Environmental fact sheet: Atlas Gigas-R

Studied and drafted at Kleemann Hellas SA
June 2018,
Dr. Sfampa Ioanna
Group Innovation Researcher
Group Innovation Department

2017

Contents

Foreword

The increased awareness over the environmental protection, and the possible impacts associated with products, have increased interest in the development of methods to better understand and address these impacts. One of the techniques being developed for this purpose is life cycle assessment (LCA). LCA addresses the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.

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 which desires 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).

For the case of the lift industry, with the already indispensable products, due to the large vertical structuring, combining the design, the comfort, but also to cover further sensitive needs, such as 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 10,500 lift systems annually.

Since 2012, KLEEMANN implements an environmental management system (EMS) for the 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 which has been certified in accordance with ISO 9001 and also applies principles 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, and also the development of the environmental superiority for our products. That aim could be achieved by introducing fundamental rules, criteria and mechanisms for the environmental protection, the prevention of pollution and the protection of human health. By that we ensure savings of natural resources and the gradual restoration of the environment which promotes its rational use and management. Main goal is to redesign all of our products on the basis of eco-design process. Our policy is orientated towards 3 directions: 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

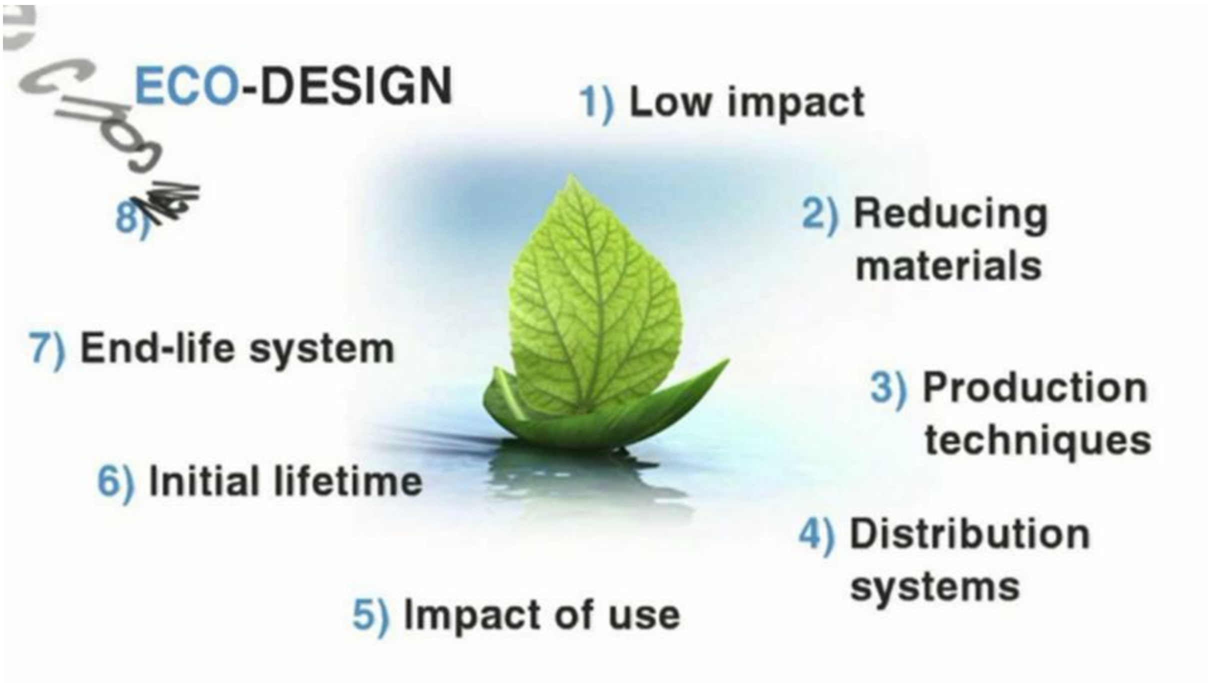
Scope: Eco-design is an approach of designing products with special consideration for the environmental impacts of the product during its whole lifecycle. In a life cycle assessment, the life cycle of a product is usually divided into procurement, manufacture, use, and disposal. It is a growing responsibility 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, VDI 4707/1 was carried out, and a number of considerations and assumptions for the average operation throughout the life cycle of the lift.



