Environmental fact sheet: HRS MR

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Foreword

Environmental protection is a practice of protecting the natural environment, for the benefit of both the environment and humans. With awareness of environmental protection increasing worldwide, demand for more efficient products to reduce energy and resource consumption is more urgent than ever. The possible environmental impacts associated with products have sparked interest in developing methods to understand and minimize these impacts. Life-cycle assessment (LCA) is a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. LCAs can help avoid a narrow outlook on environmental concerns by compiling an inventory of relevant energy and material inputs and environmental releases; Evaluating the potential impacts associated with identified inputs and releases and also interpreting the results to help make a more informed decision.

An important aspect on the companies' awareness is the ISO 14000 family of standards, which provides practical tools for companies and organizations of all kinds seeking to manage their environmental responsibilities. ISO 14006 provides guidelines to assist organizations in establishing, documenting, implementing, maintaining and continually improving their management of eco-design as part of an environmental management system (EMS).

Vertical – transportation products are indispensable to urban mobility and accessibility. Passenger comfort and attractive design must be integrated into a large, complex system. combining that with an environmental approach is a creative challenge.

Introductory information

KLEEMANN Hellas S.A. is active in the field of construction and design integrated marketing lift systems. It is one of the largest companies in this sector to the European and international market and produces more than 11,000 lift systems annually.

Since 2012, KLEEMANN implements an environmental management system (EMS) for its facilities. This system has been certified according to ISO 14001 and covers the production unit (office facilities and factories) in the industrial area of Kilkis. The company also applies quality management system certified in accordance with ISO 9001 and implements principle eco-design products in accordance with ISO 14006.

The strategic objective for our company is the sustainable development in full harmonization with the environmental protection, resulting in environmentally superior products. That aim can be achieved by adhering to fundamental rules, criteria and mechanisms for environmental protection, pollution prevention and protection of human health. This ensures preservation of natural resources and the gradual restoration of the environment. Main goal is to redesign all of our products on the basis of eco-design process. The strategy is motivated by three factors: nature, society, economy.

The largest lifts company in Greece presents the model of eco-design. The procedure of LCA in our products is constantly a growing part of research and development. This is the main and most important pillar of innovation on technological achievement. It is the most important step on achieving an integrated environmental approach on the products' design.

Description of steps and procedures of eco-design

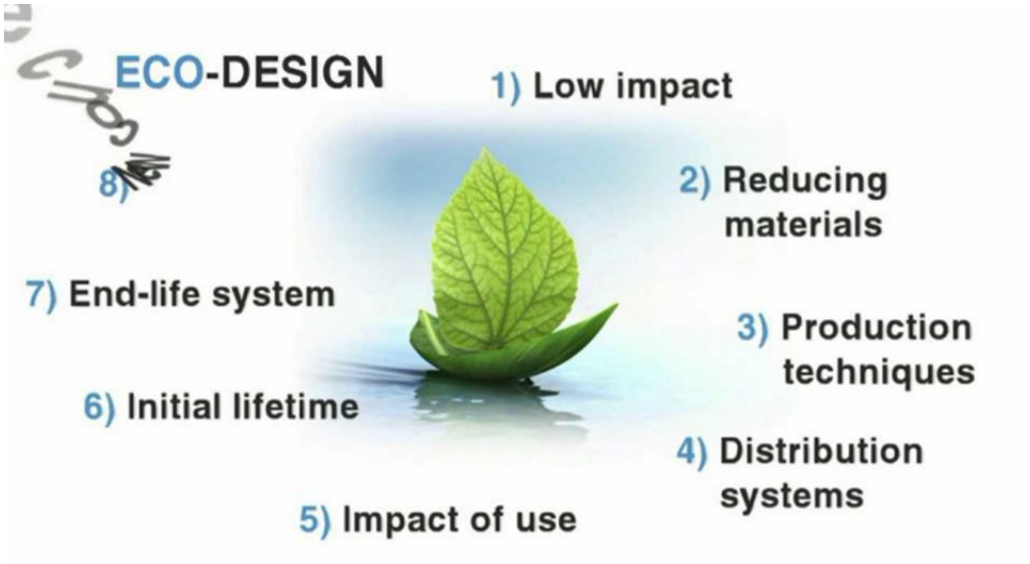
Scope: Eco-design is an approach of designing products with special consideration for the environmental impacts of the product during its whole lifecycle. In a life cycle assessment, the life cycle of a product is usually divided into procurement, manufacture, use, and disposal. It is a growing responsibility and understanding of our ecological footprint on the planet.

Terminology: The flow of energy and materials, as well as the type of pollutants examined in each system, is the part of a product's life. The system is determined by the boundaries, which are defined in advance. System boundaries in this study are the receipt of raw materials in our facilities up to the final recycling and disposal of the product.

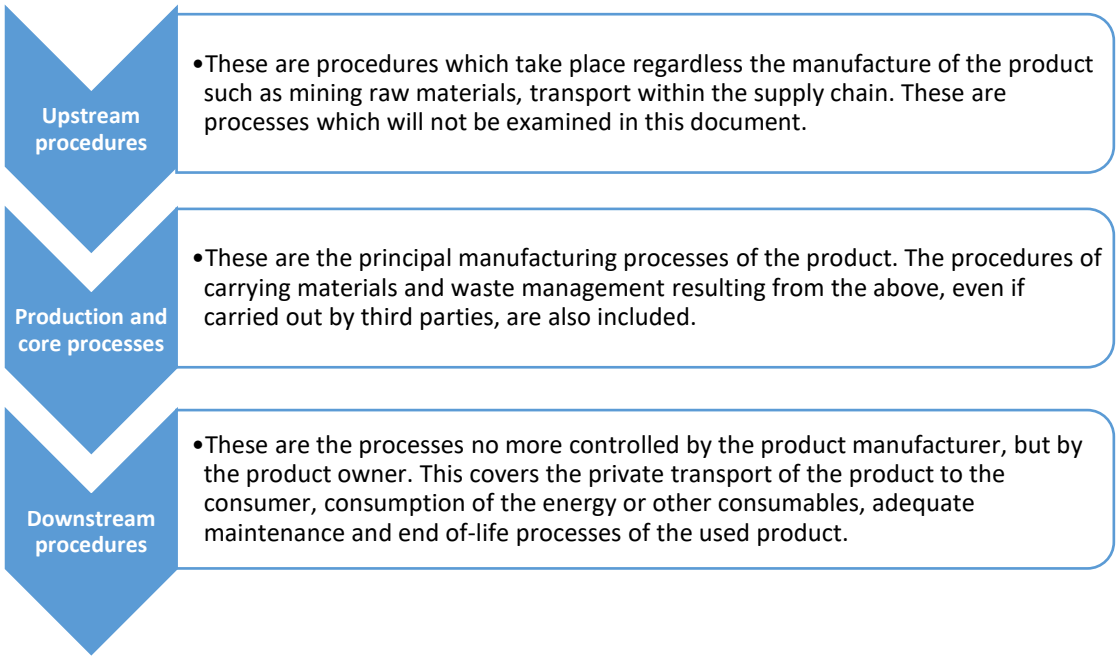
Required data: The data required for the completion of the study are the units of materials and energy required for the entire life cycle of a product as well as the quantification of their effects.

