Average technology or BAT**[2]
- Time related coverage: **2014 and after**
- Multiple output allocation: **Physical causality**
- Substitution allocation: Not applicable
- Waste treatment allocation: Not applicable
- Cut-off rules: **Less than 1% environmental relevance**

[2] BAT (Best Available Technology or Best Available Techniques) signifies the latest stage in development of activities, processes and their method of operation which indicate the practical suitability of particular techniques as the basis of emission limit values, linked to environmental regulations, such as the European Industrial Emissions Directive (IED, 2010/75/EU). In determining whether operational methods are BAT, consideration is given to economic feasibility and the availability of techniques to carry out the required function. The BAT concept is closely related to BEP (Best Environmental Practice), which is the best environment-friendly company practice.

- System boundary: **Second order (material/energy flows including operations)**
- The boundary with nature: **Agricultural production is part of the production system**

The data quality and representativeness will be assessed in part 6.3 based on the guidelines established in the EN 15804:A2 standard.

3.3.8 Type of critical review, if any

This LCA report was externally reviewed by Dr. Hüdai Kara, Metsims, hudai.kara@metsims.com (approved by the International EPD® System).

3.4 LCA Software

The life cycle impact assessment (LCIA) was made with the LCA software SimaPro 9.3[3], developed by PRé Consultants. It 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. This software includes databases with generic LCI data (e.g. ecoinvent[4]) and several readymade LCIA-methods.

3.4.1 LCI data library

Ecoinvent is one of the world's leading databases with consistent, open, and updated Life Cycle Inventory Data (LCI). With several thousand LCI datasets 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 datasets are based on industrial data and have been compiled by internationally recognised research institutes and LCA consultants.

[3] SimaPro Version 9.2 described at support.simapro.com.

[4] Ecoinvent 3.7, ecoinvent

4 Life cycle inventory (LCI)

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

Sections 4.1-4.11 describe the materials, energy and transportation required for a HydroElite Vidi lift during its technical lifetime of 75 years (including maintenance and modernisation), unless otherwise stated. Subsequently, section 4.12 describes how to generate results for the reference service life (RSL) of 25 years, in order to ensure comparability with other lift EPDs according to the relevant PCR. Additionally, results shall be presented per tkm based on the lift's transportation performance (TP), the procedure for which is described in section 4.13.

4.1 Product specification

The PCR mandates the inclusion of the information in Table 7, which details some key parameters of the lift and its performance. In particular, note the parameter "Transportation performance" (TP), which expresses the amount of function (in ton*km) that the lift achieves during its lifetime (see calculation in Table 22 below).

Table 7: Mandatory product specifications, according to the PCR.

Index	Values	Representative values chosen in case of ranges
Type of installation	*New Lift and modernization*	
Commercial name	*HydroElite 3G-5.20 Vidi – L10*	
Main purpose	*Transport of passengers & goods*	
Type of lift	*Hydraulic lift*	
Type of drive system	*Hydraulic*	
Rated load (fixed or range)	*320 … 30000 kg*	*1000 kg*
Rated speed (fixed or range)	*0,2 … 1 m/s*	*0,63 m/s*
Number of stops (fixed or range)	*2-16*	*4*
Travelled height (fixed or range)	*1 … 40 m*	*8,4 m*
Number of operating days per year (fixed or range)	*0 … 365 days*	*365 days*
Applied usage category (UC) according to ISO 25745-2	*UC1 … UC6*	*UC1*
Technical lifetime	*75 years (with two modernisations)*	
Reference Service Life (RSL)	*25 years (basis of comparison)*	
Transportation performance (TP) per RSL[5]	*84,5 … 8278 tkm (for UC1 … UC6)*	*84,5 tkm (for UC1)*
Geographic region of intended installation	*Europe*	*Berlin, Germany*
Additional information		
Recommended application (main market) - Building rise (typical) - Building type	*Low-rise residential / commercial*	
Additional requirements	*NA*	
Standby power requirement	*40 W*	
Product versions	*For an additional charge, the lift is available with lithium batteries, in which case there are no dangerous substances over 0,1 wt% in the lift (SVHC)*	

[5] See section 4.13

4.2 Product content declaration

This part describes all materials, packaging and substances of very high concern.

The hydraulic lift contains the following components, divided into six modules (see Appendix 5 for material per module):

1. Car
2. Doors
3. Shaft material
   - Guiders
   - Shaft info
   - Buffer pit
   - Cable
   - Cable ducts
   - Car door
   - Landing doors
4. Controller and converter
   - Controller
   - Connection/wiring box
   - Car node
   - Floor nodes
   - Pit control box
   - Car panel
   - Floor indicator
   - Floor panel
5. Cylinder
6. Machine
   - Tank unit
   - Mounting plate, frequency converter
   - Mounting brackets controller
   - Frequency converter
   - Motor 9kW
   - Pump 125L/min
   - Rotex coupling 38
   - Coupling house 9kW
   - Valve 180/min
   - UCM. Valve 1.2/2
   - Shut off valve 1.1/4
   - Pulsation damper
   - Pump hose
   - Outlet hose
   - Hydraulix hose 1.1/4 6m
   - Hydraulic oil 125L

Table 8 shows a summary of the material and components of the lift.

Table 8: Content declaration

Product components	Weight (kg)	Recycled material (wt%)	Renewable material (wt%)
Steel, unalloyed	1774	0	0
Steel, low alloyed	230	0	0
Lubricating oil	110	0	0
MDF	98,0	0	80%
Polypropylene	49,5	0	0
Copper	28,8	0	0
Aluminium	28,0	48%	0
Glass	22,0	0	0
Cast iron	20,6	0	0
Electronic control unit	14,1	0	0
Synthetic rubber	8,90	0	0
Battery	4,80	0	0
Electric connector	3,20	0	0
PVC	3,00	0	0
Circuit board	1,18	0	0

LCD display	0,40	0	0
Total	2396	5,6%	3,3%
Packaging materials			
Material	Weight (kg)	Weight-% (versus the product)	
Wood	135,5	5,7%	
Plastic (non-PVC)	7,7	0,3%	
Plastic (PVC)	4,0	0,2%	
Cardboard	5,3	0,2%	
Substances of Very High Concern			
Dangerous substances from the candidate list of SVHC for Authorisation	EC No.	CAS No.	Weight-% per functional or declared unit
Substance: Lead	231-100-4	7439-92-1	0,2%

SVHC and the Candidate List of SVHC are available via the European Chemicals Agency[6].

4.3 Assumptions

Assumptions that are general to the entire LCA are:

- choice of energy model: (e.g. regional averages obtained from the Ecoinvent LCI database or according to specific conditions);
- Choice of transport model: (e.g. regional averages from Ecoinvent) or according to specific conditions calculated according to the Network for Transport and the Environment (NTM).
- Transport distances have been based on Google Maps for road transportation and a port routing tool (e.g. Sea Distances or Port World) for sea transports. Possible deviating routes have not been included in the calculations.
- Ecoinvent processes that contain market funds such as "Diesel burned in building machine {GLO} | market for | Cut-off, U" includes generic shipments from producer to end customer. Therefore, these data sets have no further transport.

Specific assumptions are presented in detail for each dataset below.

[6] Candidate List of substances of very high concern for Authorisation - ECHA (europa.eu)

4.4 Raw material (A1)

Table 9 shows the modelling of all materials and the corresponding material processing. In addition, there is an electricity consumption of 158,1 kWh for welding, bending and punching in the manufacturing of the lift car in Italy. This was modelled with the ecoinvent process "Electricity, high voltage {IT}| production mix | Cut-off, U".

Table 9: Raw materials and transport to the production site, for the construction of one lift.

Material	Weight (kg)	LCI database representation - for material	LCI database representation - for material processing	Database
Steel, unalloyed	1774	Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off, U	Metal working, average for steel product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8
Steel, low alloyed	230	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, U	Metal working, average for steel product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8
Lubricating oil	110	Lubricating oil {RER}| production | Cut-off, U	-	Ecoinvent 3.8
MDF, uncoated	98,0	Medium density fibreboard {RER}| medium density fibreboard production, uncoated | Cut-off, U	-	Ecoinvent 3.8
Polypropylene, granulate	49,5	Polypropylene, granulate {RER}| production | Cut-off, U	Injection moulding {RER}| processing | Cut-off, U	Ecoinvent 3.8
Copper, cathode	28,8	Copper, cathode {GLO}| market for | Cut-off, U	Metal working, average for copper product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8
Aluminium, cast alloy	28,0	See section 4.4.1		-
Glass, coated	22,0	Flat glass, coated {RER}| production | Cut-off, U	-	Ecoinvent 3.8
Cast iron	20,6	Cast iron {RER}| production | Cut-off, U	-	Ecoinvent 3.8
Electronic control unit	14,1	Electronics, for control units {RER}| production | Cut-off, U	-	Ecoinvent 3.8
Synthetic rubber	8,90	Synthetic rubber {RER}| production | Cut-off, U	-	Ecoinvent 3.8
Battery, Li-ion	4,80	Battery, Li-ion, rechargeable, prismatic {GLO}| production | Cut-off, U	-	Ecoinvent 3.8
Electric connector	3,20	Electric connector, peripheral type buss {GLO}| production | Cut-off, U	-	Ecoinvent 3.8

Material	Weight (kg)	LCI database representation - for material	LCI database representation - for material processing	Database
PVC, bulk	3,00	Polyvinylchloride, bulk polymerised {RER}| polyvinylchloride production, bulk polymerisation | Cut-off, U	Injection moulding {RER}| processing | Cut-off, U	Ecoinvent 3.8
Circuit board	1,18	See section 4.4.2		-
LCD display	0,40	Liquid crystal display, unmounted {GLO}| production | Cut-off, U	-	Ecoinvent 3.8

4.4.1 Aluminium

The aluminium in the controller and converter (0,4 kg) and car (0,8 kg) are modelled according to Table 10.

Table 10: Modelling details for 1kg of aluminium (non-recycled)

	Database process used	Database	Amount	Comment
Materials	Aluminium, cast alloy {GLO}| aluminium ingot, primary, to market | Cut-off, U	Ecoinvent 3.8	1 kg	
Processing	Metal working, average for aluminium product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8	1 kg	

The aluminium in the door (8 kg) and machine (18,8 kg) are 50% recycled and modelled according to Table 11.

Table 11: Modelling details for 1kg of aluminium (50% recycled)

	Database process used	Database	Amount	Comment
Materials	Aluminium, cast alloy {GLO}| aluminium ingot, primary, to market | Cut-off, U	Ecoinvent 3.8	0,5 kg	Non-recycled share
	Aluminium, cast alloy {RER}| treatment of aluminium scrap, new, at refiner | Cut-off, U	Ecoinvent 3.8	0,5 kg	Recycled share
Processing	Metal working, average for aluminium product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8	1 kg	

4.4.2 Circuit board

The circuit board (1,2 kg) was approximately modelled based on a circuit board from Digisign (CILOW, 3105, used in previous projects within Miljögiraff on Cibes' lifts). The model was built on specific data from the supplier, see Table 12.

Table 12: Modelling details for 0,17992 kg of circuit board (CILOW 3105)

	Database process used	Database	Amount	Comment
	Capacitor, for surface-mounting {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,0001 kg	2 of Ceramic capacitor1206 (weight 0,00001 kg) and 40 of Ceramic capacitor 0603 (weight 0,000002 kg)

	Electric connector, wire clamp {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,0372 kg	5 of Contact 2-pole 3.81 mm (weight 0,001 kg), 4 of Contact 3-pole 3.81 mm (weight 0,00125 kg), 1 of Contact 4-pole 3.81 mm (weight 0,002 kg), 1 of Contact 6-pole 3.81 mm (weight 0,0025 kg), 1 of Contact 8-pole 3.81 mm (weight 0,004 kg), 1 of Relay 2-pole 24V safety (weight 0,0187 kg)
	Diode, glass-, for surface-mounting {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,000294 kg	1 of Diode 4004 (weight 0,00001 kg), 2 of Diode 60V, 2A (weight 0,0001 kg), 21 of Diode SOD323 (weight 0,000004 kg)
	Integrated circuit, logic type {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,000053 kg	1 of IC MCP9700 (weight 0,000004 kg), 1 of IC OP Zero Drift (weight 0,000004 kg), 1 of IC PIC32_695_BGA (weight 0,00002 kg), 1 of IC MCP16331 (weight 0,000006 kg), 1 of IC Reset 3.3V (weight 0,000003 kg), 2 of IC SOT23 (weight 0,000016 kg)
	Inductor, low value multilayer chip {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,00116 kg	1 of Inductor 15 uH, 500 mA (weight 0,0008 kg), 9 of Inductor 1206
	Light emitting diode {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,000024 kg	8 of LED 0603 (weight 0,000003 kg)
	Silicone product {RoW}| production | Cut-off, U	Ecoinvent 3.8	0,005 kg	Proxy for oscillator (which seems to be made of quartz: 1 of Oscillator 16 MHz Metal can (weight 0,005)
	Polyethylene terephthalate, granulate, amorphous {RER}| production | Cut-off, U	Ecoinvent 3.8	0,02165 kg	Proxy for plastic components: 1 of Overlay PCB Cilow_10 (weight 0,00325 kg), 2 of Plastic TS35Box end (weight 0,0092 kg, from "0.0046 kg ==> 2 X 0.0046 = 0.0092 kg")
	Printed wiring board, for surface mounting, Pb free surface {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,007822 m2	1 of Printed Circuit Board (PCB) FR4 epoxy (weight 0,0255 kg, which equals 0,00782 m2, using the density of 3,26 kg per m2 from the ecoinvent documentation)
	Resistor, surface-mounted {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,001172 kg	92 of Resistor 0603 (weight 0,000002 kg), 19 of Resistor 1206 (weight 0,00004 kg), 10 of Fuse Poly 1206 PTC Resistor (weight 0,00002 kg), 19 of Resistor 1206 (weight 0,000002 kg), 7 of Varistor 1206 (weight 0,000004 kg)
	Transistor, surface-mounted {GLO}| production | Cut-off, U	Ecoinvent 3.8	0,008404 kg	5 of Transistor PowerPAK 1212 (weight 0,001 kg), 13 of Transistor SOT23 (weight 0,000008 kg), 10 of Transistor TO252 (weight 0,00033 kg)
Processing	Mounting, surface mount technology, Pb-free solder {GLO}| mounting, surface mount technology, Pb-free solder | Cut-off, U	Ecoinvent 3.8	0,0235 m2	

4.5 Transport to site (A2)

Due to lack of data, module A2 was modelled with the same distances and weights as for transport to installation (A4), see section 4.7.