Procedures description

Upstream procedures

- These are procedures which take place regardless the manufacture of the product such as mining raw materials, transport within the supply chain. These are processes which will not be examined in this document.

Production and core processes

- These are the principal manufacturing processes of the product. The procedures of carrying materials and waste management resulting from the above, even if carried out by third parties, are also included.

Downstream procedures

- These are the processes no more controlled by the product manufacturer, but by the product owner. This covers the private transport of the product to the consumer, consumption of the energy or other consumables, adequate maintenance and end of-life processes of the used product.

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. Also the German VDI standard 4707/1 was used for the classification of the product in the field of energy efficiency during its usage stage.

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 and re-designed on the basis and principles of eco-design is a traction electric operated passenger lift.

The reference model Atlas Gigas-R is a vertical lifting system; where ΄΄R΄΄ indicates re-design, since this product is a result of the eco-designed product with the brand name Atlas Gigas.

Vertical lifts operate approximately 25 years, by assuming the appropriate cycle of maintenance, and makes about 54,750 journeys per year for the service of the user in an average building. The payload that can be carried is up to 1600 kg and the maximum rated speed is 1m/s. Placed on routes up to 4.7 m corresponding to 2 stops.

Reference model	Atlas Gigas-R
Type	Traction, Electric operated passenger lift
Estimated lifetime	25 years
Trips per day	150
Nominal load	1600kg
Nominal speed	1m/s
Travel	4.7m
Number of stops	2
Daily travel time	0.2h

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:

1. Raw materials
2. Manufacturing processes
3. Transport & Packaging
4. Installation
5. Operation - Use
6. Maintenance - Repairs
7. Disposal - Recycling

The most significant improvements that have been made on the basis of the eco-design are the following:

- Improvement and upgrade of energy efficiency
- Reducing total quantity of raw materials
- Reduction of paint and solvents products
- Reducing total lifting weight concerning the materials it is consisted of.

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 acquisition of materials and energy consumption during the 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

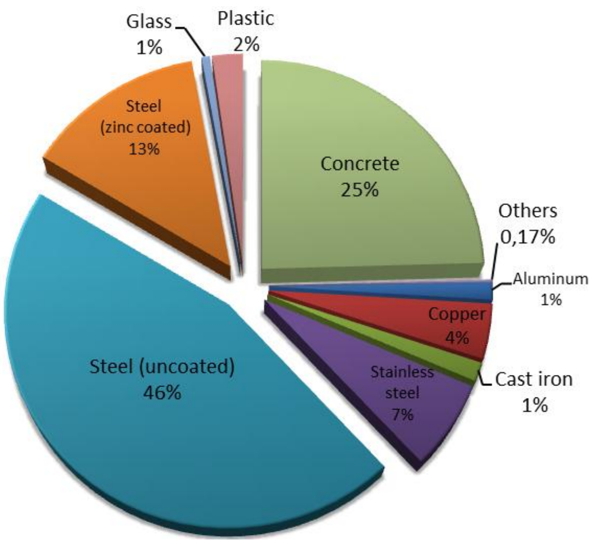
The company is gradually trying to co-operate with suppliers who meet the environmental criteria which are set by standards. So up to the present time 50% of suppliers operate, minimum, with an environmental management system and ISO14001 certification.