However, in a study of life cycle it is clear that some of the data will be taken from some pertinent cases and are necessarily accepted as they appear in them. As much as we are stretching the limits of the system the analysis of inputs and outputs becomes more difficult. If no suitable data is available, the best estimation is used.

The data relating to the production process are calculated accurately, while the impact of the extraction and production of raw materials have not been addressed. Also, on the basis of the pattern of usage and calculation of consumed energy in a lift system, ISO 25745-2 was carried out, and a number of considerations and assumptions for the average operation throughout the life cycle of the lift.



Procedure description



Calculations and environmental impact assessment

The part of the measurement of environmental impact is the criterion for the improvement actions that are required in order to reduce the first. To calculate these, Software Sima Pro® 8 was used, with method ReCiPe Endpoint, hierarchist version, for the major part of the Environmental Impact Assessment.

Moreover, the ISO 25745-2 was used for the classification of the product in the field of energy efficiency during its usage stage. ISO 25745-2:2015 specifies a method to estimate energy consumption based on measured values, calculation, or simulation, on an annual basis for traction, hydraulic and positive drive lifts on a single unit basis, and an energy classification system for new, existing, and modernized traction, hydraulic, and positive drive lifts on a single unit basis. It applies to passenger and goods passenger lifts with rated speeds greater than 0,15 m/s and only considers the energy performance during the operational portion of the life cycle of the lifts.

In the case of the integrated lift system and for the present document the study of the system begins from the purchase of raw materials to the final disposal.

The method of eco-design is applied to a lift system which is developed, manufactured and distributed by KLEEMANN. The adoption of such a model design contributes as a catalyst to reduce the environmental impact and cost.

Product structure and reference model

The product that has been assessed on the basis and principles of eco-design is a traction electric operated passenger lift. The reference model is an HRS MR traction elevator. The new high rise and speed HRS KLEEMANN Lift is an excellent solution for a range of high-rise commercial and public buildings. Offering outstanding ride quality, HRS KLEEMANN combines passenger comfort with innovative lift monitoring technology to deliver impressive results. The Remote Lift Monitoring system provides a central information system that enables the efficient and simultaneous management of up to 18 lifts, perfect for larger hotels operating high density passenger flow. Destination Control ensures reduced waiting times and a smooth and stress-free passenger experience. Featuring a maximum speed of up to 4m/sec, HRS KLEEMANN provides a series of advantages and innovations.

The main advantages of the product are:

- **Unique tailor-made design**: KLEEMANN special Design team serves as the creating force behind the development of lifts for your challenging projects.
- **Ride quality**: The isolated roller guide shoes limit vibrations and offer outstanding ride quality and cost saving. Due to the spring system and the permanent contact with the guide rail, the high-quality rollers are granted with an exceptionally long service life.
- **Remote Lift Monitoring System**: Providing the opportunity for improved lift management, the Remote Lift Monitoring System is an excellent solution for buildings with multiple lifts.
- **Reduced waiting times**: The Destination Control System reduces waiting times by serving the increased number of calls, where it is important for the passengers to be transported rapidly.
- **Extra safety features**: Safety and durability in public buildings are enhanced with the special features for vandal resistant lifts (EN81-71), firefighting lifts (EN81-72) and earthquake resistant lifts (EN 81-77 or ASME A17.1).
- **Eco-friendly**: Energy saving product which reduces CO2 emission up to 60% using a regeneration drive, stand-by-mode and led lighting.

General Specifications	HRS MR
Rated Load (Kg)	1000-1600
Suspension	2:1
Machine Room	MR
Max Travel (m)	150
Max Number of Stops	47
Max Speed (m/s)	4.0
Min Pit Depth (mm)	1800
Min Headroom (mm)	4140
Maximum car entrances	2
Complies with	Lifts Directive 2014/33/EU

Vertical lifts operate approximately 25 years, by assuming the appropriate cycle of maintenance, and makes about 36,500 journeys per year for the service of the user in an average building. The reference model presents the following specifications:

Reference model	HRS MR
Type	Traction, Electric operated passenger lift
Estimated lifetime	25 years
Trips per day	100
Nominal load	1600kg
Nominal speed	2m/s
Travel	52m
Number of stops	13
Daily travel time	0.5h

The main goal of designing high-speed elevators is to create products that may serve the needs of tall buildings (>35m). It is the first product of the company that may move with maximum speed of 4m/s. It is not produced by a standard product development process, and meets the quality requirements at the same time, to maintain relatively low costs, production and installation time, as well as to pay to the fullest all the safety conditions of both the user and the maintainer. For the needs of the present study the HRS MR will be compared to an older product, namely TLCF43. It has to be mentioned that we are not able to declare that HRS substitutes TLCF, since TLCF even under special conditions might move with speed up to 2m/s, far less that HRS. Generally, HRS may cover a wider range of modern buildings and requirements, such as rated load, maximum travel etc.

Furthermore, HRS production is lean and its installation is easier and faster. The additive advantages are the reduction of SKUs (Stock Keeping Units) and their management and storing cost.

At the same time, the compared products include different electronic controller type. The HRS includes the newly designed GENIUS 20. Especially, should be mentioned the comparison of the controller GENIUS 20 to a previously used controller.

The previously used controllers are namely:

- Lisa 20
- Ucontrol / Uctrl – H2O
- KLLC
- CH1000
- Serial

The above-mentioned controllers were third party products specially altered for KLEEMANN, but they were not directly controlled by KLEEMANN. The main drawbacks were:

- Dependence on 3rd party suppliers
- Difficult or in cases impossible special functions implementation
- Complicated and heavy maintenance processes
- Don’t satisfy 100% customer needs

- Don’t satisfy KLEEMANN strategy and vision

On the other hand, GENIUS 20 is totally developed and designed in-house. It is a unique product with advanced hardware and software. More than 60 new materials are used, more than 40 materials abolished and more than 30 circuits redesigned, in order to fulfil the desired requirements. The achieved improvements are summarized following:

- Hardware design to match KLEEMANN subsystems
  - Easy and fast connections
  - Decreased cost
  - Reduced production time
  - Faster installation time
- Tailor made software
  - Independence from 3rd parties
  - Flexibility to apply new functions and custom-made solutions
- New plug & play wiring
  - Smaller number of deliverables to the customer
  - Reduced cost
  - Decreased production time
  - Faster installation time by 1 day
  - Increased EMC protection according to EN12015/16
- Same wiring package for traction and hydraulic lifts
  - Easier installation of different products by customers
  - Reduced cables running the shaft
  - Halogen free wiring
  - Smaller amount of ERP codes
- Improved controller layout
  - Uniformity between different combinations
  - Reduced production time
  - Increased EMC protection
- Redesigned COPs, LOPs and HOPs
  - According to market needs
  - 47% slimmer
  - Redesigned buttons
- Improved protection from EMC interferences
  - Measures to meet EN12015 and EN12016 demands
- Advanced operation
  - CAN BUS connectivity (flexibility, compatibility)
  - High speed elevators
  - Windows based Building Management System BMS
  - Destination Control System DCS
  - Stand-by mode with minimum energy consumption
  - Android and ios applications / hand terminal replacement
  - Internet of Things (IoT) applications

Present study presents the comparison of GENIUS 20 and LISA 20. LISA 20 was selected as one of the most widely used controller in the past few years.