4.6 Manufacturing (A3)

The activities carried out by Hydroware before installation (so-called pre-assembly) are modelled in a simplified way. The lift is divided into six modules (see section 4.2); the controller, converter and machine are assembled in Hydroware's facility in Alvesta, Sweden, while the remaining four modules are assembled in Italy (in reality, one of the modules is partly assembled in both Sweden and Italy, but in the model it is conservatively assumed to be assembled only in Italy, with its more carbon intensive electricity). The total energy demand for one finished module is 23 kWh. This gives a total energy demand of 138 kWh for constructing one lift, which was modelled with Swedish electricity (Electricity, high voltage {SE}| market for | Cut-off, U) and Italian electricity (Electricity, high voltage {IT}| market for | Cut-off, U), respectively.

4.6.1 Packaging

Table 13 summarises the packaging required for one lift. Due to lack of data on transportation, it was modelled approximately as the distance 620 km (from Alvesta to Berlin) using the process "Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U".

Table 13: Packaging used for product

Material	Amount (kg)	LCI data representation in ecoinvent 3.8
Wood	135,5	Sawnwood, board, softwood, dried (u=20%), planed {Europe without Switzerland}| market for sawnwood, board, softwood, dried (u=20%), planed	Cut-off, U
Plastic (Non-PVC)	7,7	Polypropylene, granulate {RER}| production	Cut-off, U
Plastic (PVC)	4	Polyvinylchloride, bulk polymerised {RER}| polyvinylchloride production, bulk polymerisation	Cut-off, U
Cardboard	5,3	Corrugated board box {RER}| market for corrugated board box	Cut-off, U

4.7 Transport to installation (A4)

The pre-assembled modules are transported by truck to the installation location, here represented by Berlin, Germany. Transportation was modelled using the ecoinvent process "Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U".

Table 14: Distribution of one lift

Module	Transport type	Transport distance (km)	Route
Controller and converter	Truck	620 km	Alvesta, Sweden to Berlin, Germany

Machine	Truck	620 km	Alvesta, Sweden to Berlin, Germany
Doors	Truck	1030 km	Milan, Italy to Berlin, Germany
Cylinder	Truck	1030 km	Milan, Italy to Berlin, Germany
Shaft material	Truck	1030 km	Milan, Italy to Berlin, Germany
Car	Truck	1030 km	Milan, Italy to Berlin, Germany

4.8 Installation (A5)

Energy for installation is assumed to be negligible. Thus, the only relevant activity in module A5 is the disposal of the packaging. While all packaging material is possible to reuse and separate at source, due to a lack of data it was modelled with generic waste management (according to module C, see section 4.10) and an additional transportation to the nearest waste management site at an assumed distance of 30 km, using the ecoinvent process "Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U".

4.9 Usage (B1-B7)

The use of the lift entails maintenance (B2), modernisation (B5) and energy use (B6).

4.9.1 Maintenance (B2)

Maintenance was modelled as a change of oil and some rubber and plastic, see Table 15. Maintenance occurs every 15 years which means 4 maintenance occasions during the technical lifetime of 75 years. The replaced materials are sent to generic waste management (according to module C, see section 4.10) with an additional transportation to the nearest waste management site at an assumed distance of 30 km, using the ecoinvent process "Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U".

Table 15: Materials consumed for one maintenance occasion (B2)

	Database process used	Database	Amount	Comment
Materials	Lubricating oil {RER}| production | Cut-off, U	Ecoinvent 3.8	110 kg	
	Synthetic rubber {RER}| production | Cut-off, U	Ecoinvent 3.8	1 kg	
	Polypropylene, granulate {RER}| production | Cut-off, U	Ecoinvent 3.8	1 kg	
	Sawnwood, board, softwood, dried (u=20%), planed {Europe without Switzerland}| market for sawnwood, board, softwood, dried (u=20%), planed | Cut-off, U	Ecoinvent 3.8	15 kg	Packaging for hydraulic oil. Using a density for softwood of 430 kg/m3 (for pinewood)
	Polyvinylchloride, bulk polymerised {RER}| polyvinylchloride production, bulk polymerisation | Cut-off, U	Ecoinvent 3.8	4 kg	Packaging for hydraulic oil
Processing	Injection moulding {RER}| processing | Cut-off, U	Ecoinvent 3.8	6 kg	Material processing for rubber, PP and packaging PVC

	Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	Ecoinvent 3.8	81,22 tkm	Approximation for transportation of maintenance materials

4.9.2 Modernisation (B5)

Modernisation was modelled as a replacement of certain components and materials, according to Table 16. The replaced materials are sent to generic waste management (according to module C, see section 4.10) with an additional transportation to the nearest waste management site at an assumed distance of 30 km, using the ecoinvent process "Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U".

Table 16: Materials consumed for one modernisation occasion (B5)

	Database process used	Database	Amount	Comment
Materials	HydroElite Vidi Controller and Converter	-	-	Entire module is replaced, see Appendix 5 for list of materials.
	HydroElite Vidi Machine	-	-	Entire module is replaced, see Appendix 5 for list of materials.
	Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off, U	Ecoinvent 3.8	138 kg	
	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, U	Ecoinvent 3.8	10,7 kg	
	Aluminium, cast alloy {RER}| treatment of aluminium scrap, new, at refiner | Cut-off, U	Ecoinvent 3.8	0,8 kg	Recycled share
	Aluminium, cast alloy {GLO}| aluminium ingot, primary, to market | Cut-off, U	Ecoinvent 3.8	0,8 kg	Non-recycled share
	Copper, cathode {GLO}| market for | Cut-off, U	Ecoinvent 3.8	15,9 kg	
	Polypropylene, granulate {RER}| production | Cut-off, U	Ecoinvent 3.8	19,4 kg	
	Electronics, for control units {RER}| production | Cut-off, U	Ecoinvent 3.8	0,6 kg	
	Sawnwood, board, softwood, dried (u=20%), planed {Europe without Switzerland}| market for sawnwood, board, softwood, dried (u=20%), planed | Cut-off, U	Ecoinvent 3.8	25 kg	Packaging for Controller and converter and machine
	Polypropylene, granulate {RER}| production | Cut-off, U	Ecoinvent 3.8	2 kg	Packaging for Controller and converter and machine
	Corrugated board box {RER}| market for corrugated board box | Cut-off, U	Ecoinvent 3.8	2 kg	Packaging for Controller and converter and machine
Processing	Electricity, high voltage {SE}| market for | Cut-off, U	Ecoinvent 3.8	46 kWh	Energy for pre-assembly of Controller/converter and Machine
	Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	Ecoinvent 3.8	46 tkm	Transport Controller and converter to Berlin. Total mass component multiplied with distance from Alvesta to Berlin

	Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	Ecoinvent 3.8	206 tkm	Transport Machine to Berlin. Total mass component multiplied with distance from Alvesta to Berlin
	Metal working, average for steel product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8	148,7 kg	
	Metal working, average for aluminium product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8	1,6 kg	
	Metal working, average for copper product manufacturing {RER}| processing | Cut-off, U	Ecoinvent 3.8	15,9 kg	
	Injection moulding {RER}| processing | Cut-off, U	Ecoinvent 3.8	21,4 kg	Material processing for PP and packaging PP

4.9.3 Energy use (B6)

The energy use of the lift was measured and calculated according to the standard EN-ISO 25745-2:2015. Table 17 presents the total energy consumption, per year and over the 25 year RSL, for all different usage categories (UC1-UC6). Electricity consumption was modelled with the ecoinvent process "Electricity, high voltage {DE}| market for | Cut-off, U", to reflect an average European customer. For the results in section 5, UC1 is used as a representative case, unless all usage categories can be displayed in the same table.

Table 17: Electricity consumed in the use phase, for each usage category (B6)

Material or energy	UC1	UC2	UC3	UC4	UC5	UC6
Trips per day	50	125	300	750	1500	2500
Operating days per year	365	365	365	365	365	365
Yearly energy use (MWh)	0,61	1,14	2,37	5,18	9,40	13,84
Energy use per RSL (25 years) (MWh)	15,4	28,6	59,3	129,6	235,0	345,9

4.10 End-of-Life (C1-C4)

The end of life stages were modelled generically, due to a lack of data on what happens to the product after it reaches the end of its life. Consequently, all materials were sent to the generic waste scenario summarised in Table 18.

The end of life model included transport (of 2396 kg) an assumed distance of 30 km to the nearest waste treatment facility, modelled simply with the process "Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U". Dismantling was cut off.

Table 18: Summary of waste scenario ("Municipal solid waste (waste scenario) {EU27}| Treatment of waste | Cut-off, U"), showing the rate of different waste management options for different waste types.

Waste type	Recycling rate	Incineration rate	Landfill rate
Cardboard	82,3%	9,3%	8,4%
Packaging paper	82,3%	9,3%	8,4%
Glass	76,3%	12,5%	11,2%
Ferro metals	78,0%	11,6%	10,4%

Aluminium	78,0%	11,6%	10,4%
Steel	78,0%	11,6%	10,4%
Plastics	41,0%	31,2%	27,8%
PE	41,0%	31,2%	27,8%
PET	41,0%	31,2%	27,8%
PP	41,0%	31,2%	27,8%
PS	41,0%	31,2%	27,8%
PVC	41,0%	31,2%	27,8%
Paper	82,3%	9,3%	8,4%
Newspaper	82,3%	9,3%	8,4%
Compost	40,2%	31,6%	28,2%
Other	0%	52,8%	47,2%

4.11 Benefits from material recycling or energy recovery (D module)

Module D aims to describe consequences or benefits that can be related to material and energy recovery as well as reuse outside the system boundary. Recycled material or energy has the potential to replace primary resources that would otherwise have been used in new production if the recycled material has not been available, this benefit is calculated with the d-module. For products that contain recycled material as raw material, the recycled proportion is deducted to avoid double counting.

The following formula indicates how to calculate the potential consequences of recycling the product:

$$e_{module\ D1} = \sum_i \left(M_{MR\ out}\Big|_i - M_{MR\ in}\Big|_i\right) \cdot \left(E_{MR\ after\ EoW\ out}\Big|_i - E_{VMSub\ out}\Big|_i \cdot \frac{Q_{R\ out}}{Q_{Sub}}\Bigg|_i\right)$$

Equation 1, describes how the potential benefit of recycling of material and energy has been calculated.

- MMR out = The amount of material that leaves the product system and will be reused / recycled in subsequent systems.
- MMR in = The amount of material that has previously been recycled and that enters the product system as raw material from previous systems as secondary material.
- EMR after EoW out = Specific emissions and consumed resources that arise in material treatment processes up to recycling.
- EVMSub out = Specific emissions and consumed resources that arise during the acquisition and pre-treatment of primary materials in the manufacturing process.
- QR out = Quality of the recycled material at replacement.
- QSub = Average quality of primary material that the recycled material substitutes.

In this report, the D-module was modelled in a simplified way, according to Table 19 and Table 20. All numbers were based on the end of life modelling done in the C-module, and include all materials in the lift itself as well as materials replaced during maintenance and modernisation.

The following materials were considered in the model of the D module:

- Aluminium

- Glass
- Plastic
- Steel
- Wood

As a simplified approximation, all types of plastics, oil and electronics are grouped as "Plastics".

Table 19: Benefits from material recycling of product, per RSL (25 years)

Material	Parameters	Amount for recycling (Q*(R2-R1))	Avoided process	Database
Aluminium	R1= 6,95 kg R2= 18,1 kg Q= 1	11,5 kg	Aluminium, cast alloy {GLO}| aluminium ingot, primary, to market | Cut-off, U	Ecoinvent 3.8
Glass	R1= 0 kg R2= 5,6 kg Q= 1	5,6 kg	Flat glass, coated {RER}| production | Cut-off, U	Ecoinvent 3.8
Plastic	R1= 0 kg R2= 18,7 kg Q= 0,8	14,96	Polyethylene terephthalate, granulate, bottle grade {GLO}| market for | Cut-off, U	Ecoinvent 3.8
Steel	R1= 0 kg R2= 724,3 kg Q= 1	724,3 kg	Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off, U	Ecoinvent 3.8
R1 is the amount of recycled material used as raw material input R2 is the amount sent to recycling at end of life, based on the material weight and the recycling rate described in the waste scenario in Table 18 (except for electronics, where copper and steel are assumed to be 100% recycled) Q is the ratio between the value of the secondary and primary material (simplified assumption used for each material)				

The energy recovered from incinerating materials is shown in Table 20. This energy was then used to calculate the avoided heat production by plugging it into the following avoided process in ecoinvent 3.8: "*Heat, for reuse in municipal waste incineration only {DE}| market for | APOS, U*". The waste incineration process was chosen from the APOS (or "allocation at the point of substitution") library, as a proxy for heat production from waste. This is because it contains both the inputs and outputs of the incineration process (unlike the corresponding process in the "Cut-off" library, which is an empty process because of the polluter pays principle).

Table 20: Calculation of the energy recovered from incineration based on the amount of material sent to incineration, per RSL (25 years), and an estimation of its lower heating value (LHV).

Material	Material sent to incineration	LHV (simplified estimates)	Energy recovered/avoided
Plastic	161,6 kg	30 MJ/kg	4848 MJ
Wood	17,2 kg	19 MJ/kg	326,8 MJ

4.12 Calculation of reference flows per RSL (25 years)

Because the lift undergoes modernisation, its technical lifetime is longer than the 25 year RSL. With two modernisations, the lift can be used for 75 years. To ensure comparability with other EPDs of lifts, the results should reflect a reference period of 25 years (EPD International, 2019). Consequently, since the lifetime is extended by a factor of 3, this means that the results for all life cycle stages for 75 years should be divided by 3 in order to scale the reference flows to the RSL of 25 years, according to the PCR.

See Table 21 for a summary of the reference flows. In practice, this means that in order to generate results for a RSL of 25 years, the processes described in sections 4.4-4.8 should be divided by 3, the maintenance (described in section 4.9.1) should be multiplied by a factor of 4/3 while the modernisation (described in section 4.9.2) should be multiplied by a factor of 2/3. The energy use (described in section 4.9.3) and the D-module (section 4.11) are already scaled to the RSL of 25 years.

Table 21: Reference flows showing how many instances of each module are needed

Time period	A1-A5 (raw material to installation for one lift)	B2 (maintenance of one lift)	B5 (modernisation of one lift)
75 years	1	4	2
25 years	1/3	4/3	2/3

4.13 Calculation of reference flows per tkm

In addition to presenting results per RSL, the PCR mandates results per trip, in terms of tkm of transportation performance (TP). Once the TP fulfilled during the RSL has been calculated, the results per RSL should be divided by this TP, which gives the final results per tkm.