The total mass of the elevator for the life cycle inventory without packing is 5267kg. Roughly 73% of the elevator materials were metals. Following are presented the sub-assemblies and the materials they are consisted of:

- **Elevator** 5817kg
  - **Cabin** 283kg
    - Steel (uncoated) 3.5kg
    - Steel (zinc coated) 20kg
    - Aluminium 0.25kg
    - PVC 15kg
    - Stainless steel 196kg
    - Plastics (mix) 0.1kg
    - PMMA 13kg
    - LED 2kg
    - Glass 33kg
  - **Car Frame** 578kg
    - Steel (uncoated) 238kg
    - Steel (zinc coated) 335kg
    - Cast iron 5kg
  - **Ctw Frame** 213kg
    - Steel (zinc coated) 188kg
    - Nylon 22kg
    - Polyurethane 3kg
  - **Ctws** 2195kg
    - Concrete 1296kg
    - Steel (uncoated) 899kg
  - **Doors** 535kg
    - Steel (uncoated) 406kg
    - Steel (zinc coated) 7kg
    - Stainless steel 114kg
    - Aluminium 8kg
  - **Electronic Equipment** 161kg
    - Steel (uncoated) 36kg
    - Copper 21kg
    - Aluminium 30kg
    - PVC 37kg
    - PP 10kg
    - Plastic (mix) 20kg
    - Printed wiring board 2kg
    - Lead 2.5kg
    - Others 2kg
  - **Guide Rails and Brackets** 688kg
    - Steel (uncoated) 590kg
    - Steel (zinc coated) 98kg
  - **Shaft Components** 202kg
    - Steel (uncoated) 127kg
    - Steel (zinc coated) 63kg
    - Cast iron 12kg
  - **Machine** 412kg
    - Steel (uncoated) 88kg
    - Cast iron 200kg
    - Stainless steel 37kg
    - Copper 53kg
    - Aluminium 28kg
    - Plastic 0.5kg
    - Magnet 5kg
  - **Paint** 28kg
  - **Lubricants** 2kg
  - **Packing** 520kg
    - Wood 440kg
    - Steel (uncoated) 23kg
    - Nylon 31kg
    - Carton 26kg

Gathered data about the materials used are presented on the following:

Material	Weight (kg)	Weight (%)
Metals	**3802.75**	**72.28**
Aluminum	*66.25*	*1.26*
Cast iron	*217*	*4.12*
Copper	*74*	*1.41*
Stainless steel	*347*	*6.6*
Steel (uncoated)	*2416.5*	*45.82*
Steel (zinc coated)	*711*	*13.51*
Glass	**33**	**0.63**
PVC	**52**	**0.98**
PP	**10**	**0.19**
PMMA	**13**	**0.25**
Nylon	**22**	**0.42**
Polyurethane	**3**	**0.06**
Plastics (mix)	**20.6**	**0.39**
Concrete	**1296**	**24.63**
LED	**2**	**0.04**
Lead	**2.5**	**0.05**
Printed wiring board	**2**	**0.04**
Others	**2**	**0.04**
TOTAL	**5266.85**	**100.00**



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 (min)
Laser	5,31	1,38	9,28	0,12		**16,09**
Welding	17,64	53	33,5		9,5	**113,64**
Saw	6,05	0,3	2,7	38,94	4	**51,99**
Drill	2		0,7		0,5	**3,2**
Bending	3,25	4,6	2,6	5,56	2	**18,01**
CNC	2	3,4	1,06		1,06	**7,52**
Punching		7,26		51,54		**58,8**
Scissors		0,5		35	5	**40,5**
Pressing Machine			0,4	7,53	0,4	**8,33**
Panting	22	13	12		6	**53**
Assembly	16,98	31,5	8	387,21	15,8	**459,49**
Packaging				135		**135**
Wiring				9,2		**9,2**
Consumed Energy	**27.1kWh**	**37.35kWh**	**31.69kWh**	**64.22kWh**	**9.29kWh**	**169.65kWh**

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	440
Nylon	23
Steel (nails etc)	31
Carton boxes	26