Analysis of life cycle parameters of the new products

The life cycle analysis, which is an important and integral tool for the eco-design steps, is divided at the level of registration of a product's life cycle stages on the following main categories:

The HRS MR is more eco-friendly product due to:

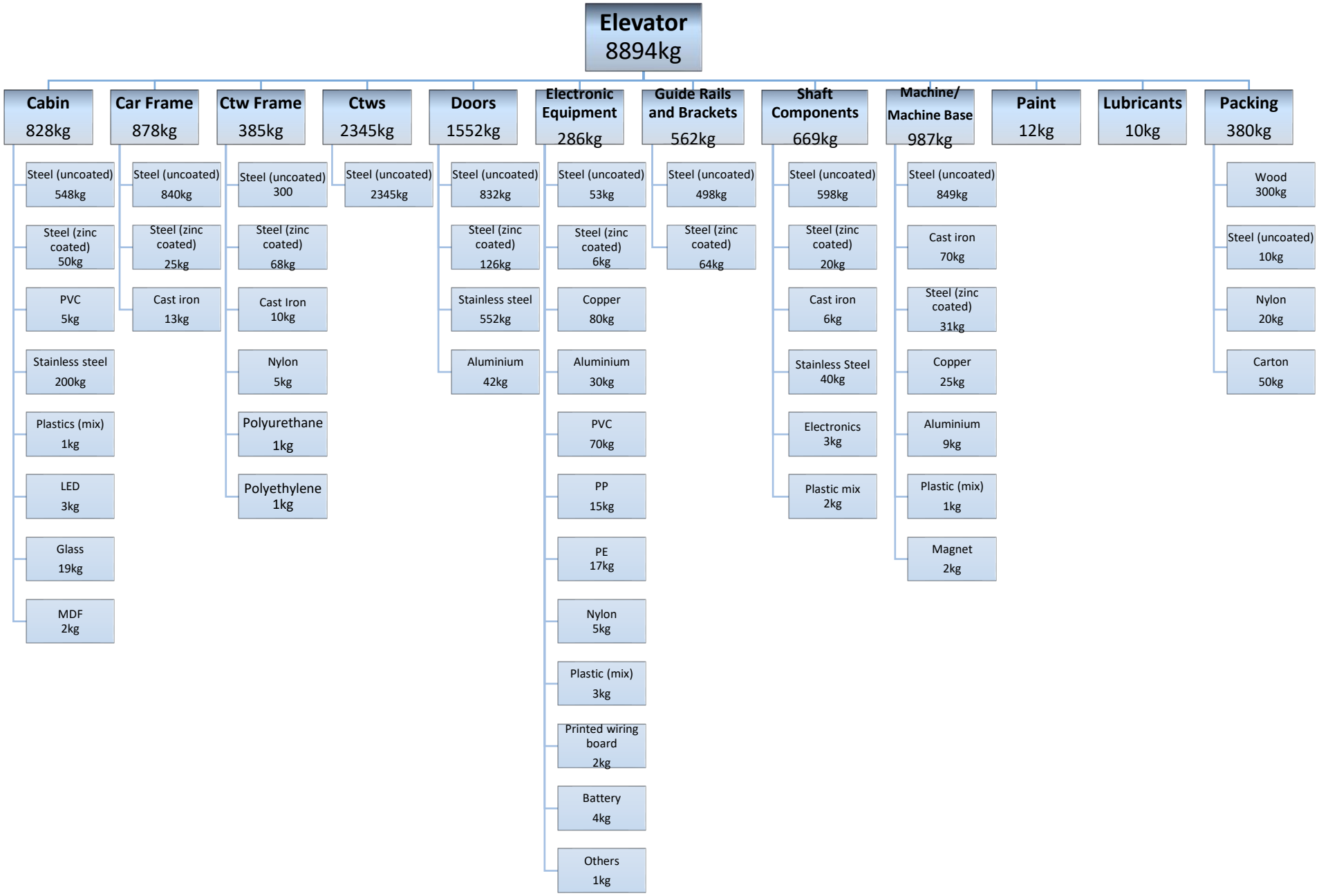
- Reduced quantity of raw materials
- Reduced quantity of paints and solvents
- Less harmful material (less cables, halogen free materials etc)
- More energy efficient features

In accordance to the relevant literature, the major environmental impact on the life cycle of a life is during the usage stage, followed by the stage when materials are acquired and energy is consumed during construction. These are the stages that company takes into account and interfere with the process of eco-design. The service plays also an important role in product's life cycle. The other parameters related to the life cycle of a product, such as packaging, transport and installation shall contribute much lower in overall impact.

Raw materials

The company is gradually trying to co-operate with suppliers who meet the environmental criteria which are set by standards. So up to the present time 50% of suppliers operate, minimum, with an environmental management system and ISO14001 certification.

The total mass of the elevator for the life cycle inventory without packing is 8514kg. Roughly 90% of the elevator materials were metals. Following are presented the sub-assemblies and the materials they are consisted of:


Elevator
8894kg
Cabin
828kg
Steel (uncoated)
548kg
Steel (zinc coated)
50kg
PVC
5kg
Stainless steel
200kg
Plastics (mix)
1kg
LED
3kg
Glass
19kg
MDF
2kg
Car Frame
878kg
Steel (uncoated)
840kg
Steel (zinc coated)
25kg
Cast iron
13kg
Ctw Frame
385kg
Steel (uncoated)
300
Steel (zinc coated)
68kg
Cast Iron
10kg
Nylon
5kg
Polyurethane
1kg
Polyethylene
1kg
Ctws
2345kg
Steel (uncoated)
2345kg
Doors
1552kg
Steel (uncoated)
832kg
Steel (zinc coated)
126kg
Stainless steel
552kg
Aluminium
42kg
Electronic Equipment
286kg
Steel (uncoated)
53kg
Steel (zinc coated)
6kg
Copper
80kg
Aluminium
30kg
PVC
70kg
PP
15kg
PE
17kg
Nylon
5kg
Plastic (mix)
3kg
Printed wiring board
2kg
Battery
4kg
Others
1kg
Guide Rails and Brackets
562kg
Steel (uncoated)
498kg
Steel (zinc coated)
64kg
Shaft Components
669kg
Steel (uncoated)
598kg
Steel (zinc coated)
20kg
Cast iron
6kg
Stainless Steel
40kg
Electronics
3kg
Plastic mix
2kg
Machine/ Machine Base
987kg
Steel (uncoated)
849kg
Cast iron
70kg
Steel (zinc coated)
31kg
Copper
25kg
Aluminium
9kg
Plastic (mix)
1kg
Magnet
2kg
Paint
12kg
Lubricants
10kg
Packing
380kg
Wood
300kg
Steel (uncoated)
10kg
Nylon
20kg
Carton
50kg

Manufacturing processes

Listed below are the manufacturing processes through which each component and the individual parts of the product are made. The facilities of the company have been amended as to the production line (lean flow), which ensures low stocks and flexibility at the same time.

	Shaft Components	Guide Rails and Brackets	Car Frame	Cabin	Ctws Frame	Total
Laser		25	137,025		70,5	15,5
Welding	4.4	25,67	91,41		33,264	50,233
Saw			13,149	6,948	3,72	17,094
Drill			1,205		0,0871	0,836
Bending	2.5	5	9,738	7,6	1,1025	0,575
CNC	4.6		46,541		7,931	
Punching						
Scissors				5,5		
Painting				1,875		
Punching		1,35	76,35	17,5	34,65	81
Turn cutting machine		0,13	1,053	68,6		
Consumed Energy	**11.5kWh**	**57.15kWh**	**395.108kWh**	**108.023kWh**	**162.457kWh**	**165.239kWh**

Transportation & Packaging

Transportation: Average mileage for the product from the production site to the installation site is 800km (average distance from the factory to the various installations in accordance with the measurements of 2014). The carriage of cargo is up to 16tones.