The total TP, in tkm, fulfilled by the lift during the RSL is calculated according to the PCR and ISO 25745-2, see Table 22. The TP depends on how often the lift is used. In this report, UC1 has been chosen as the representative case, why results per tkm are presented for UC1 only.

The calculation requires the following parameters:

- TP = transportation performance
    - Average car load (Q_{av}) multiplied by the distance travelled by the lift during the service life (s_{RSL})
- Q_{av} = average car load
    - Rated load (in tonnes) multiplied by the corresponding percentage from Table 3 of ISO 25745–2
- s_{RSL} = Distance travelled by the lift during the service life
    - One-way average travel distance (sav) * number of trips per day (nd) * number of operating days per year (dop) * Reference Service Life (RSL)

Table 22: Calculation of transportation performance (TP), according to ISO 25745-2.

	UC1	UC2	UC3	UC4	UC5	UC6

TP	0,045 tonnes * 1878 km = **84,5 tkm**	0,045 tonnes * 4695 km = **211 tkm**	0,045 tonnes * 11 268 km = **507 tkm**	0,06 tonnes * 25 295 km = **1518 tkm**	0,082 tonnes * 44 840 km = **3677 tkm**	0,135 tonnes * 61 320 km = **8278 tkm**
Q_{av}	1 ton * 0,045 = 0,045 tonnes	1 ton * 0,045 = 0,045 tonnes	1 ton * 0,045 = 0,045 tonnes	1 ton * 0,06 = 0,06 tonnes	1 ton * 0,082 = 0,082 tonnes	1 ton * 0,135 = 0,135 tonnes
s_{RSL}	8,4 m * 50 trips * 365 days * 25 yrs = 1878 km	8,4 m * 125 trips * 365 days * 25 yrs = 4695 km	8,4 m * 300 trips * 365 days * 25 yrs = 11 268 km	8,4 m * 750 trips * 365 days * 25 yrs = 25 295 km	8,4 m * 1500 trips * 365 days * 25 yrs = 44840 km	8,4 m * 2500 trips * 365 days * 25 yrs = 61 320 km

5 Result of Life cycle impact assessment (LCIA)

In this part, the result from the different environmental impact assessment methods will be presented. First, the results from the method Environmental Footprint 3.0 (EF), Midpoint and Endpoint are presented, second from the method IPCC GWP 2021 100 and third the inventory results based on the list of aspects required by the PCR. Note that the LCIA results are relative expressions, which means that they do not predict impacts on category endpoints or the exceeding of thresholds, safety margins or risk.

Sankey diagrams are used to display the results as flow diagrams where the thickness of the arrows reflects the relative amount of that flow. All the nodes cannot be displayed simultaneously due to the vast amounts of background data. Therefore, only processes that contribute to a minimum of 4% or 2% of total impacts are shown in the diagram.

All tables are presented in two sets, one per functional unit (1 tkm for usage category 1) and one per RSL (25 years, for all usage categories).

5.1 Environmental Footprint Midpoint

The total environmental impact (according to the LCIA method Environmental footprint 3.0 midpoint level) of the HydroElite Vidi lift is presented in two tables below. Table 23 shows the life cycle impacts per functional unit, i.e. the impacts from providing 1 ton*km of function. Table 24 shows the total impacts over a reference service life (RSL) of 25 years lifetime of the lift.

Table 23: Environmental footprint midpoint results per functional unit (1 tkm) for the HydroElite Vidi lift of usage category 1 (UC1)

Impact category		**Unit**	**A1-C4**	**A1**	**A2**	**A3**	**A1-A3**	**A4**	**A5**	**B2**	**B5**	**B6 (UC1)**	**C2**	**C3**	**D**
GWP	Fossil	kg CO_2 eq	1,64E+02	3,36E+01	1,48E+00	4,65E-01	**3,56E+01**	1,48E+00	4,44E-02	3,28E+00	2,13E+01	1,02E+02	1,54E-02	4,52E-01	-1,71E+01
	Biogenic	kg CO_2 eq	1,24E+01	7,71E-01	1,28E-03	-9,01E-01	**-1,28E-01**	1,28E-03	4,43E-01	1,18E+00	1,20E+00	8,82E+00	1,33E-05	8,62E-01	1,01E-01
	LULUC	kg CO_2 eq	2,03E-01	3,01E-02	5,91E-04	1,96E-03	**3,27E-02**	5,91E-04	8,14E-06	2,72E-03	2,73E-02	1,39E-01	6,15E-06	3,27E-05	9,55E-03
	Total	kg CO_2 eq	1,77E+02	3,45E+01	1,48E+00	-4,33E-01	**3,55E+01**	1,48E+00	4,89E-01	4,52E+00	2,26E+01	1,11E+02	1,54E-02	1,33E+00	-1,70E+01
ODP		kg CFC11 eq	9,51E-06	2,60E-06	3,42E-07	7,54E-08	**3,02E-06**	3,42E-07	3,68E-09	1,50E-06	2,09E-06	2,55E-06	3,57E-09	9,29E-09	-2,66E-06
AP		mol H+ eq	7,24E-01	2,28E-01	4,20E-03	2,19E-03	**2,34E-01**	4,20E-03	1,39E-04	1,85E-02	2,41E-01	2,26E-01	4,37E-05	4,03E-04	-6,82E-02
EP- Freshwater[7]		kg PO_4^{-3} eq	6,22E-01	7,19E-02	2,97E-04	4,16E-04	**7,26E-02**	2,97E-04	1,14E-05	2,57E-03	6,91E-02	4,77E-01	3,10E-06	1,04E-04	-2,34E-02

[7] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

Impact category	Unit	A1-C4	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6 (UC1)	C2	C3	D
EP - Freshwater	kg P eq	2,03E-01	2,34E-02	9,68E-05	1,36E-04	**2,36E-02**	9,68E-05	3,72E-06	8,38E-04	2,25E-02	1,55E-01	1,01E-06	3,40E-05	-7,62E-03
EP - Marine	kg N eq	1,46E-01	3,63E-02	8,53E-04	5,17E-04	**3,77E-02**	8,53E-04	1,54E-04	4,42E-03	2,83E-02	7,42E-02	8,88E-06	8,30E-04	-1,49E-02
EP – Terrestrial	mol N eq	1,24E+00	3,66E-01	9,29E-03	5,29E-03	**3,80E-01**	9,29E-03	6,33E-04	3,08E-02	2,95E-01	5,18E-01	9,68E-05	1,64E-03	-1,58E-01
POCP	kg NMVOC eq	4,51E-01	1,48E-01	3,57E-03	1,80E-03	**1,53E-01**	3,57E-03	1,77E-04	4,83E-02	1,16E-01	1,28E-01	3,72E-05	5,25E-04	-7,64E-02
ADPE[8]	kg Sb eq	7,85E-03	2,85E-03	5,24E-06	1,97E-06	**2,86E-03**	5,24E-06	7,09E-08	3,80E-05	4,84E-03	1,11E-04	5,46E-08	1,63E-07	-4,73E-05
ADPF[11]	MJ	2,35E+03	4,46E+02	2,24E+01	9,94E+00	**4,78E+02**	2,24E+01	1,73E-01	1,19E+02	3,11E+02	1,42E+03	2,33E-01	6,67E-01	-1,71E+02
WSF[11]	m3 depriv.	2,24E+01	1,01E+01	6,82E-02	2,27E-01	**1,04E+01**	6,82E-02	4,34E-03	9,17E-01	7,23E+00	3,79E+00	7,10E-04	1,55E-02	-3,56E+00
PM	disease inc.	4,81E-06	2,08E-06	1,19E-07	3,62E-08	**2,24E-06**	1,19E-07	1,56E-09	1,51E-07	1,45E-06	8,50E-07	1,24E-09	6,52E-09	-1,19E-06
IR[9]	kBq U-235 eq	2,70E+01	3,95E+00	1,15E-01	1,47E-01	**4,21E+00**	1,15E-01	1,13E-03	6,55E-01	2,63E+00	1,94E+01	1,20E-03	3,32E-03	-5,69E-01
ETP – FW[11]	CTUe	4,43E+03	1,64E+03	1,76E+01	6,23E+00	**1,66E+03**	1,76E+01	9,46E-01	8,14E+01	1,85E+03	8,05E+02	1,83E-01	4,57E+00	-4,51E+02
HTP - C[11]	CTUh	2,57E-07	1,48E-07	5,66E-10	2,39E-10	**1,49E-07**	5,66E-10	9,50E-11	1,96E-09	8,61E-08	1,84E-08	5,89E-12	1,43E-09	-9,30E-08
HTP - NC[11]	CTUh	5,29E-06	1,82E-06	1,78E-08	5,35E-09	**1,85E-06**	1,78E-08	5,58E-10	5,30E-08	2,57E-06	7,13E-07	1,85E-10	8,86E-08	-3,49E-07
SQP[11]	Pt	7,65E+02	1,95E+02	1,56E+01	1,06E+02	**3,16E+02**	1,56E+01	2,07E-01	6,45E+01	1,74E+02	1,93E+02	1,63E-01	1,02E+00	-3,02E+01
Acronyms	**GWP:** Global Warming Potential, **LULUC:** Land Use and Land Use Change, **ODP:** Ozone Depletion Potential, **AP:** Acidification Potential. **EP:** Eutrophication Potential, **POCP:** Photochemical Ozone Creation Potential, **ADPE:** Abiotic Depletion Potential – Elements, **ADPF:** Abiotic Depletion Potential – Fossil Fuels, **WDP:** Water Scarcity Footprint, **PM:** Particulate Matter, **IRP:** Ionizing Radiation - Human Health, **ETP-FW:** Ecotoxicity Potential – Freshwater, **HTP-C:** Human Toxicity Potential – Cancer, **HTP-NC:** Human Toxicity Potential – Non-Cancer, **SQP:** Soil Quality Potential Index													
Legend	**A1-C4:** Sum of impacts inside system boundary**, A1:** Raw Material, **A2:** Raw Material Transport, **A3:** Manufacturing, **A1-A3:** Sum of A1-A3, **A4** Transport to Customer, **A5:** Installation, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport, **C3:** Waste Processing, **C4:** Disposal**, D:** Reuse, Recovery, Recycling Potential													

Table 24: Environmental footprint midpoint results per RSL (25 years) for the HydroElite Vidi lift, for all usage categories

Impact category		Unit	A1-C4	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6 (UC1)	B6 (UC2)	B6 (UC3)	B6 (UC4)	B6 (UC5)	B6 (UC6)	C2	C3	D
GWP	Fossil	kg CO_2 eq	4,63E+05	2,84E+03	1,25E+02	3,93E+01	3,01E+03	1,25E+02	3,75E+00	2,77E+02	1,80E+03	8,64E+03	1,61E+04	3,34E+04	7,29E+04	1,32E+05	1,95E+05	1,30E+00	3,82E+01	-1,45E+03
	Biogenic	kg CO_2 eq	3,98E+04	6,52E+01	1,08E-01	-7,61E+01	-1,08E+01	1,08E-01	3,74E+01	1,00E+02	1,01E+02	7,45E+02	1,39E+03	2,88E+03	6,29E+03	1,14E+04	1,68E+04	1,12E-03	7,29E+01	8,54E+00
	LULUC	kg CO_2 eq	6,30E+02	2,55E+00	4,99E-02	1,66E-01	2,76E+00	4,99E-02	6,88E-04	2,30E-01	2,31E+00	1,18E+01	2,19E+01	4,56E+01	9,95E+01	1,80E+02	2,66E+02	5,20E-04	2,77E-03	8,07E-01
	Total	kg CO_2 eq	5,04E+05	2,91E+03	1,25E+02	-3,66E+01	3,00E+03	1,25E+02	4,13E+01	3,82E+02	1,91E+03	9,41E+03	1,75E+04	3,64E+04	7,94E+04	1,44E+05	2,12E+05	1,30E+00	1,13E+02	-1,44E+03
ODP		kg CFC11 eq	1,20E-02	2,20E-04	2,89E-05	6,37E-06	2,55E-04	2,89E-05	3,11E-07	1,27E-04	1,76E-04	2,15E-04	4,00E-04	8,32E-04	1,82E-03	3,29E-03	4,85E-03	3,01E-07	7,85E-07	-2,25E-04

[8] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[9] **Disclaimer:** This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