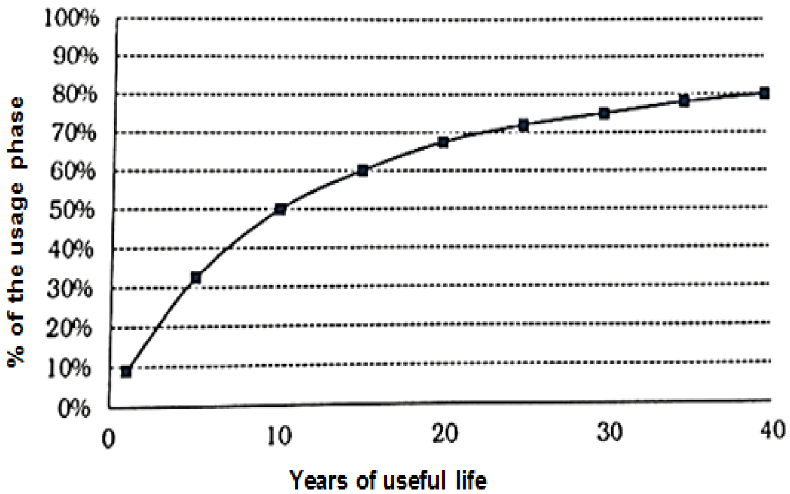
Installation

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

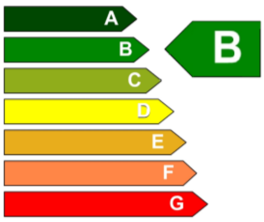
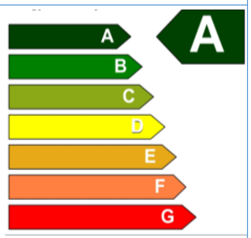
It has been pointed out, on the basis of surveys which have been carried out on this field, that the maximum impact on the environment can be observed in the consumption period. Showing the catalytic role has for the products of lifts. More specifically, if a product has usage duration of 25-30 years 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).

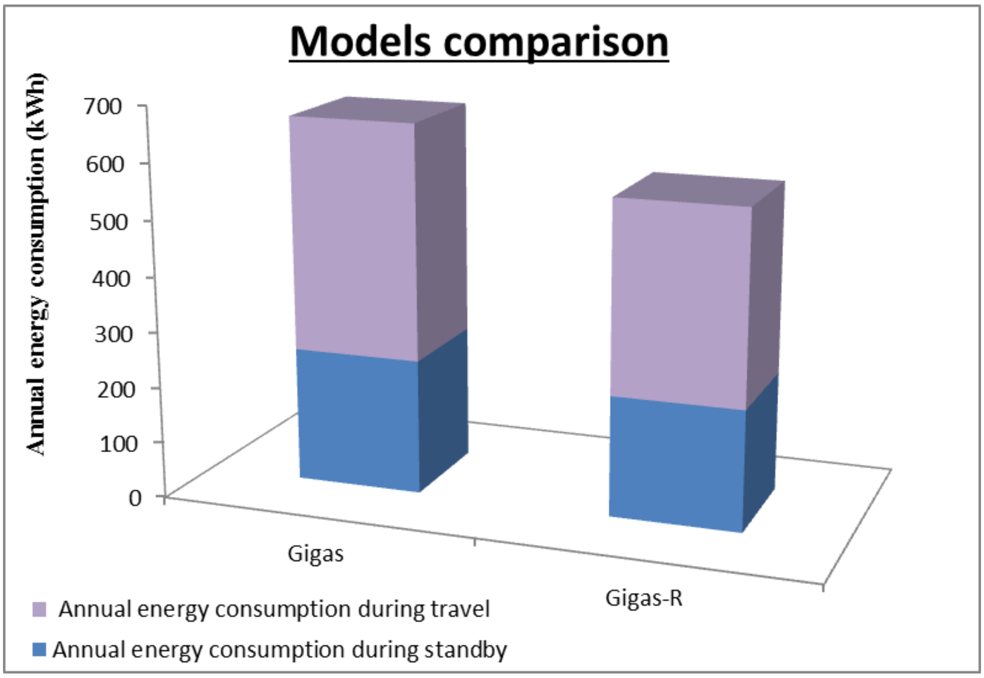


Therefore it is significant that the new model is upgraded in the energy efficiency class during the eco-design from B which was the previous model, in A.