Packaging: For the packaging of products wood, nylon, nails and cartons are used. The packaging for by-product required is listed below:

Material	Quantity [kg]
Wood pallet	300
Nylon	20
Steel (nails etc)	10
Carton boxes	50

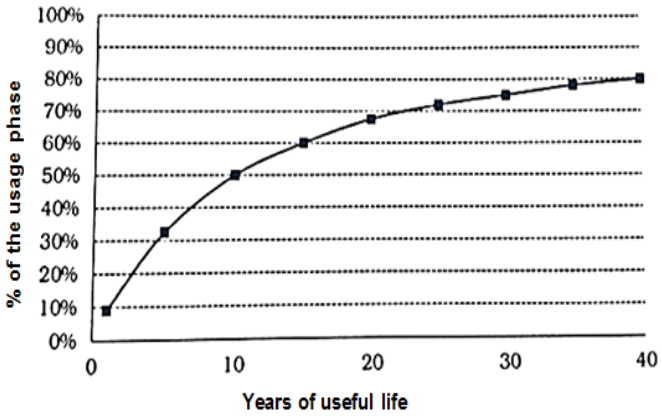
Installation

KLEEMANN does not deal with the part of the installation but provides all the necessary auxiliary tools to the installer so that the time and energy to be spent are reduced to the minimum level. Because of this and because the time and the energy per installation can vary these data are not calculated in detail. An approximation over the installation concerning the man-hours needed is generally 10days and one day for each extra elevator's stop.

Operation – Use

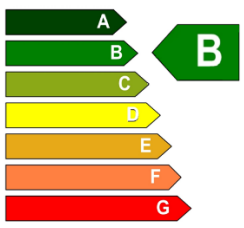
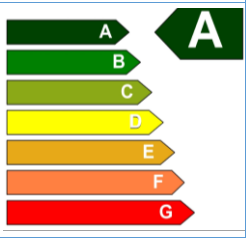
It has been pointed out, on the basis of surveys which have been carried out on this field, that the maximum impact on the environment can be observed in the consumption period. Showing the catalytic role has for the products of lifts. More specifically, if a product has usage duration of 25-30 years the use phase would be responsible for 75% of the whole environmental impact, whereas the same phase would only represent 50% of the environmental bill if it had a reduced life of 10years. On the other hand, an increased product life will always reduce the impact of the materials phase, because the number of functional units served will increase.

In the following figure, the percentage of environmental impact associated with the use phase of the lift (y-axis) and in accordance with the years of working life (x-axis) (LCA and energy modeling of lifts, Ana Lorente Lafuente, 2013).

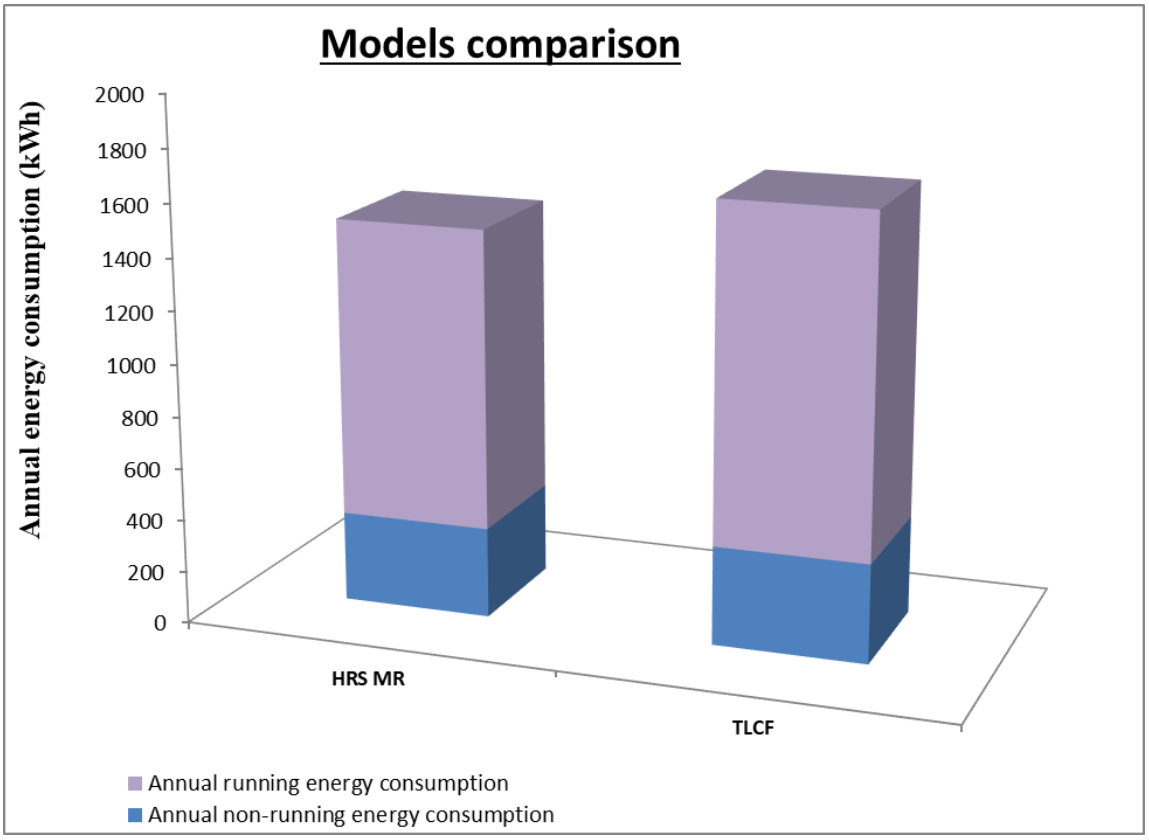


Therefore, it is significant that the new model is upgraded concerning its energy efficiency during the eco-design. The energy class is A for the new product and the nominal demand per year is improved.

Following the methodology of ISO 25745, the results are:

	TLCF	HRS MR
Nominal load [kg]	1600	1600
Nominal speed [m/s]	2	2
Operating days per year	365	365
Standby demand [W]	38	33
Specific travel demand [mWh/(kg·m)]	0.87	0.77
Usage category according to VDI 4707-1	1	1
Nominal demand per year [kWh]	1667	1491
Energy efficiency class according to VDI 4707-1		

The annual energy consumption can be illustrated graphically as is presented:



Maintenance - Repairs

KLEEMANN does not deal with maintenance but offers all the spare parts that this process requires. The maintenance work is a continuous process throughout the phase of operation of the lift. It consists of (a) the periodic preventive maintenance and (b) the unregulated operations required after a failure.

Preventive maintenance is obligatory by the legislation of each country; however, the frequency varies. In each case the lift can be considered serviced six times a year from a team of two technicians. The maintenance procedure in addition to the transfer of technicians at the spot includes a limited use of tools and materials (light, grease, etc). The ecological footprint of this phase can be estimated from the fuel consumption for the transfer of staff (6 x 15 km per year), from the use of electricity during maintenance (max 6 x 1 kWh including the motion of the lift).