Impact category	Unit	A1-C4	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6 (UC1)	B6 (UC2)	B6 (UC3)	B6 (UC4)	B6 (UC5)	B6 (UC6)	C2	C3	D
AP	mol H+ eq	1,05E+03	1,92E+01	3,55E-01	1,85E-01	1,98E+01	3,55E-01	1,17E-02	1,57E+00	2,03E+01	1,91E+01	3,55E+01	7,37E+01	1,61E+02	2,92E+02	4,30E+02	3,70E-03	3,41E-02	-5,76E+00
EP-Freshwater[10]	kg PO_4^{-3} eq	6,45E+03	1,82E+01	7,54E-02	1,06E-01	6,13E+00	7,54E-02	2,90E-03	6,52E-01	1,75E+01	1,21E+02	2,25E+02	4,67E+02	1,02E+03	1,85E+03	2,73E+03	7,85E-04	2,65E-02	-5,93E+00
EP - Freshwater	kg P eq	7,00E+02	1,98E+00	8,18E-03	1,15E-02	2,00E+00	8,18E-03	3,15E-04	7,08E-02	1,90E+00	1,31E+01	2,44E+01	5,08E+01	1,11E+02	2,01E+02	2,96E+02	8,52E-05	2,87E-03	-6,44E-01
EP - Marine	kg N eq	3,38E+02	3,07E+00	7,21E-02	4,37E-02	3,18E+00	7,21E-02	1,30E-02	3,74E-01	2,40E+00	6,27E+00	1,17E+01	2,42E+01	5,29E+01	9,59E+01	1,41E+02	7,51E-04	7,01E-02	-1,26E+00
EP – Terrestrial	mol N eq	2,38E+03	3,09E+01	7,86E-01	4,47E-01	3,21E+01	7,86E-01	5,35E-02	2,60E+00	2,49E+01	4,38E+01	8,15E+01	1,69E+02	3,70E+02	6,70E+02	9,87E+02	8,18E-03	1,38E-01	-1,33E+01
POCP	kg NMVOC eq	6,01E+02	1,25E+01	3,02E-01	1,52E-01	1,30E+01	3,02E-01	1,50E-02	4,08E+00	9,84E+00	1,08E+01	2,01E+01	4,18E+01	9,14E+01	1,66E+02	2,44E+02	3,14E-03	4,43E-02	-6,46E+00
ADPE[11]	kg Sb eq	1,15E+00	2,41E-01	4,43E-04	1,66E-04	2,42E-01	4,43E-04	6,00E-06	3,21E-03	4,09E-01	9,41E-03	1,75E-02	3,64E-02	7,95E-02	1,44E-01	2,12E-01	4,61E-06	1,38E-05	-4,00E-03
ADPF[11]	MJ	6,45E+06	3,77E+04	1,89E+03	8,40E+02	4,04E+04	1,89E+03	1,46E+01	1,00E+04	2,63E+04	1,20E+05	2,24E+05	4,65E+05	1,01E+06	1,84E+06	2,71E+06	1,97E+01	5,64E+01	-1,44E+04
WSF[11]	m3 depriv.	1,85E+04	8,54E+02	5,76E+00	1,92E+01	8,79E+02	5,76E+00	3,67E-01	7,75E+01	6,11E+02	3,20E+02	5,95E+02	1,24E+03	2,70E+03	4,90E+03	7,22E+03	6,00E-02	1,31E+00	-3,01E+02
PM	disease inc.	4,14E-03	1,76E-04	1,01E-05	3,06E-06	1,89E-04	1,01E-05	1,32E-07	1,28E-05	1,22E-04	7,18E-05	1,34E-04	2,78E-04	6,06E-04	1,10E-03	1,62E-03	1,05E-07	5,51E-07	-1,00E-04
IR[12]	kBq U-235 eq	8,74E+04	3,34E+02	9,75E+00	1,24E+01	3,56E+02	9,75E+00	9,52E-02	5,53E+01	2,22E+02	1,64E+03	3,04E+03	6,33E+03	1,38E+04	2,51E+04	3,69E+04	1,02E-01	2,81E-01	-4,81E+01
ETP – FW[11]	CTUe	3,91E+06	1,38E+05	1,49E+03	5,27E+02	1,40E+05	1,49E+03	7,99E+01	6,88E+03	1,57E+05	6,80E+04	1,27E+05	2,63E+05	5,74E+05	1,04E+06	1,53E+06	1,55E+01	3,86E+02	-3,81E+04
HTP - C[11]	CTUh	1,03E-04	1,25E-05	4,78E-08	2,02E-08	1,26E-05	4,78E-08	8,02E-09	1,66E-07	7,28E-06	1,56E-06	2,90E-06	6,02E-06	1,31E-05	2,38E-05	3,51E-05	4,98E-10	1,21E-07	-7,86E-06
HTP - NC[11]	CTUh	3,58E-03	1,54E-04	1,50E-06	4,52E-07	1,56E-04	1,50E-06	4,72E-08	4,48E-06	2,17E-04	6,02E-05	1,12E-04	2,33E-04	5,08E-04	9,22E-04	1,36E-03	1,56E-08	7,49E-06	-2,95E-05
SQP[11]	Pt	9,12E+05	1,65E+04	1,32E+03	8,94E+03	2,67E+04	1,32E+03	1,75E+01	5,45E+03	1,47E+04	1,63E+04	3,03E+04	6,30E+04	1,38E+05	2,49E+05	3,67E+05	1,37E+01	8,59E+01	-2,55E+03
Acronyms	**GWP:** Global Warming Potential, **LULUC:** Land Use and Land Use Change, **ODP:** Ozone Depletion Potential, **AP:** Acidification Potential. **EP:** Eutrophication Potential, **POCP:** Photochemical Ozone Creation Potential, **ADPE:** Abiotic Depletion Potential – Elements, **ADPF:** Abiotic Depletion Potential – Fossil Fuels, **WDP:** Water Scarcity Footprint, **PM:** Particulate Matter, **IRP:** Ionizing Radiation - Human Health, **ETP-FW:** Ecotoxicity Potential – Freshwater, **HTP-C:** Human Toxicity Potential – Cancer, **HTP-NC:** Human Toxicity Potential – Non-Cancer, **SQP:** Soil Quality Potential Index																		
Legend	**A1-C4:** Sum of impacts inside system boundary**, A1:** Raw Material, **A2:** Raw Material Transport, **A3:** Manufacturing, **A1-A3:** Sum of A1-A3, **A4** Transport to Customer, **A5:** Installation, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport**, C3:** Waste Processing, **C4:** Disposal**, D:** Reuse, Recovery, Recycling Potential																		

[10] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

[11] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[12] **Disclaimer:** This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

5.2 Environmental Footprint Endpoint

The environmental footprint endpoint shows the contribution of each environmental impact category to the total environmental impact. This is done by calculating a weighted single score and comparing the contribution from different impact categories.

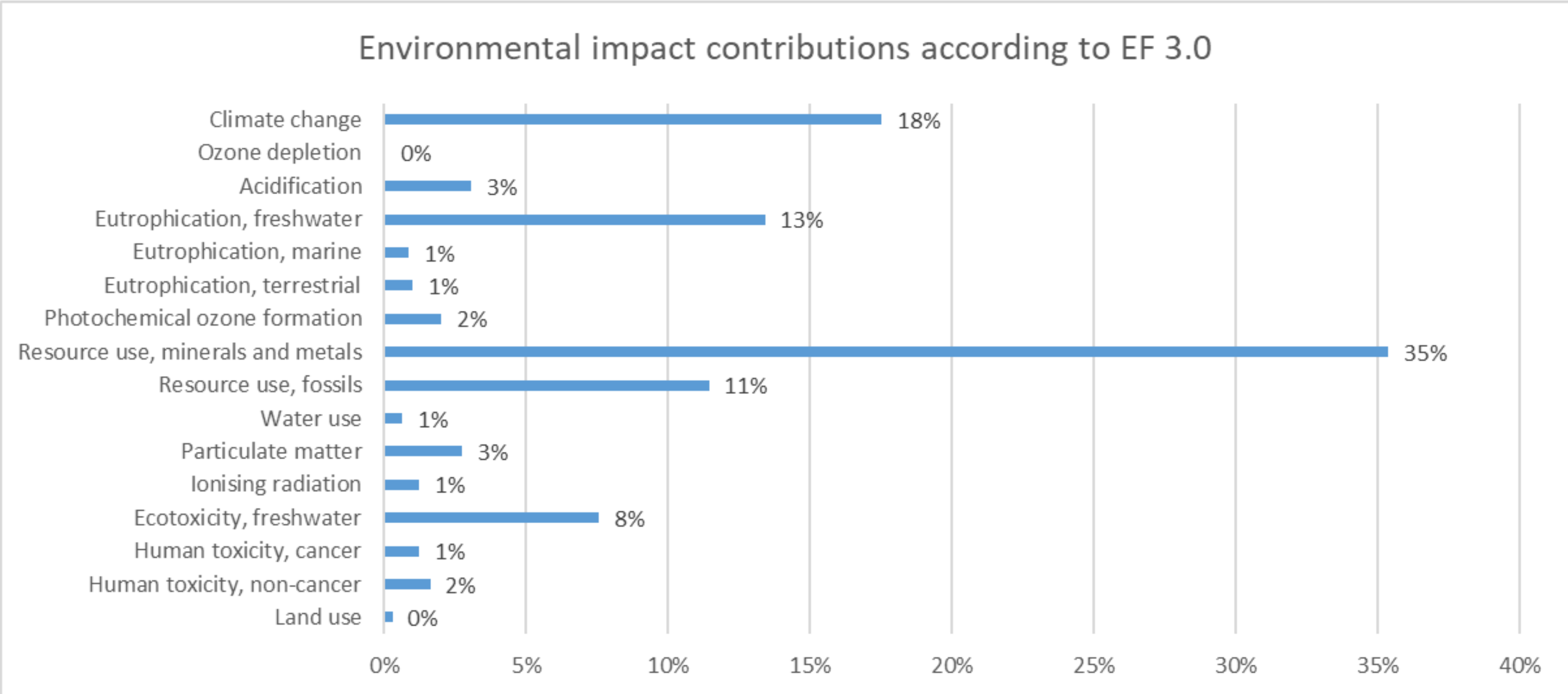

Figure 7: Share of environmental impact per impact category

Figure 8 shows a Sankey diagram of the product life cycle, showing all processes that contribute more than 4% of the total environmental impact.

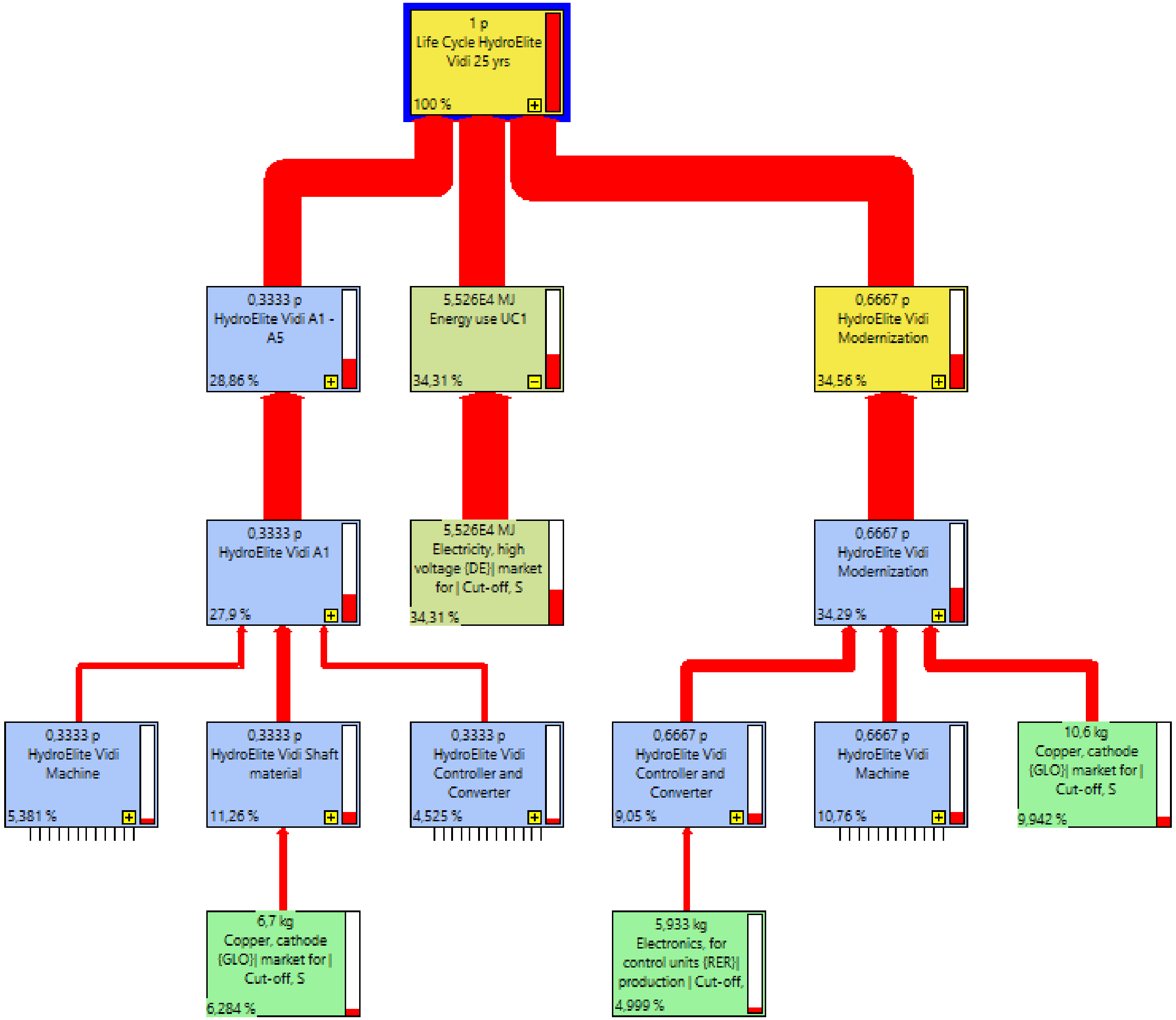

Figure 8: Sankey diagram over Environmental footprint weighted impact (figure hides everything contributing less than 4%)

5.3 Climate impact (GWP) - IPCC GWP 2021 100

The total climate impact over the life cycle of the HydroElite Vidi lift is ca 200 kg CO2-eq. per functional unit, or 16 868 kg CO2-eq. over the reference service life (RSL = 25 years), both cases assuming usage category 1 (UC1). Most of these emissions come from the production of materials and components (A1) and from the use-phase (B6), as can be seen in Table 25 and Figure 9. The Sankey diagram in Figure 10 shows all processes that contribute more than 2% to the total climate impact.