Following the methodology of VDI 4707-1, the results are:

	Atlas Gigas	Atlas Gigas-R
Nominal load [kg]	1600	1600
Nominal speed [m/s]	1	1
Operating days per year	365	365
Standby demand [W]	28	25
Specific travel demand [mWh/(kg·m)]	1.02	0.84
Usage category according to VDI 4707-1	1	1
Nominal demand per year [kWh]	664.9	562.1
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 ability to facilitate and the fullest possible recycling percentage of the product. This model has been designed in such a way that its different materials can be dismantled and separated easily in various categories for the process of recycling.

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

<u>General instructions for disposal</u>

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

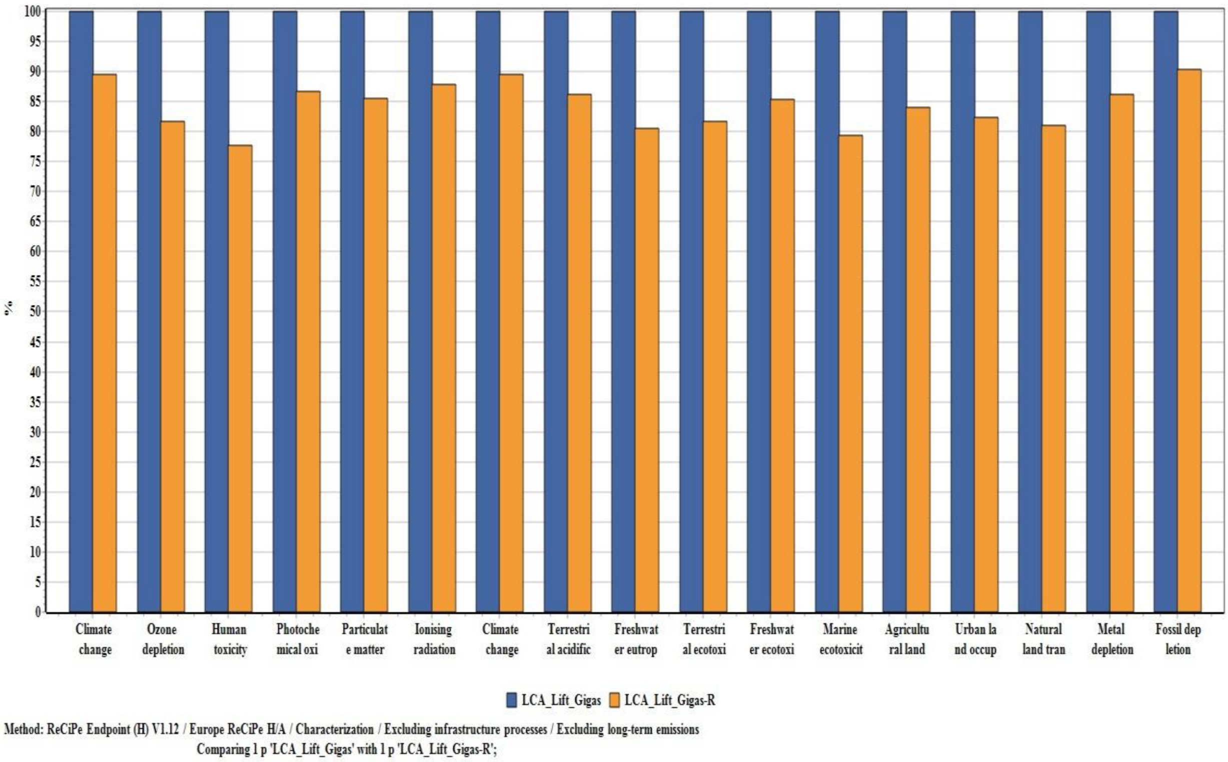
The assessment of operational phase based on system UCTE mix of electricity low voltage. If a different mixture is applied of electricity of medium or high voltage, a new study can be carried out for the environmental impacts.

The results of this study illustrate the environmental impact of the product Atlas Gigas- R 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 Atlas Gigas to the re-designed Atlas Gigas - R.

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.