Finally, the lubricant used to lubricate the guides can be estimated as 2 lt per year.

The work required after a failure of the lift is difficult to assess accurately.

However, on the basis of the engineering of the lifts and the statistics, these amounts can be tackled satisfactorily.

Disposal - Recycling

Key element in the final stage of the life cycle is the easiest and the fullest possible recycle of the product. The best scenario for a lift is to be designed in such a way that its materials can be dismantled and easily separated into various categories for recycling.

KLEEMANN lifts comprise a high percentage of metal, alloy steel, cast iron, aluminum alloy and copper that can be recycled directly.

Following is presented figuratively the partitioning of the materials in the reference model. This figure could be used as a guide during the dismantling of the product after its end of life. Some parts of different materials will:

- Be material recycled
- Be incinerated
- End up at a landfill.

General instructions for disposal: The basic distinction in hazardous substances and in secondary raw materials should be carried out during the course of the dissolution in accordance with the following classification:

- Hazardous waste
- Waste Electrical and electronic equipment
- Non-magnetic steel waste
- Scrap aluminum
- Magnetic steel and scrap
- Residues containing copper (cables, motor)
- Lead waste (batteries)
- The waste for incineration

If the whole lift at the end of its life is able to be transferred to the central plant of KLEEMANN, the company takes over its full recycling.

Environmental Impact Assessment

Terminology

Materials: For the calculation of the indicator for the production of materials, including all the procedures, from the extraction of raw materials to the final production stage. The calculation includes even the transfers made during the production of the material.

Manufacturing processes: Indicators of production processes represent the emissions both from the production process itself, as well as those which were released during the production of electricity used from each production process.

Transport: Indicators of transport include the effects of emissions caused both for the production of fuels and their combustion during the process of transport of the products.

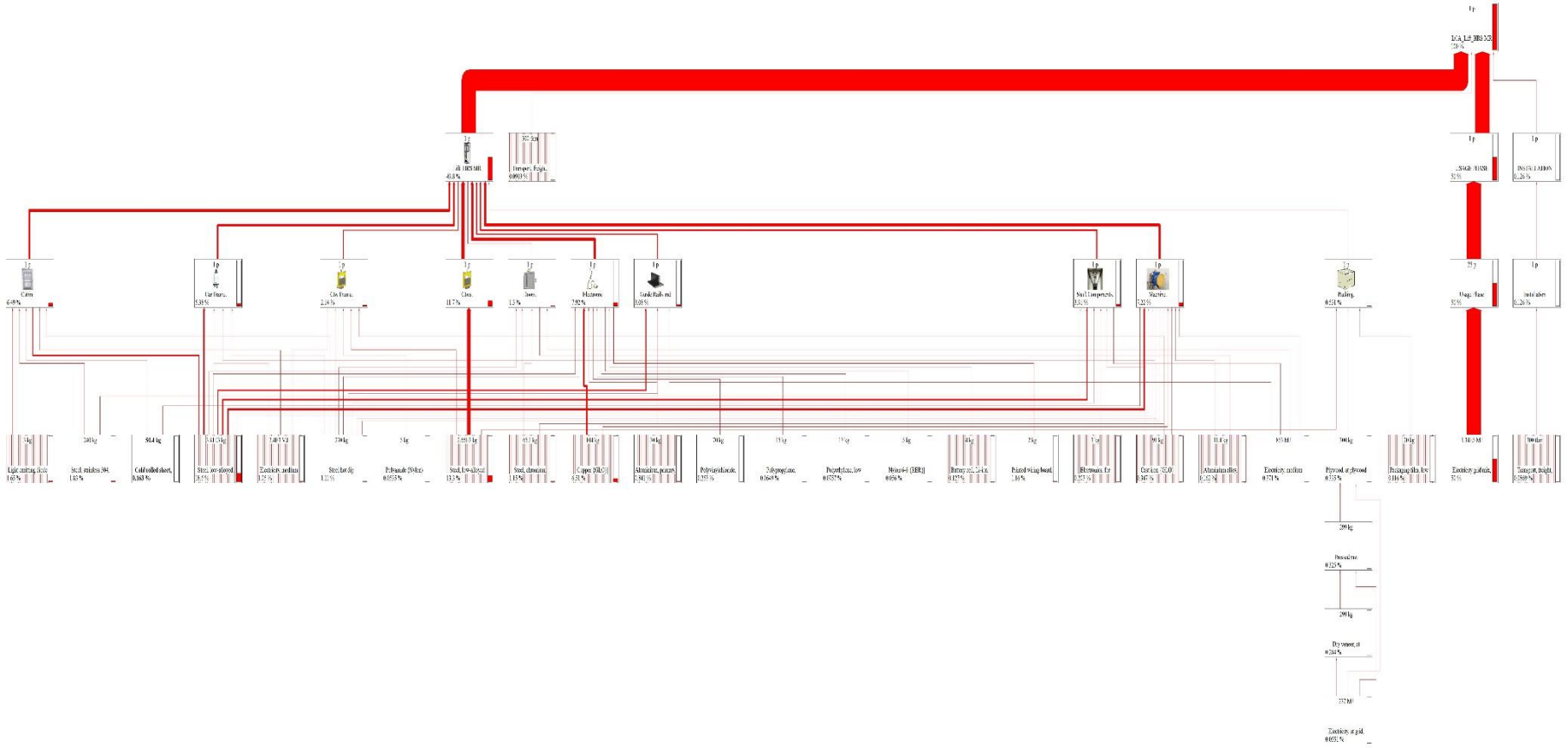
Power Consumption: Indicators of energy are referred to the mining of various fossil fuels, such as lignite, and their use for the electricity production. These indicators will vary from country to country due to different technology and the energy mix used for the production of electricity. These indicators include a separate indicator for the production of energy in the country of usage.

Disposal Procedures and collection: This category includes indicators for the recycling of various materials, incineration, burial at burial site and using biological treatment

The assessment of operational phase based on system UCTE mix of electricity low voltage. If a different mixture is applied of electricity of medium or high voltage, a new study can be carried out for the environmental impacts.