Table 25: Climate impact per module of the HydroElite Vidi lift (UC1), according to IPCC GWP100 2021

Impact category	Unit	A1-C4	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6	C2	C3	D
GWP 100 per f.u.	kg CO2 eq	200	33,1	1,47	0,460	35,0	1,47	0,0625	3,69	21,3	102	0,0153	0,646	-16,4
GWP 100 per RSL	kg CO2 eq	16868	2797	124	38,8	2960	124	5,28	312	1796	8656	1,29	54,6	-1387

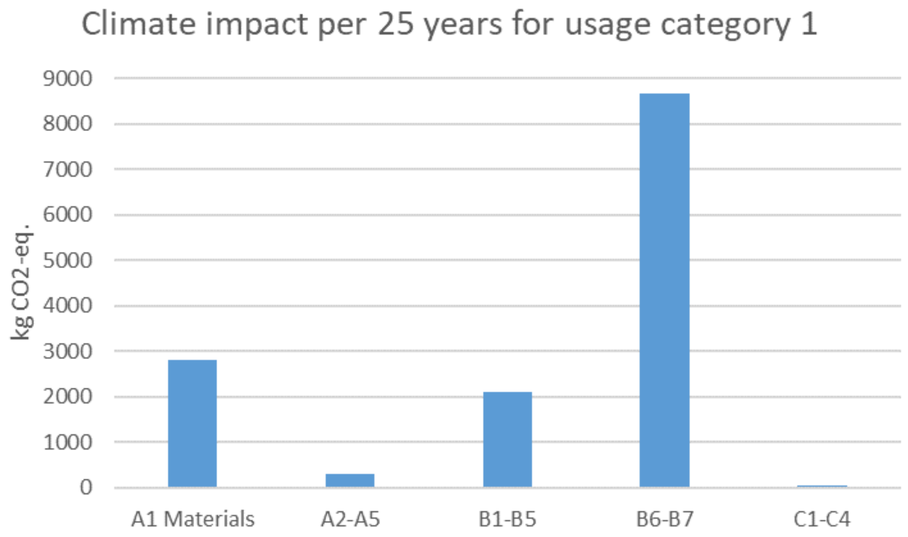

Figure 9: Climate impact according to IPCC 2021 GWP 100

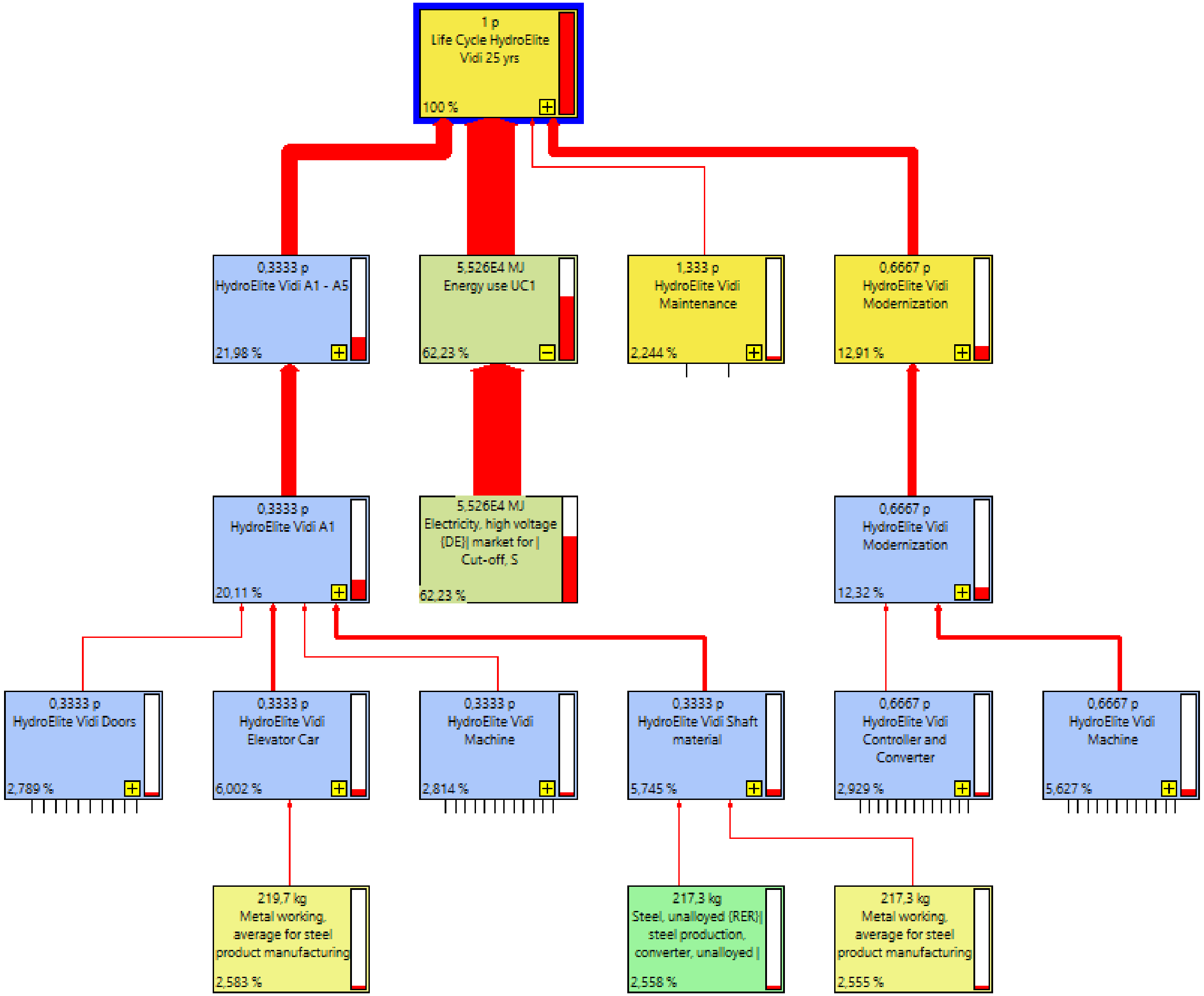

Figure 10: Sankey diagram over share of climate impact contributions per module per RSL for UC1 (figure hides everything contributing less than 2%)

5.4 Use of resources and energy CED 1.11

The consumption of resources in terms of energy is measured as primary energy demand with the method Cumulative Energy Demand 1.11 (see Appendix 4 for further details on the method). These results are presented in Table 26 and Table 27.

Table 26: Use of resources and energy for module A-D, per functional unit (1 tkm) for the HydroElite Vidi lift of usage category 1 (UC1)

Para-meter	Unit	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6	C2	C3	D
PERE	MJ	3,97E+03	9,58E+00	1,07E-01	3,35E+00	1,30E+01	1,07E-01	3,10E-03	3,75E+00	1,20E+01	7,43E+01	1,11E-03	7,22E-03
PERM	MJ	8,94E+00	5,45E+00	0,00E+00	3,49E+00	8,94E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	3,98E+03	1,50E+01	1,07E-01	6,84E+00	2,20E+01	1,07E-01	3,10E-03	3,75E+00	1,20E+01	7,43E+01	1,11E-03	7,22E-03
PENRE	MJ	2,74E+04	1,54E+02	7,93E+00	2,91E+00	1,65E+02	7,93E+00	6,15E-02	4,22E+01	1,10E+02	5,10E+02	8,26E-02	2,37E-01
PENRM	MJ	4,44E+00	3,82E+00	0,00E+00	6,15E-01	4,44E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	2,74E+04	1,58E+02	7,93E+00	3,52E+00	1,69E+02	7,93E+00	6,15E-02	4,22E+01	1,10E+02	5,10E+02	8,26E-02	2,37E-01
SM	kg	5,30E-02	5,30E-02	0,00E+00	0,00E+00	5,30E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m3	1,26E-01	3,61E-02	4,21E-04	3,09E-04	3,68E-02	4,21E-04	4,72E-05	1,85E-03	2,48E-02	6,17E-02	4,39E-06	1,61E-04
Abbrevi-ations	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water												

Table 27: Use of resources and energy for module A-D, per RSL (25 years) for the HydroElite Vidi lift, for all usage categories

Para-meter	Unit	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6 UC1	B6 UC2	B6 UC3	B6 UC4	B6 UC5	B6 UC6	C2	C3	D
PERE	MJ	2,43E+03	2,71E+01	8,48E+02	3,31E+03	2,71E+01	7,87E-01	9,51E+02	3,05E+03	1,88E+04	3,50E+04	7,28E+04	1,59E+05	2,88E+05	4,24E+05	2,82E-01	1,83E+00	-5,16E+02
PERM	MJ	1,38E+03	0,00E+00	8,85E+02	2,27E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	3,81E+03	2,71E+01	1,73E+03	5,57E+03	2,71E+01	7,87E-01	9,51E+02	3,05E+03	1,88E+04	3,50E+04	7,28E+04	1,59E+05	2,88E+05	4,24E+05	2,82E-01	1,83E+00	-5,16E+02
PENRE	MJ	3,90E+04	2,01E+03	7,37E+02	4,17E+04	2,01E+03	1,56E+01	1,07E+04	2,79E+04	1,29E+05	2,40E+05	5,00E+05	1,09E+06	1,98E+06	2,91E+06	2,09E+01	6,01E+01	-1,52E+04
PENRM	MJ	9,69E+02	0,00E+00	1,56E+02	1,12E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	4,00E+04	2,01E+03	8,93E+02	4,29E+04	2,01E+03	1,56E+01	1,07E+04	2,79E+04	1,29E+05	2,40E+05	5,00E+05	1,09E+06	1,98E+06	2,91E+06	2,09E+01	6,01E+01	-1,52E+04
SM	Kg	1,34E+01	0,00E+00	0,00E+00	1,34E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	M3	9,16E+00	1,07E-01	7,84E-02	9,34E+00	1,07E-01	1,20E-02	4,69E-01	6,30E+00	1,56E+01	0,00E+00	0,00E+00	1,11E-03	4,08E-02	0,00E+00	1,11E-03	4,08E-02	0,00E+00
Abbrevi-ations	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water																	

5.5 Waste production and output flows

The production of waste in terms of final waste and the output of materials for recycling, is measured from the calculation of selected inventory results. Final waste and output flows refers to flows that are leaving the system of the LCA. In this LCA only elementary flows (substances) are actually leaving the system (except materials sent for recycling). Waste production (hazardous, non-hazardous, radioactive) is zero across all modules.

Table 28: Output flows for module A1-D, per functional unit (1 tkm) for the HydroElite Vidi lift

Indicator	Unit	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6	C2	C3	D
Components for reuse	kg	0	0	0	0	0	0	0	0	0	0	0	0
Material for recycling	kg	0	0	0	0	0	6,31E-03	1,29E-02	8,40E-01	0	0	6,42E+00	0
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy, electricity	MJ	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy, thermal	MJ	0	0	0	0	0	0	0	0	0	0	0	0

Table 29: Output flows for module A-D, per RSL (25 years) for the HydroElite Vidi lift

Indicator	Unit	A1	A2	A3	A1-A3	A4	A5	B2	B5	B6	C2	C3	D
Components for reuse	kg	0	0	0	0	0	0	0	0	0	0	0	0
Material for recycling	kg	0	0	0	0	0	1,60E+00	3,28E+00	2,13E+02	0	0	1,63E+03	0
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy, electricity	MJ	0	0	0	0	0	0	0	0	0	0	0	0

Exported energy, thermal	MJ	0	0	0	0	0	0	0	0	0	0	0	0

5.6 Biogenic carbon content

Equation 1 Biogenic carbon content according to EN 16449 (chapter 4)

$$\text{Biogenic carbon content} = \text{Biogenic carbon fraction} \bullet \frac{\text{Wet density of the biomass} \bullet \text{Wet volume of the biomass}}{1 + \frac{Moisture\ percentage}{100}}$$

Approximative values:
Biogenic share of MDF and cardboard: 80%
Moisture: 10% for wood and cardboard
Biogenic Carbon fraction: 0,5 for wood and cardboard

Table 30: Shows the biogenic carbon content of the product and the product packaging

Share of biogenic carbon	Unit	Amount
Biogenic carbon in the product	kg C	35,3
Biogenic carbon in the packaging	kg C	62,9

6 Interpretation

This section covers the key aspects of the results, sensitivity analyses, scenario analyses and an evaluation of the model and underlying data.

6.1 Key aspects of results

From a life cycle perspective, the environmental impact of the HydroElite Vidi lift can mainly be attributed to the production of materials and components (module A1), the production of replacement materials and components for modernisation (module B5) as well as electricity consumption in the use phase (module B6), which depends on the usage category of the lift. The EF 3.0 weighting method expresses the total environmental impact of the product by weighting all impact categories together into a single score (see section 5.2). 29% of this single score is caused by the production of raw materials (module A1), 35% is caused by the raw materials for modernisation (module B5), while 34% is caused by the use phase (module B6 for usage category 1). These numbers represent a lift in usage category 1 (the most common category for Hydroware's lifts), but for the higher usage categories, almost all of the impact comes from the use phase (92% for UC6).

Modernisation enables the lift to last longer, and while replacement materials and components need to be produced, the net effect is a reduction of overall impacts per reference service life. Minimising the replaced materials would bring further environmental benefits.

The environmental impact of the raw materials is dominated by resource use of minerals and metals and by climate impacts. The copper and electronics in the shaft material, machine and controller and converter represent the largest amount of resource use. Of the raw materials, the steel components and associated metal working cause most of the climate impacts. The impact of the raw material production is partly mitigated by modernisation. Replacing certain components and materials enables the lift to last longer (75 years with two modernisations), so for a certain time period (like RSL=25 years) or amount of transportation performance, less materials need to be produced compared to a lift that lasts a shorter time.

The use-phase electricity consumption was calculated to be 15,4 MWh of electricity consumed over the reference service life of 25 years (for the most common usage category, UC1). For the highest usage category, the amount was instead 346 MWh). The majority (ca 56%) of this comes from stand-by energy use (for higher usage categories, the share of stand-by power is significantly less, down to 0,3% in UC6). The lift is assumed to be used in Germany, as an approximation for average European use, and the environmental impact of this electricity consumption is dominated by climate impacts, freshwater eutrophication and fossil resource use. Since the electricity represented a large share of all environmental impact, regardless of usage category, the model of the product system is sensitive to the source of energy in the use phase. If the lift is driven by only wind power instead, the total climate impact per functional unit is reduced by ca 60%.

6.2 Sensitivity and scenario analysis

The LCA is a holistic analysis that includes simplifications and value-based choices to cover the complete system. The objective of the sensitivity check is to assess the reliability of the results and conclusions by determining how they are affected by various parameters. Here, seven scenarios were investigated (A-G), shown in Figure 11 and Figure 12. The baseline represents the model as described in sections 1-5, while the other scenarios are described in sections 6.2.1 - 6.2.3. In all cases, the usage category is UC1.