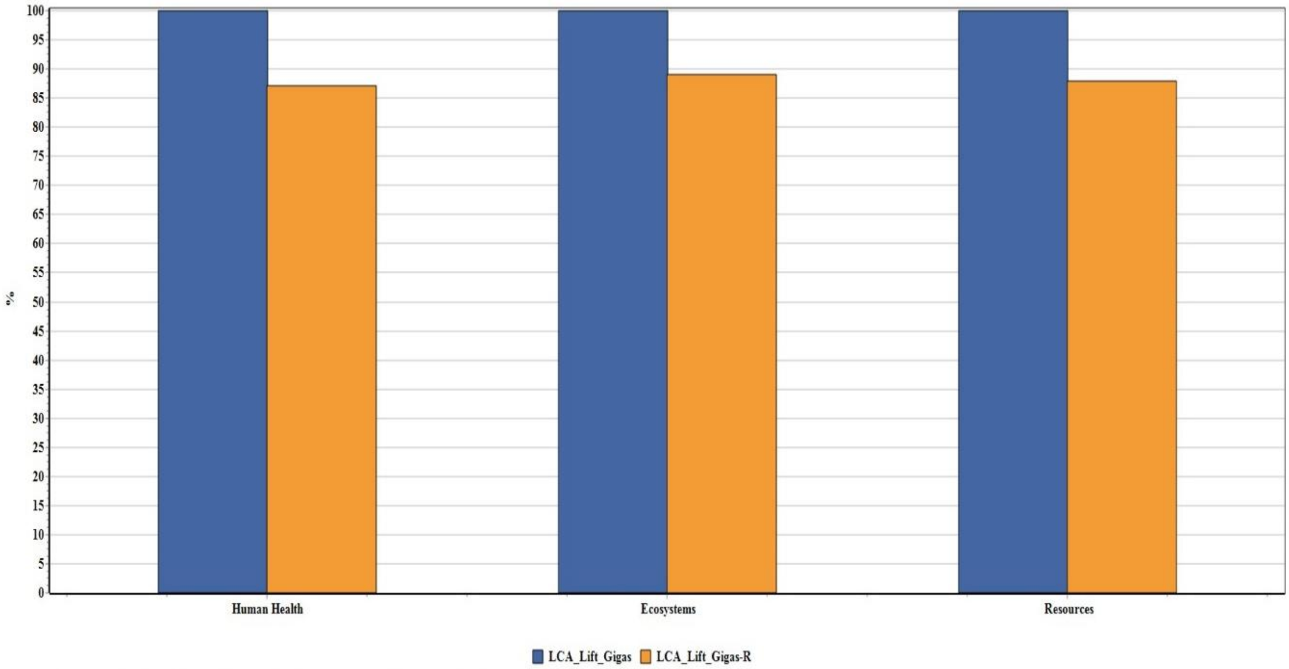
Damage Assessment

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.



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.

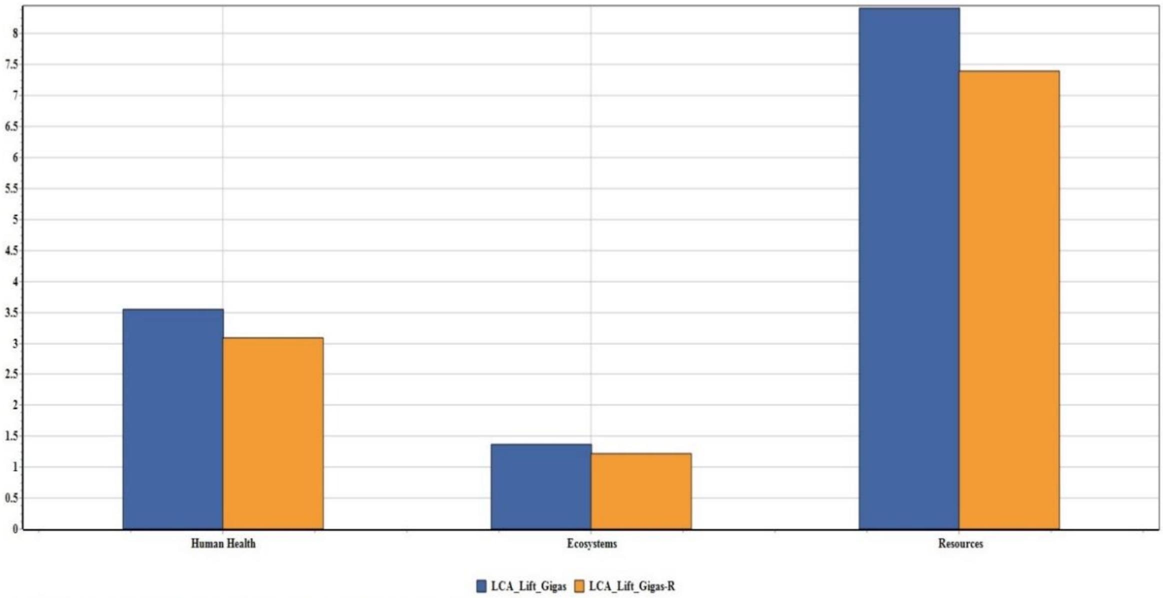
In the next chart the total impact per model and comparatively is presented. The purpose of damage assessment is to combine a number of impact category indicators into a damage category. In the damage assessment step, impact category indicators with a common unit can be added. All impact categories that 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 / Excluding infrastructure processes / Excluding long-term emissions
Comparing 1 p 'LCA_Lift_Gigas' with 1 p 'LCA_Lift_Gigas-R';