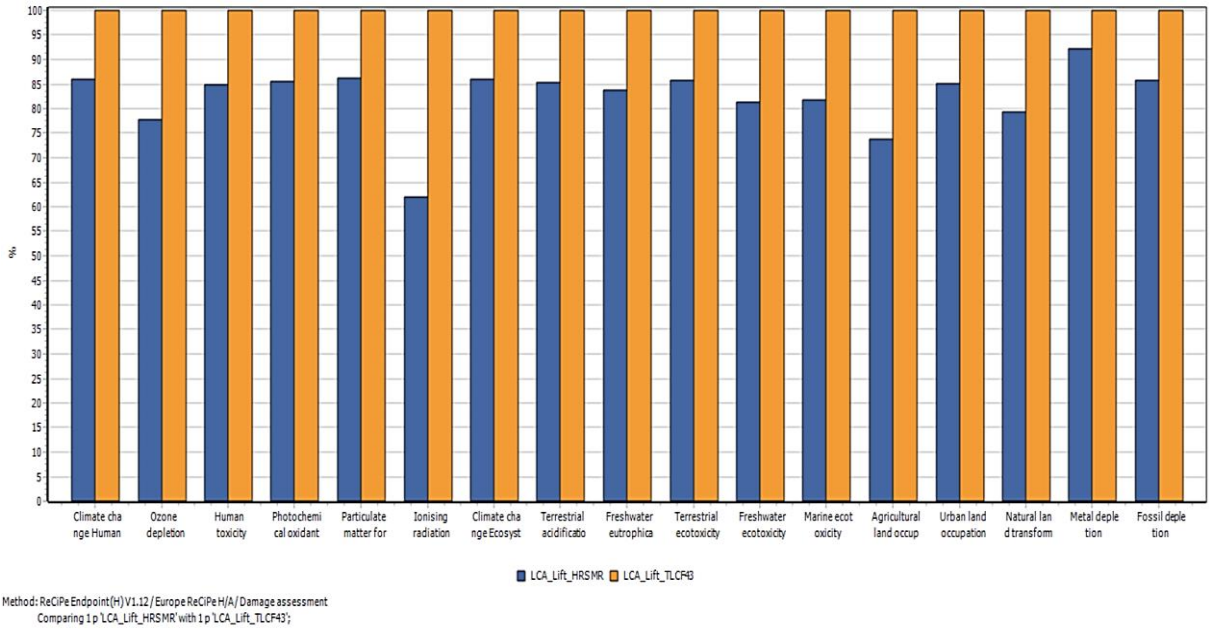
The results of this study illustrate the environmental impact of the product HRS MR lifecycle. It is also possible to devise again the study and with other methods of analysis. On the diagrams extracted from the software SimaPro® is illustrated a comparative study between the earlier model TLCF43 to the newly designed HRS MR.

First of all, is shown the Product Structure Tree, where the elevator is presented as function of its life cycle, including the manufacturing part, the transportation, the usage phage, till the disposal scenario. The sub-assemblies that contribute with the major percentage are described through the materials and the processes they are consisted of.



Damage Assessment

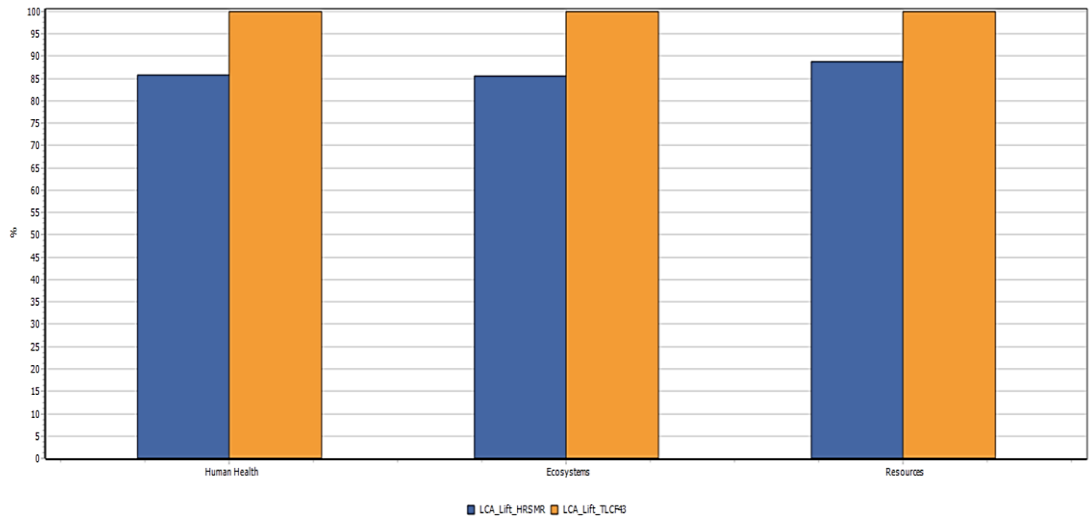
To quantify how much impact a product or service has in the different impact categories, we use characterization factors (CFs). CFs express how much a single unit of mass of the intervention contributes to an impact category; how much 1 kg of chemical emission contributes to Eco toxicity, for instance. Next chart compares the two elevator models according to their contribution to different impact categories.



Method: ReCiPe Endpoint(H) V1.12 / Europe ReCiPe H/A / Damage assessment
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';

The comparison of the two models clearly shows the reduction of the environmental impact that has been achieved in the field of human health and the reduction of resources which have been used, the area of human health even if is affected indirectly, the reduction that has been achieved is critical. The deterioration of the environment and the balance of ecosystems affected by the extraction and initial processing of materials also have differed positively with the new design.

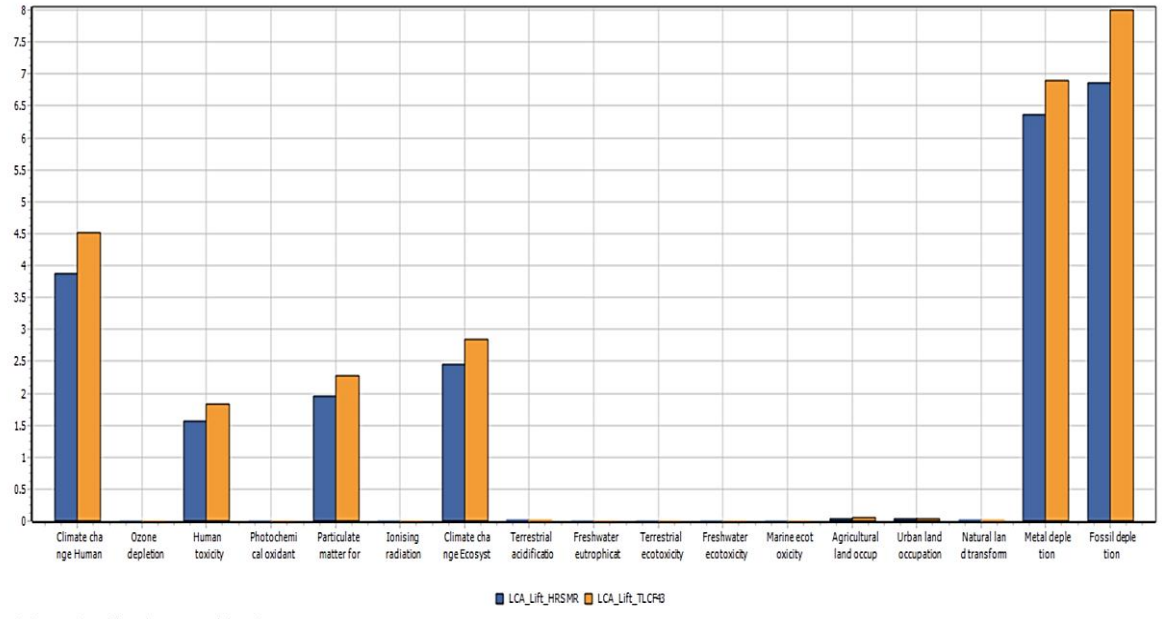
In the next chart the total impact per model and comparatively is presented. The purpose of damage assessment is to combine a number of impact category indicators into a damage category. In the damage assessment step, impact category indicators with a common unit can be added. All impact categories that refer to human health are expressed in DALY (disability adjusted life years). DALYs caused by carcinogenic substances can be added to DALYs caused by climate change



Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Damage assessment
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';

Normalization

Many methods allow the impact category indicator results to be compared by a reference (or normal) value. This means that the impact category is divided by the reference. A commonly used reference is the average yearly environmental load in a country or continent, divided by the number of inhabitants. After normalization the impact category indicators all have the same unit, which makes it easier to compare them.