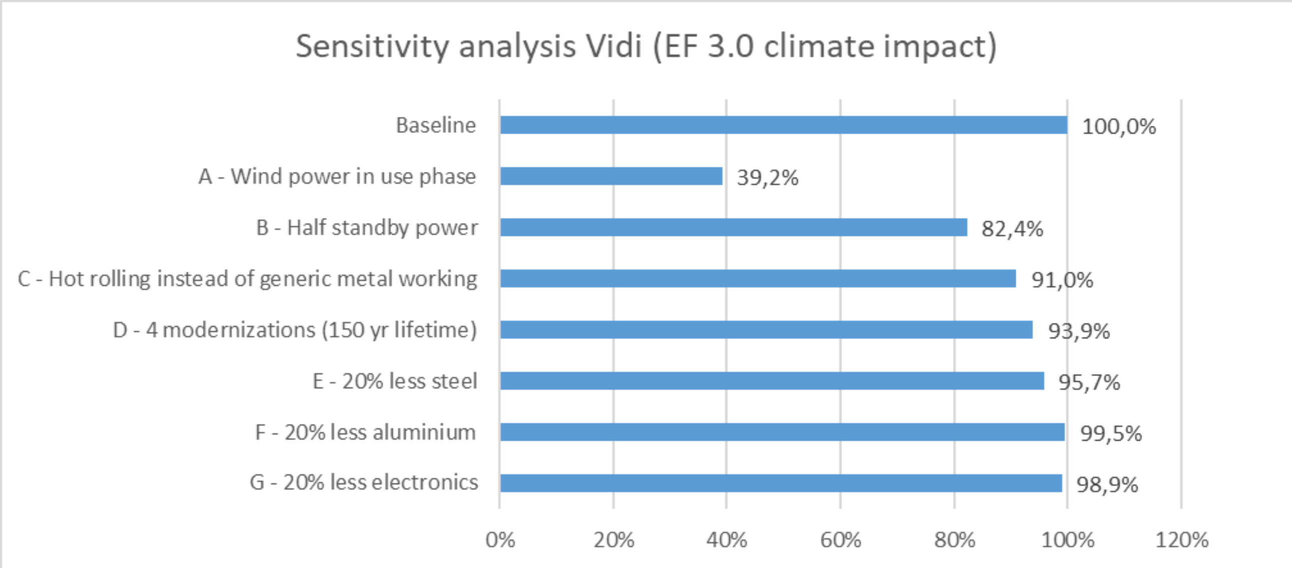

Figure 11: Sensitivity scenario results for the HydroElite Vidi lift (UC1) - climate impacts using EF 3.0

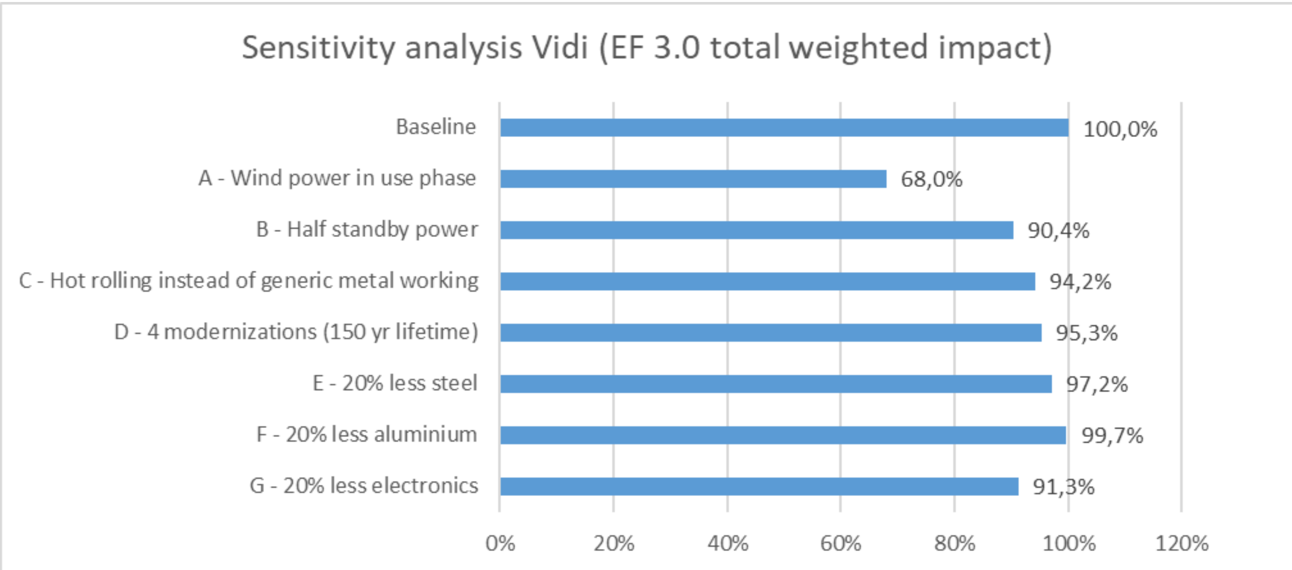

Figure 12: Sensitivity scenario results for the HydroElite Vidi lift (UC1) - total weighted impacts using EF 3.0

6.2.1 Sensitivity scenario A-B: Use phase energy

The impact of the use phase was investigated by changing the source of the electricity towards a more renewable source. Changing to wind power would decrease climate impact by ca 61% and total impact by ca 32% (for a lift in usage category 1). For higher usage categories, the reduction would be even larger.

Another potential way to reduce impacts is by reducing the total energy consumption, for example by reducing the standby power consumption. Halving the standby-power draw reduces total power consumption from ca 15 MWh to 11 MWh and thus reduces climate impacts by ca 28% and total impact by ca 10% (for a lift in usage category 1). For higher usage categories, the share of standby power is lower, so the reduction would be smaller.

This shows that the use phase energy is a critical parameter in the life cycle of the HydroElite Vidi lift, and represents a large opportunity for impact reduction.

Table 31: Details for the sensitivity analysis testing the effects of having different energy sources for the use phase.

	Representation in ecoinvent 3.8	Effect on the results (IPCC climate impacts)	Effect on the results (EF3.0 single score)
Baseline	Electricity, low voltage {Europe without Switzerland}| market group for | Cut-off, U	-	-
Wind power in use	Electricity, high voltage {SE}| electricity production, wind, <1MW turbine, onshore | Cut-off, U	Reduced by 61%	Reduced by 32%
Halved standby power	-	Reduced by 28%	Reduced by 10%

6.2.2 Sensitivity scenario C: Changing metal processing

In the baseline model, all processing of steel components is modelled approximately with generic metal working. To test the importance of this approximation, the generic metal working was replaced with hot rolling, which reduced climate impacts by 9% and total impact by 6%. The impacts can be reduced further e.g. by making sure that renewable electricity is used for the processing.

This shows that it is relevant for Hydroware to collect more specific data on the metal production processes that their suppliers utilise and what energy source is used.

Table 32: Details for the sensitivity analysis testing the effects of prolonging the life of the product.

	Representation in ecoinvent 3.8	Effect on the results (IPCC climate impacts)	Effect on the results (EF3.0 single score)
Baseline	Metal working, average for steel product manufacturing {RER}| processing | Cut-off, U	-	-
Hot rolling instead of generic metal working	Hot rolling, steel {GLO}| market for | Cut-off, U	Reduced by 9%	Reduced by 6%

6.2.3 Sensitivity scenario D: Different number of modernisations

In the baseline model, the lift goes through two modernisations, which prolongs its lifetime to 75 years, i.e. by a factor of three compared to the RSL. Here, the effects of doing a total of four modernisations was tested, which prolongs the life to 150 years, at the cost of more materials and components that need to be replaced.

The climate impacts were reduced by 6 % while the total impacts were reduced by 5%. Conversely, doing no modernisation at all would increase climate impacts by ca 22% compared to the baseline of two modernisations. Figure 13 shows the climate impacts relative to the baseline for various numbers of modernisations (0 to 4). This indicates that modernisation significantly contributes to impact reduction, but with diminishing returns, so two modernisations seems like a suitable amount. If the replacement of materials and components can be minimised, the benefits of modernisation would be even higher, since quite a significant share of the lift is replaced at every modernisation.

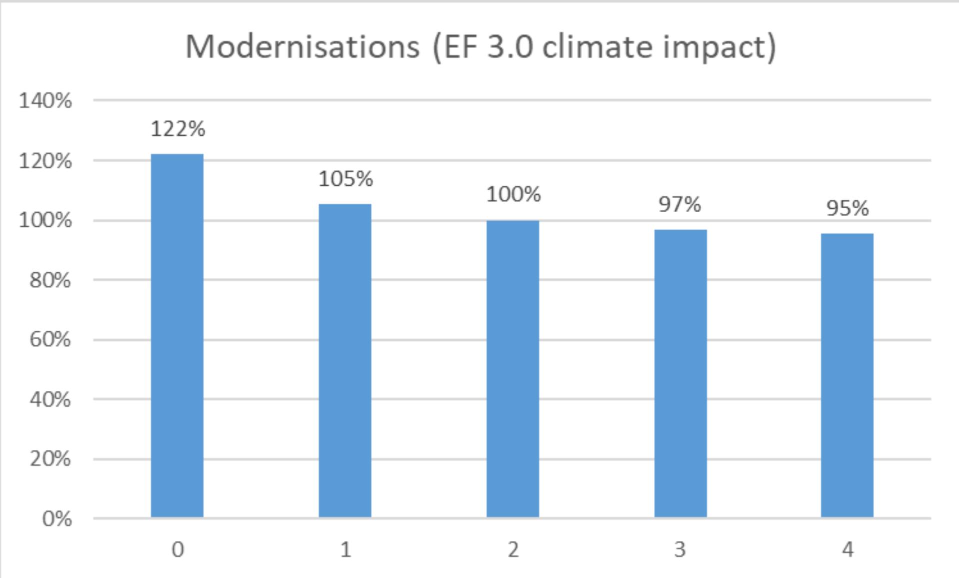

Figure 13: Climate impact (EF 3.0) relative to the baseline, depending on the number of modernisations carried out. 0 modernisations corresponds to a lifetime of 25 years, while 4 modernisations corresponds to 150 years.

6.2.4 Sensitivity scenario E-G: Reducing material weight

To test the environmental potential of reducing the weight of the lift, a reduction of 20% for all steel components was investigated. This gave a reduction in climate impacts of 4% and total impacts by 3%. The same test was done for aluminium and electronics, showing a reduction in climate impacts of 0,5% and 1%, respectively, and a reduction in total impacts of 0,3% and 9%, respectively. The 9% reduction in total impact from reducing the weight of electronics comes mainly from a reduction of copper, which was contributing significantly to the depletion of minerals and metals.

The relative importance of reducing the material use will be larger in the future scenarios with more renewable electricity running the lift. Furthermore, this sensitivity analysis does not include any changes in electricity consumption, which in reality may be reduced by reducing the weight to be transported for every trip, thus giving still further environmental benefits.

Table 33: Details for the sensitivity analysis testing the effects of reducing the weight of different materials in the lift.

	Weight reduction	Effect on the results (IPCC climate impacts)	Effect on the results (EF3.0 single score)
Baseline	-	-	-
Less steel	20%	Reduced by 4%	Reduced by 3%
Less aluminium	20%	Reduced by 0,5%	Reduced by 0,3%

Less electronics	20%	Reduced by 1%	Reduced by 9%

6.3 Data quality assessment

The data is valid for production in Sweden and use in a European country. An evaluation of the model and underlying data is made by a data quality assessment which includes a completeness check, assessing validity of data and a consistency check.

The data are assessed according to the DQR defined in part 3.3.7. The data quality assessment is based on the requirements in the PCR and the EN 15804 standards.

Table 34: Data quality assessment for the study.

Aspect	Notes
Data quality assessment scheme	The data quality level and criteria from the product category rules have been applied in this study. The distinction between Very good, good, fair etc is based on the schemes described in Annex E of EN15804
Geographical coverage	Upstream data: Poor (Generic data from regional or global averages) Core module (A3): Good (electricity from Italy or Sweden) Downstream data: Good (electricity from Germany representing average European use, average European waste management)
Technological representativeness	Upstream data: Fair (Generic data based on plant averages) Core module (A3): Fair (pre-assembly of all modules approximated by the electricity consumption for one module) Downstream data: Good (regionalised energy use and waste management)
Time-related coverage	Upstream data: Good (ecoinvent 3.8 data) Core module (A3): Very good Downstream data: Very good
Validity	The technological and geographical coverage of the data chosen reflects the physical reality of the product system modelled.
Plausibility	The data and results have been checked for plausibility, using EPDs of similar products as reference.
Precision	Material and energy flow quantified based on generic data from the ecoinvent 3.8 database.
Completeness	Data accounts for all known sub-processes. All upstream processes were modelled using generic data from the ecoinvent 3.8 database, using European or global datasets.
Consistency, allocation method, etc.	No allocations were made in specific data.
Completeness and treatment of missing data	No data are found missing.
Final result of data quality assessment	Data quality as required in EN15804 is met.

7 Conclusions and recommendations

This section will summarize the conclusions from the study and highlighting the most important aspects from the results and the interpretation. Recommendations will be presented in suggestions of how to mitigate the hot spots, how to communicate the results and how to reduce the uncertainties of the study.

7.1 Recommendation on how to mitigate the hot spots

The HydroElite Vidi lift causes 200 kg CO2-eq of climate impacts per tkm of transportation performance. Expressed per reference service life of 25 years, the climate impacts are instead 16 868 kg CO2-eq. These and other impacts would be considerably larger if the lift did not undergo modernisation. Since the lift undergoes modernisation, part of the environmental impacts have already been mitigated, and minimising the replacement of materials and components could reduce impacts further.

The majority of impacts come from the production of materials and components and from the use phase. Particularly, the main hotspot was found in the electricity consumption in use phase, which contributes to climate impacts, freshwater eutrophication and fossil resource use. This can be mitigated by:

- Ecodesign for improved energy efficiency, particularly of the standby-energy consumption, which represents the largest share (ca 56% for a lift in usage category 1) of overall energy consumption
- While Hydroware have no direct control over the electricity mix in the use phase, there may be ways to influence this, e.g. by
    - Communicating the importance of using clean energy to Hydroware's customers
    - Nudging or implementing reward systems for customers who can prove that they use clean energy.

Other hotspots included production of raw materials and components, such as steel components and electronics which contribute the most to resource use of minerals and metals as well as to climate change. These hotspots can, for instance, be mitigated in the following ways (without any particular order of priority):

- Using less material in the product
    - Requires ecodesign
- Using a larger share of recycled material
    - Can be achieved by procurement
- Convincing suppliers of bulk materials (such as steel) to use renewable energy in their production
- Increasing the recycling of the product.
    - Can be achieved through communication or altering the business model. Requires more insight and control into the end of life of the product and potentially a take-back system in some form

7.2 How to communicate the results

This report is meant as a technical background that will be made into an EPD. As such, the report acts as the basis for review and ensures that the model is transparent and that the results can be reproduced.

The report shows that fossil and mineral resource use and climate change are the most important environmental aspects, but it also shows that eutrophication is relevant.

In addition to an EPD, the report can also be used as a basis for ecodesign or for external communication documents or presentations.

7.3 How to reduce uncertainties

Some parts of the model were built on data of low quality and in some cases there were data gaps. Finding more specific data for the following areas can highly improve the overall data quality of the LCA:

- More specific data for materials and components and their processing/manufacturing, particularly for steel and copper components
    - Now built on generic data which potentially overestimates environmental impacts
- Investigate and confirm how much recycled material is used as input into each of the major components

7.4 Internal follow-up procedures

For EPDs, internal follow-up procedures shall be established to confirm whether the information in the EPD remains valid or if the EPD needs to be updated during its validity period. The GPI states that the main parameters that may mandate an update shall be identified through a sensitivity analysis. The established procedure may or may not involve a contracted verifier. The follow-up shall be at least annually and should be made with a frequency that will allow for an acceptable coverage of changes that might occur.

The procedure should include how the organisation monitors any significant changes that have taken place in the information submitted as input data for the information in the EPD, such as raw material acquisition, transportation modes, manufacturing processes, changes in product design, or updated legislation. The follow-up procedure may be made part of an existing quality or environmental management system.

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9 Appendix list

Appendix 1 Basics of Life Cycle Assessment 54
Appendix 2 Methods for Impact Assessment 61
Appendix 3 IPCC 2021 66
Appendix 4 Cumulative Energy Demand, CED 67
Appendix 5 Material per module 68

Appendix 1 Basics of Life Cycle Assessment

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 14.

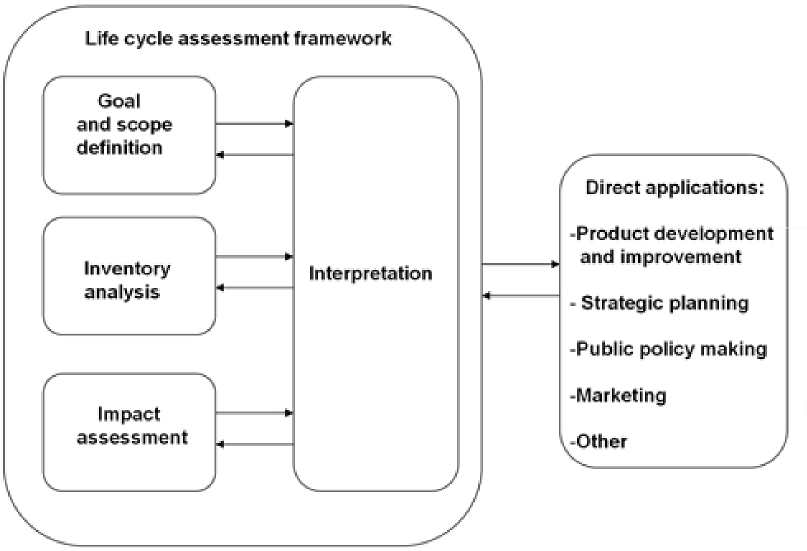

Figure 14. The four phases of the Life Cycle Assessment

A. Goal and scope definition

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.

B. Inventory analysis (LCI)

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.

C. Impact assessment (LCIA)

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. Mandatory steps in the lifecycle impact assessment are classification and characterisation. An optional step is weighting. Classification, characterisation, weighting and examples of common impact categories will now briefly be explained. The LCIA-method is explained in more details in Appendix 2.

i. Classification and characterisation

The process of determining what effects an environmental aspect can contribute to is called classification, e.g. that the use of water contributes to the environmental effect of water depletion.

Characterization in turn means defining how much an environmental aspect contributes to the environmental impact category to which it is classified, e.g. the use of 1 tonne of river water contributes a factor of 0.5 to water depletion. Evaluating how critical it is in a specific area depends on the current environmental impact, the pressure from resource consumption and the ecosystem's carrying capacity. This is done through normalization.

ii. Weighting

To compare between different environmental effects and to identify "hot spots", so-called *weighting* is applied. The calculated environmental effects are weighted together to form an index called a "*single score*" which describes the total environmental impact.

Because weighting involves subjective weighting (e.g. by an expert panel) it is recommended for internal communication only. Otherwise, there is a risk of mistrust if the choice of weighting method used leads to results that emphasise the "upsides" and hide the "downsides" of the analysed product. For external communication, only *Single issues* should be communicated.

iii. Impact categories

An impact category groups different emissions into one effect on the environment. The impact categories from the Environmental footprint 3.0 method will now be presented (European Commission, 2012).

Acidification – EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NOx, NH3 and SOx lead to releases of hydrogen ions (H+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.

Climate change - All inputs or outputs that result in greenhouse gas emissions. The consequences include increased average global temperatures and sudden regional climatic changes. Climate change is an impact affecting the environment on a global scale.

Ecotoxicity, freshwater – Environmental footprint impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.

Eutrophication – Nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass. Three EF impact categories are used to assess the impacts due to eutrophication: Eutrophication, terrestrial; Eutrophication, freshwater; Eutrophication, marine.

Human toxicity – cancer: Impact category that accounts for adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.

Human toxicity - non cancer: Impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to noncancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.

Ionising radiation, human health – EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.

Land use: The land use impact category reflects the damage to ecosystems due to the effects of occupation and transformation of the 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 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.

Ozone depletion – EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs, Halons).

Particulate matter formation – Fine Particulate Matter with a diameter of smaller than 10 μm (PM10) represents a complex mixture of organic and inorganic substances. PM10 causes health problems as it reaches the upper part of the airways and lungs when inhaled. Secondary PM10 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.

Photochemical ozone formation – EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.

Resource use, fossil: Impact category that addresses the use of non-renewable fossil natural resources (e.g. natural gas, coal, oil).

Resource use, minerals and metals: Impact category that addresses the use of non-renewable abiotic natural resources (minerals and metals).

Water use – It represents the relative available water remaining per area in a watershed, after the demand of humans and aquatic ecosystems has been met. It assesses the potential of water deprivation, to either humans or ecosystems, building on the assumption that the less water remaining available per area, the more likely another user will be deprived (see also http://www.wulca-waterlca.org/aware.html).

D. Interpretation

The life cycle interpretation phase of an LCA or an LCI study comprises several elements:

- identification of the significant issues based on the results of the LCI and LCIA phases of LCA
- an evaluation that considers completeness, sensitivity and consistency checks
- conclusions, limitations, and recommendations.

The interpretation of the results in this study is done by first identifying the aspects that contribute the most in each individual environmental effect category. After that, the sensitivity of these aspects are evaluated, and the completeness and consistency of the study are assessed. Conclusions and recommendations are then based on the results and a clear understanding of how the LCA was conducted with any subsequent limitation.

i. Evaluation of the results

The objectives of the evaluation element are to establish and enhance confidence in, and the reliability of, the results of the LCA or the LCI study, including the significant issues identified in the first element of the interpretation. The evaluation should use the following three techniques:

- 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.
- Sensitivity check
  The objective of the sensitivity check is to assess the reliability of the final results and conclusions by determining how they are affected by uncertainties in the data, allocation methods or calculation of category indicator results, etc.
- Consistency check
  The objective of the consistency check is to determine whether the assumptions, methods and data are consistent with the goal and scope.
- Uncertainty check
  Is a systematic procedure to quantify the uncertainty introduced in the results of a life cycle inventory analysis due to the cumulative effects of model imprecision, input uncertainty and data variability

E. Further details on system boundaries, allocation and data quality

i. System boundary

The system boundary determines which modules and activities are included within the LCA. The selection of the system boundary shall be consistent with the goal of the study. A system boundary I chosen to include all contributing processes for the system while facilitating the modelling and analysis of the system. Therefore, there may be reasons to exclude activities that contribute insignificantly to the environmental effects (so-called "cut-off"). However, the omission of life cycle stages, processes, inputs, or outputs is permitted only if it does not significantly change the study's overall conclusions. It should be clearly stated if decision to skip life cycle stages, processes, inputs, or outputs are made and the reasons and implications for their exclusion must be explained.

When the life cycle is defined by the system boundary the environmental aspects included and the data used to represent the different aspects is in detail described under the LCI part.

Figure 15 shows all the life cycle stages included in an LCA, divided into modules A-D.

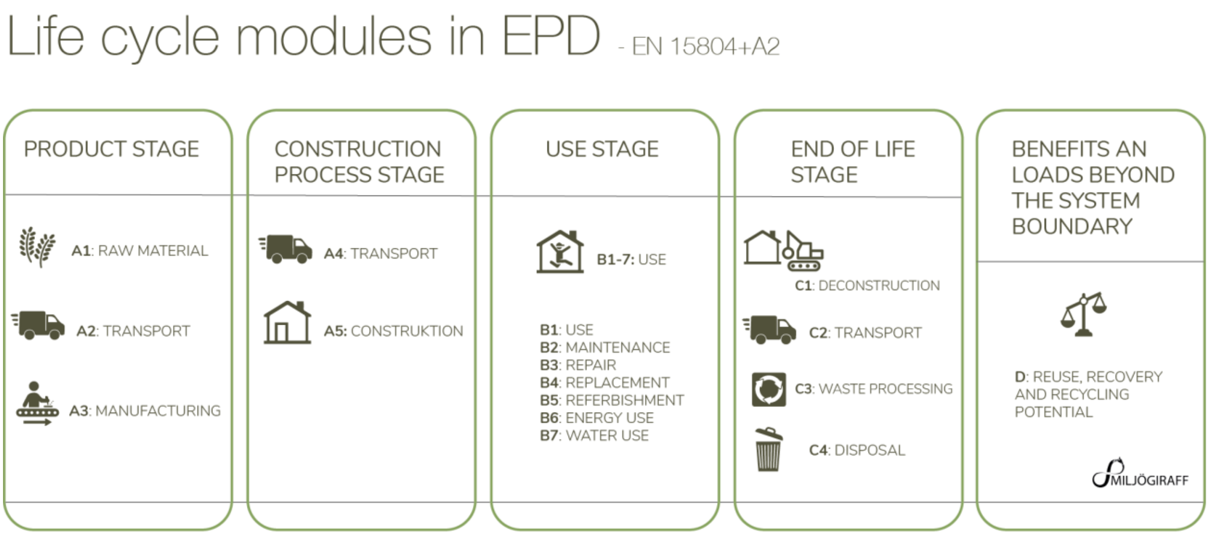

Figure 15: General summary of the modules included in an LCA, based on EN 15804.

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[13], which are also in line with the requirements and guidelines of the ISO14040/14044 standards. Following these recommendations, the Polluter Pays (PP) allocation method is applied (see Figure 16). For allocation of environmental burdens when incinerating waste, all processes in the waste treatment phase, including emissions from the incineration, are allocated to the life cycle in which the waste is generated. Subsequent procedures for refining energy or materials to be used as input in a following/receiving process are allocated to the next life cycle.

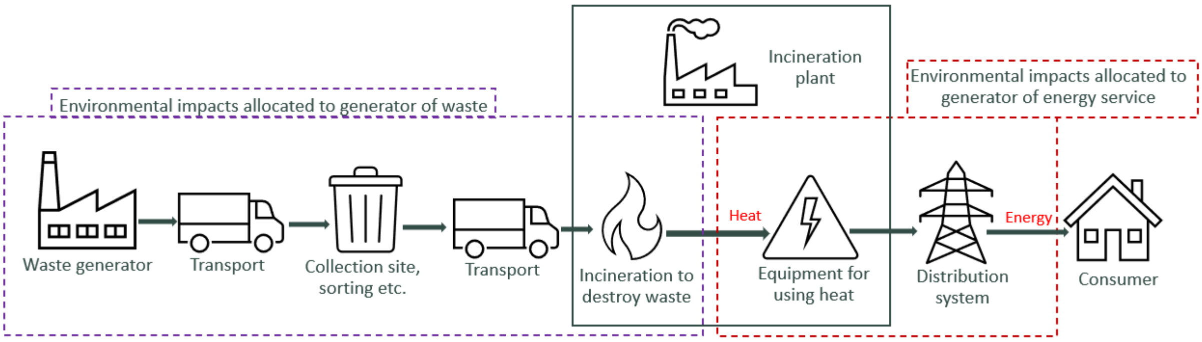

Figure 16: Allocation of environmental impacts between two life cycles according to the PP allocation method. Here in regards to incineration of waste and resulting energy products.

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

Avoided materials due to recycling are typically not considered in the main scenario, per the International EPD system's recommendation of the Polluter Pays Principle. In other words, only if the generating life cycle uses recycled material as input material will it account for the benefits of recycling.

[13] EPD (Environmental Product Declarations) by EPD International®

ii. Cut-off

It is common to scan for the most important factors (a "cut off" of 95% is a minimum) to avoid putting time and effort on irrelevant parts of the life cycle. In general, LCA focuses on the essential material and energy flows, while the flows that can be considered negligible are excluded. By setting cut-off criteria, a lower limit is defined for 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 determined for inflows concerning mass, energy, or outflows, e.g., waste.

iii. Allocation

The study shall identify the processes shared with other product systems, as co-products, 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 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 how 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.

When other allocation methods are used, it should be documented and assessed whether it may be significant to the results.

iv. Data requirements (DQR)

General LCI databases contain a large amount of third party reviewed LCI data compiled according to the ISO 14048 standard. Certified LCI data forms a basis for a robust and transparent study. However, it is crucial to understand that specific producers may differ considerably from general practice and average data.

The LCI data can be either specific or general. Specific data means that all data concerning material, energy and waste are specifically modelled for the conditions at the manufacturing facility and the technology used. Generic data means that material or energy are represented using average LCI data from ecoinvent 3.8.

Specific data
1. Environmental Product Declarations (type III)
2. Collected data (web format, site visits and interviews).
3. Reported data (EMS, Internal data systems or spreadsheets)

Selected generic data
1. Close proxy with data on a similar product
2. Statistics

3. Public documents

Generic data

1. Public and verified libraries with LCI data
2. Trade organisations libraries with LCI data

Sector-based IO data, national

Appendix 2 Methods for Impact Assessment

Classification and characterisation

Classification means that all categories of data are sorted into different categories of environmental effects (see Figure 17). Readymade methods for this have been used to evaluate environmental effects from a broad perspective and find the categories with the most potential impact. The most commonly used methods include Ecoindicator and EPS. These methods also include characterisation (and weighting, described below). In characterisation, the aim 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 characterisation factors that are specific for the data and the category of environmental effect. The result of the characterisation indicates what or which emissions lead to a significant environmental influence. Each of these characterisations represents the potential environmental influence that could arise if an element were released into the environment or if a resource was consumed. Classification and characterisation are where all items in the inventory are assigned to the effect it is likely to have on the environment.

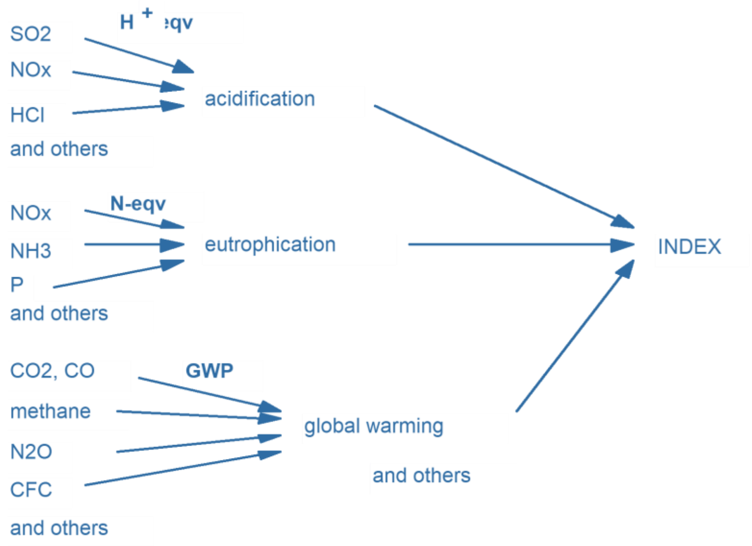

Figure 17: An illustration of the Impact Assessment of an LCA.