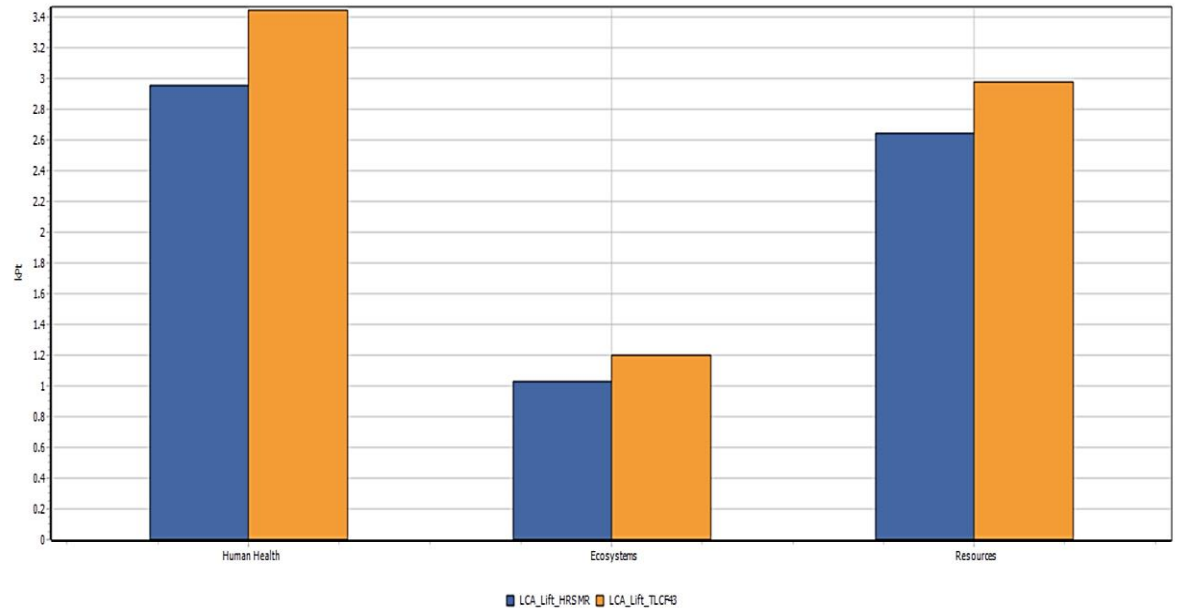


Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Normalization
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';

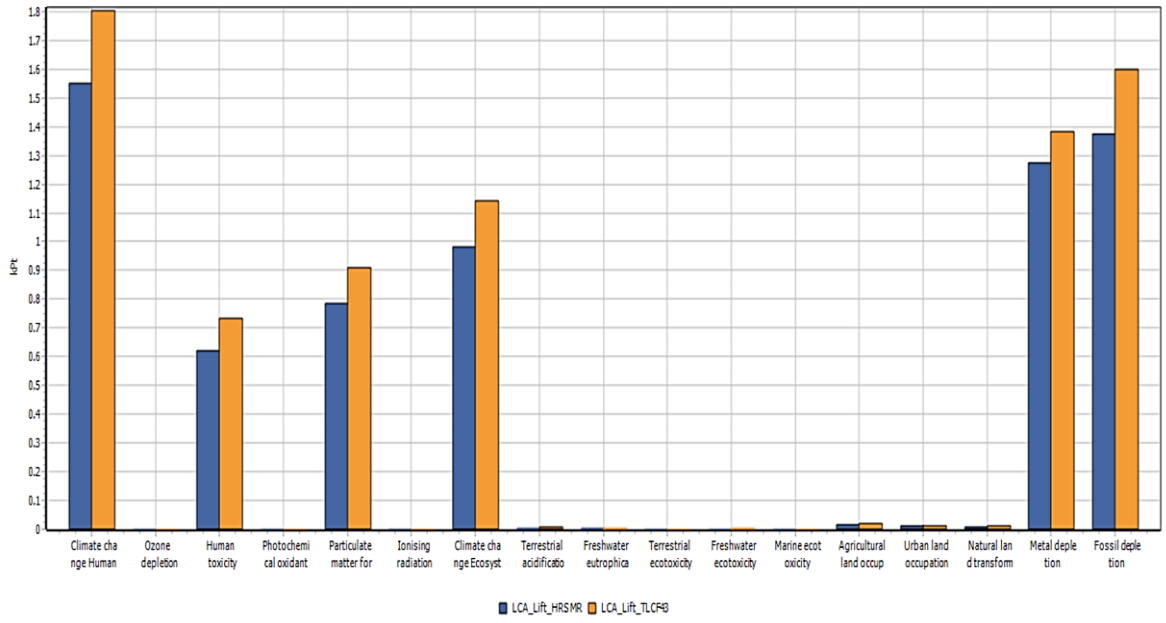
Weighting

Weighting method implies that all of the data classes are weighted together so that only one number is expressed for the weighting method. In order to do a weighting, different data categories are weighed from some form of valuations principle. The weighting expresses the

relation between values in the community and variations in the nature. The ReCiPe method is the most recently updated the most comprehensive and best adapted to the environmental effects that are relevant in the area (Europe). ReCiPe is a life cycle impact assessment method which comprises harmonized category indicators at the midpoint and the endpoint level.



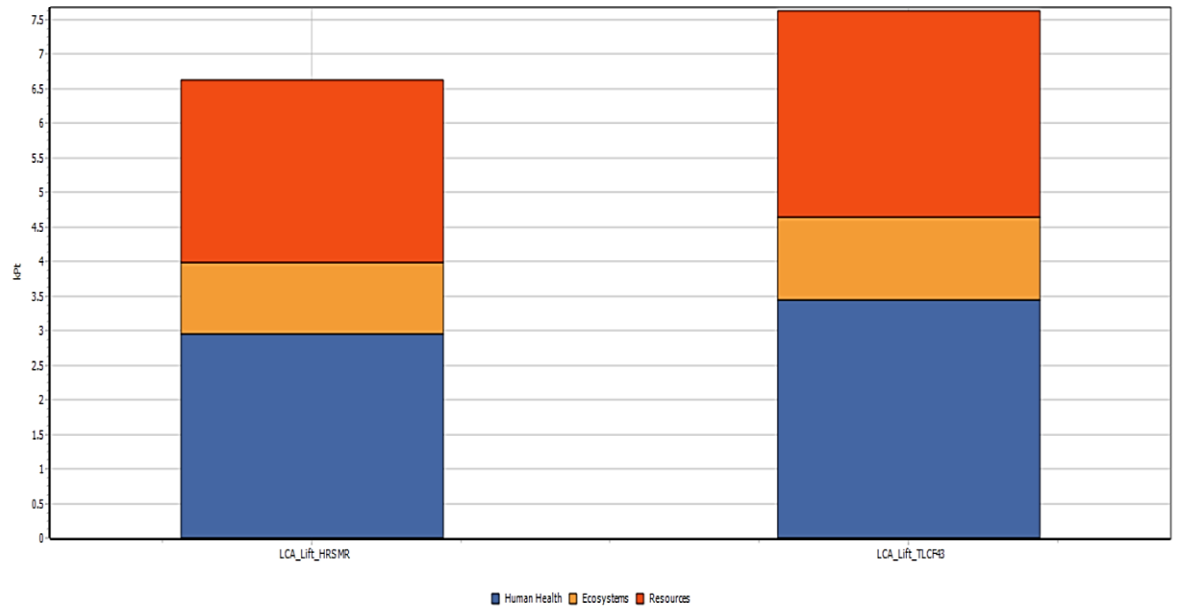
Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Weighting
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';