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 the Life Cycle Assessment, substances that were found in the inventory are assigned to environmental aspects. In order to contribute to the ultimate goal of sustainability, it is important to also describe the local and global environment. Environmental aspects that may have an impact are located and after that, the link to the inventory and the process path features may be analysed and established.

LCA impact categories vs planetary boundaries

It can be relevant to note that the impact categories described above do not have a one to one correlation with the planetary boundaries as described by Steffen et al. (Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, 2015). Table 35 maps the planetary boundaries to mid-point indicators in LCA (when possible) and classifies whether there is a high or low level of correspondence between the indicators.

Climate change, ozone depletion, eutrophication and human- and ecotoxicity are included in similar ways in the two frameworks (Böckin et al., 2020). However, the ILCD indicators of photochemical ozone creation potential and respiratory effects are meant to represent direct human health impacts.

The corresponding planetary boundary is atmospheric aerosol loading, but this is instead mainly meant to represent effects on monsoon rains. Furthermore, acidification in ILCD represents impacts from e.g. nitrogen and sulphur oxides on land and water ecosystems, while ocean acidification in the planetary boundaries instead represents the effects of carbon dioxide being dissolved in oceans, thus lowering pH levels and affecting marine life. Moreover, the ILCD standard does not include an indicator that matches the planetary boundary of biospheric integrity, while the closest category can be said to be land use, since it is a driver of biodiversity loss. Lastly, there are some differences between land system change and freshwater use in the planetary boundaries and land use and water use in ILCD, while the planetary boundaries do not include a category for abiotic resource depletion.

Table 35: Planetary boundaries, by Steffen et al. (Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, 2015), and mid-point environmental impact indicators in LCA recommended by ILCD (Hauschild & Huijbregts, 2015). Adapted from (Tillman et al., 2020).

Planetary boundaries	Mid-point indicators in LCA as recommended by ILCD	Level of correspondence between impact categories
Climate change	Climate change	High level of correspondence
Stratospheric ozone depletion	Ozone layer depletion	
Biogeochemical flows (nitrogen and phosphorus cycles)	Freshwater, marine and terrestrial eutrophication	
Novel entities (chemical pollution)	Freshwater ecotoxicity	
	Human toxicity (cancer and non-cancer)	
Atmospheric aerosol loading	Photochemical ozone creation	Some correspondence
	Respiratory effects, inorganic	
Ocean acidification	Freshwater acidification	
Biospheric integrity (biodiversity loss)	Resources land use	
Land system change	Resources land use	
Freshwater use	Resources dissipated water	
-	Resources minerals and metals	No correspondence
-	Resources fossils	
-	Ionising radiation	

Weighting
The results of an LCA may depend on the method for impact assessment. There are several different models to assist in the 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.

Using a weighting method implies that all of the data classes are weighted together so that only one number is expressed for the weighting method. The different data categories are weighed from some form of valuation principle. The basis of 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 nature. The more effect or deviation an environmental aspect has from the valuations, the higher the weighting value assigned to that environmental aspect.

The basis of the valuations used to develop weighting methods could be; political decisions, technical-financial conditions, nature conditions, health effects, panels or studies of behavioural patterns. In a weighting method, there is either one or a combination of valuation bases. Since the basis of valuations varies for each weighting method, a comparison between different methods will give a corresponding shift in the result.

The most commonly used weighting methods are collected in the book "The Hitch Hiker's Guide to LCA", written by Baumann & Tillman (Baumann & Tillman, 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 of 5 % ecosystem degeneration, or similar. Ecoindicator'99 weights are determined from three different cultural perspectives; hierarchist, egalitarian and individualist perspectives. Ecoindicator'99 is based on Goedkoop and Spriensma (Goedkoop & Spriensma, 1999).

EPS 2000 is based on the willingness-to-pay for avoiding damages on environmental safeguard subjects. The EPS method is especially suitable for the assessment of global impacts, such as climate change potential and resource depletion. The EPS indices are prepared by a group at the Chalmers University of Technology and a steering committee from the industry in Sweden.

Among the most common methods, however, are EF and ReCiPe and they deserve some more details, which are presented below.

The impact assessment methods EF 3.0 and ReCiPe 2008
While the Environmental Footprint method is used in this report, it is built on the foundation of the ReCiPe 2008 method, which is presented in detail here.

ReCiPe LCIA Methodology is a methodological tool used to quantitatively analyse the life cycle of products/activities. ISO 14040 and 14044 provide a generic framework. After the goal and scope have been determined and data collected, an inventory result is calculated. This inventory result is often a long list of emissions, consumed resources and sometimes other items. The interpretation of this list is difficult. An LCIA procedure, such as the ReCiPe method is designed to help with this interpretation. The primary objective of the ReCiPe method is to transform the long list of inventory results, into a limited number of indicator scores. These indicator scores express the relative severity of an environmental impact category. In ReCiPe indicators are determined on two levels:

- Eighteen midpoint indicators
- Three endpoint indicators

ReCiPe uses an environmental mechanism as the basis for the modelling. An environmental mechanism can be seen as a series of effects that together can create a certain level of damage to, for instance, human health or ecosystems. For climate change, we know that a number of substances increase radiative forcing. This means that heat is prevented from being radiated from Earth to space. As a result, more energy is trapped on Earth and temperature increases. As a result, we can expect changes in habitats for living organisms, resulting in the potential extinction of species. From this example, it is clear that the longer the chains of environmental mechanisms, the higher the uncertainties (see Figure 18). Radiative forcing is a physical parameter that can be relatively easily measured in a laboratory. The resulting temperature increase is less easy to determine, as there are many parallel positive and negative feedback. Our understanding of the expected change in habitat is also not complete, etc.

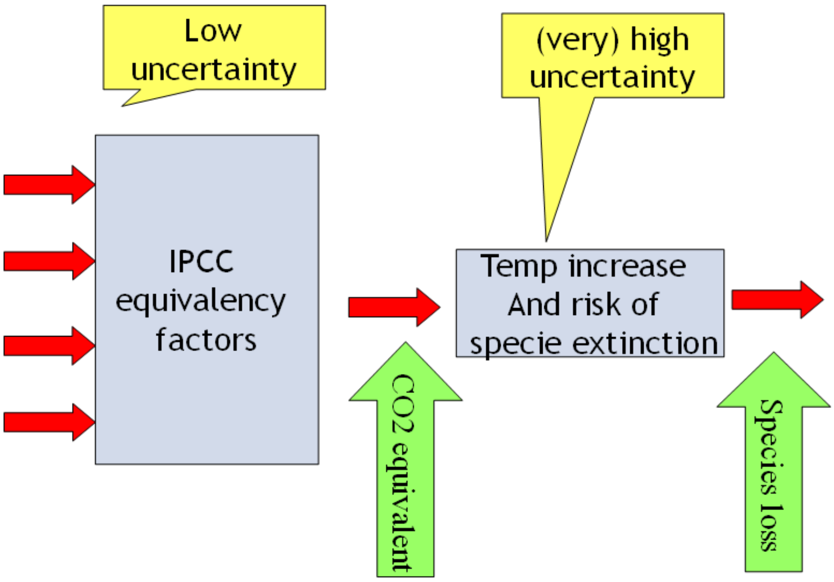

Figure 18: Example of a harmonised midpoint-endpoint model for climate change, linking to human health and ecosystem damage.

Hence, the obvious benefit of only taking the first step is the relatively low uncertainty. However, ReCiPe combines mid- and endpoints. Eighteen midpoint indicators are used, but three much more uncertain endpoint indicators are also calculated. The motivation to calculate the endpoint indicators is that the large number of midpoint indicators is difficult to interpret, partially as there are too many, partially because they have a very abstract meaning. How to compare radiative forcing with base saturation numbers that express acidification? The indicators at the endpoint level are intended to facilitate easier interpretation, as there are only three, and they have a more easily grasped meaning. The idea is that each user can choose at which level they wants to have the result:

- Eighteen robust midpoints, that are relatively robust, but not easy to interpret
- Three easy to understand, but more uncertain endpoints:
    - Damage to Human health
    - Damage to ecosystems
    - Damage to resource availability

The user can thus choose between uncertainty in the indicators on the one hand and uncertainty in the correct interpretation of indicators on the other hand. Figure 19 provides the overall structure of the method.

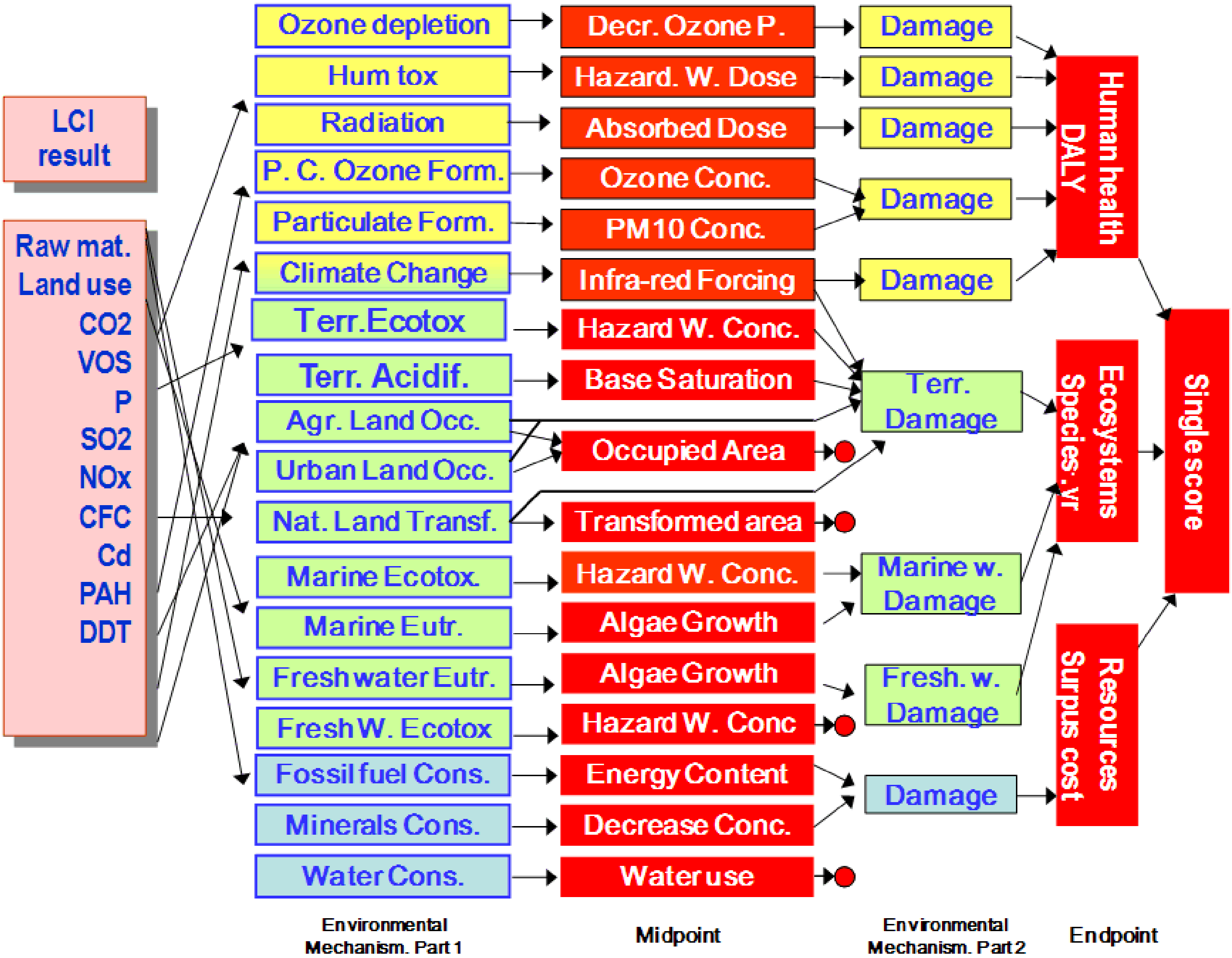

Figure 19: ReCiPe Characterisation links.

Appendix 3 IPCC 2021

Direct solar radiation heats the Earth. The heated crust emits heat radiation, which is partially absorbed by gases, known as greenhouse gases, in the Earth's atmosphere. Some of this heat radiation radiates back to Earth and heats it. 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 2021 GWP 100 v.1.0, 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 Cumulative Energy Demand, CED

Cumulative Energy Demand (CED) is a method to calculate direct and indirect use of energy resources, commonly referred to as *primary energy*. Characterisation factors are given for the energy resources divided into five impact categories:

- Non-renewable, fossil
- Non-renewable, nuclear
- Renewable, biomass
- Renewable, wind, solar, geothermal
- Renewable, water

Some studies also add energy from waste as an indicator. This is not done here, since waste is not considered to be primary energy, and thus the input of energy resources may be less than the final energy (heat and electricity) delivered by the system.

Normalisation is not a part of this method. To get a total ("cumulative") energy demand, each impact category is given the weighting factor 1 (Frischknecht et al., 2007).

Appendix 5 Material per module

Table 36 shows the weights of each material divided into the six modules of the lift.

Table 36: Material weights (kg) for each module of one lift

Material	Car	Controller & Converter	Machine	Cylinder	Shaft Material	Doors
Steel, unalloyed	442,2	48,2	163,39	164,6	652	303,7
Steel, low alloyed	217	0	0	0	0	12,7
Aluminium, cast alloy	0,8	0,4	18,806	0	0	8
Copper, cathode	0	1,9	6,288	0	20,1	0,5
Polypropylene, granulate	22	5,1	0,28	0,4	21,75	0
PVC, bulk	0	0	0	0	0	3
Glass, coated	22	0	0	0	0	0
MDF, uncoated	98	0	0	0	0	0
Electronic control unit	0	8,9	4,6	0	0,6	0
Electric connector	0	3,2	0	0	0	0
LCD display	0	0,4	0	0	0	0
Battery, Li-ion	0	4,8	0	0	0	0
Synthetic rubber	0	0	8,9	0	0	0
Lubricating oil	0	0	110	0	0	0
Circuit board	0	1,18	0	0	0	0
Cast iron	0	0	20,56	0	0	0
Total	802,0	74,1	332,8	165	694,5	327,9