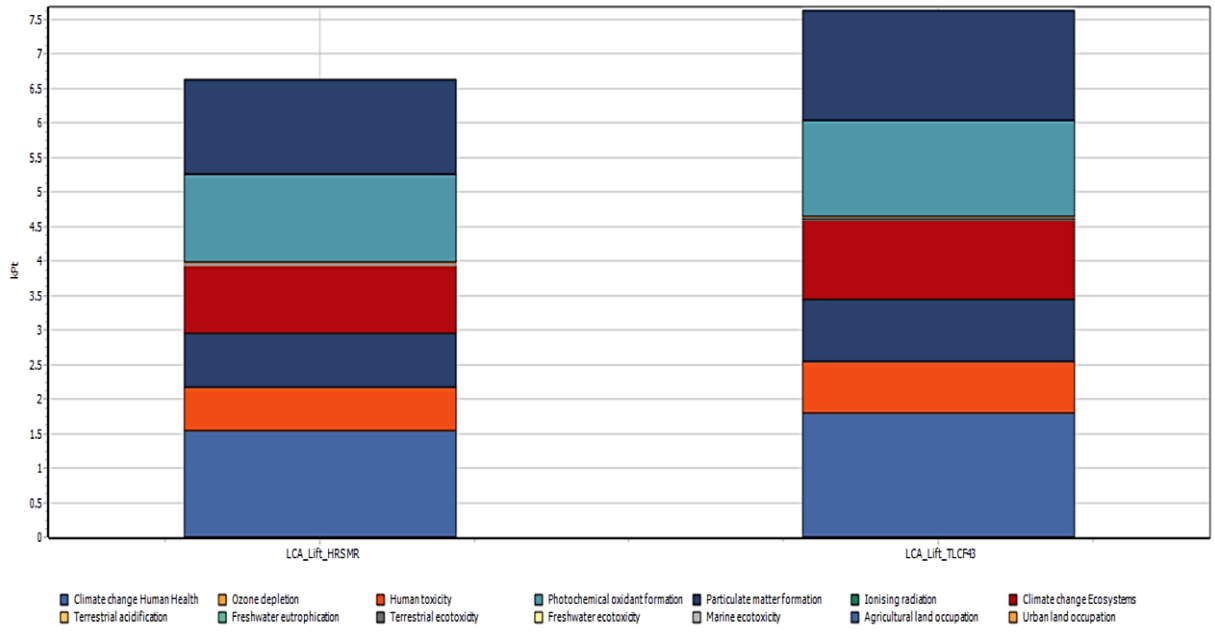
Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Weighting
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';

Single Score

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



Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Single score
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';



Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Single score
Comparing 1 p 'LCA_Lift_HRSMR' with 1 p 'LCA_Lift_TLCF43';

It has already been referred that the use of a lift to the total duration of life, has the greatest impact on the environment. In these charts for both models appear what shall entail this. The saving of fossil fuels, which is crucial to continuously minimize these stocks, has been significantly reduced.

The burden of land for its use is expressed through the units of Potentially Disappeared Fraction (PDF) * m^2 * year/m^2. The raw materials, which are mined, are quantified as to the surplus of energy per kg of minerals. Finally, the fossil fuels in excess are quantified as energy per exported MJ, kg or m^3.

Three more methods were applied in order to compare different impact indicators. The following table presents these results.

Impact category	Unit	EPD		IPCC		CML	
		TLCF	HRS MR	TLCF	HRS MR	TLCF	HRS MR
Acidification	***kg SO2 eq***	513	438			568	486
Eutrophication	***kg PO4--- eq***	42.4	36.4			42.4	36.4
Global warming (GWP100a)	***kg CO2 eq***	65000	55900	65700	56400	65100	55900
Photochemical oxidation	***kg C2H4 eq***	29.4	25.7			29.4	25.7
Ozone layer depletion (ODP)	***kg CFC-11 eq***	0.00178	0.00136			0.00178	0.000136
Abiotic depletion	***kg Sb eq***	0.77	0.727			0.77	0.727
Abiotic depletion (fossil fuels)	***MJ***					666000	572000

BEAR IN MIND: If required a corresponding study with other methods in addition to the ReCiPe Endpoint, hierarchist version, can be carried out by the company for any proper use.

The continuous development of all products with these principles of life cycle analysis, impact assessment and Eco design, is the basis for the sustainable development of the services and products offered to the final customer with respect to humans and the environment.

Appendix

Acidification potential: Phenomenon by which atmospheric rainfall has a pH which is lower than average. This may cause damage in forests and cultivated fields, as well as in water ecosystems and objects in general. This phenomenon is due to the emissions of SO_2, of NO_x, and NH_3, which are included in the Acidification Potential (AP) index expressed in masses of SO_2 produced.

Eutrophication potential: Enrichment of the watercourses by the addition of nitrates and phosphates. This causes imbalance in water ecosystems due to the overdevelopment encouraged by the excessive presence of nourishing substances, so is increased the growth of aquatic plants and can produce algal blooms that deoxygenate water and smother other aquatic life. In particular, the Eutrophication Potential (EP) includes phosphorous and nitrogen salts and it is expressed in grams of oxygen (kg O_2).

Global warming potential (GWP100): Phenomenon by which the IR irradiation emitted by the earth's surface are absorbed by the molecules in the atmosphere, as a result of solar warming, and then re-emitted in the form of heat, thus giving rise to a process of global warming of the atmosphere. The indicator used for this purpose is GWP (Global Warming Potential). This mainly includes the emissions of carbon dioxide, the main greenhouse gas, as well as other gases with a lower degree of absorption of infrared rays, such as ethane (CH_4), nitrogen protoxide (N_2O), chlorofluorocarbons (CFC), which are expressed according to the degree of absorption of CO_2 (kg CO_2).

Ozone depletion potential (ODP): Degradation and depletion of the ozone layer in the stratosphere, which has the property of blocking the UV components of sunlight thanks to its particularly reactive compounds, originated by chlorofluorocarbons (CFC) or by chlorofluoromethanes (CFM). The substance used as a point of reference for assessing the ODP (Ozone Depletion Potential) is trichlorofluoromethane, or CFC-11. ODPs are calculated as the change that would result from the emission of 1kg of a substance to that from emission of 1 kg of CFC-11 (a Freon).

Photochemical oxidation: The index used to translate the level of emissions of various gases into a common measurement to compare their contributions to the change of ground-level ozone concentration. POCPs are calculated as the change that would result from the emission of 1 kg of a gas to that from emission of 1 kg of ethylene.

Depletion of abiotic resources: Two impact categories: Abiotic depletion (elements, ultimate reserves) and abiotic depletion (fossil fuels). Abiotic depletion (elements, ultimate reserves) is related to extraction of minerals due to inputs in the system. The Abiotic Depletion Factor (ADF) is determined for each extraction of minerals (kg antimony equivalents/kg extraction) based on concentration reserves and rate of deaccumulation. Abiotic depletion of fossil fuels is related to the Lower Heating Value (LHV) expressed in MJ per kg of m^3 fossil fuel. The reason for taking the LHV is that fossil fuels are considered to be fully substitutable.

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