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.

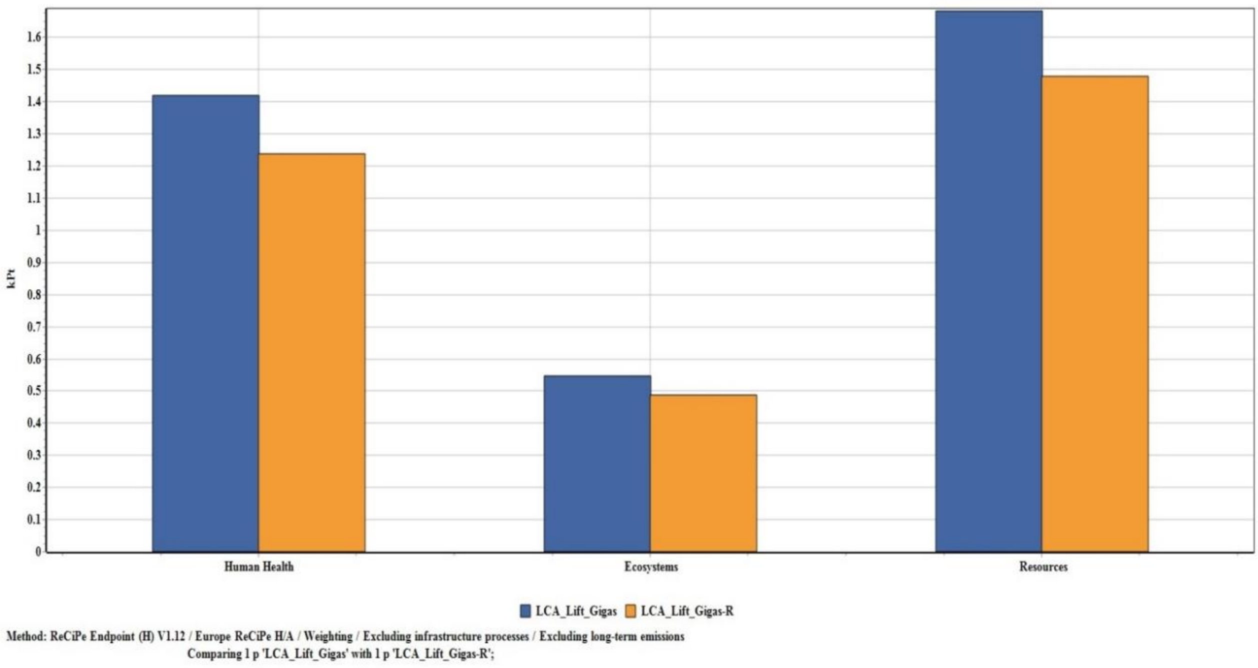


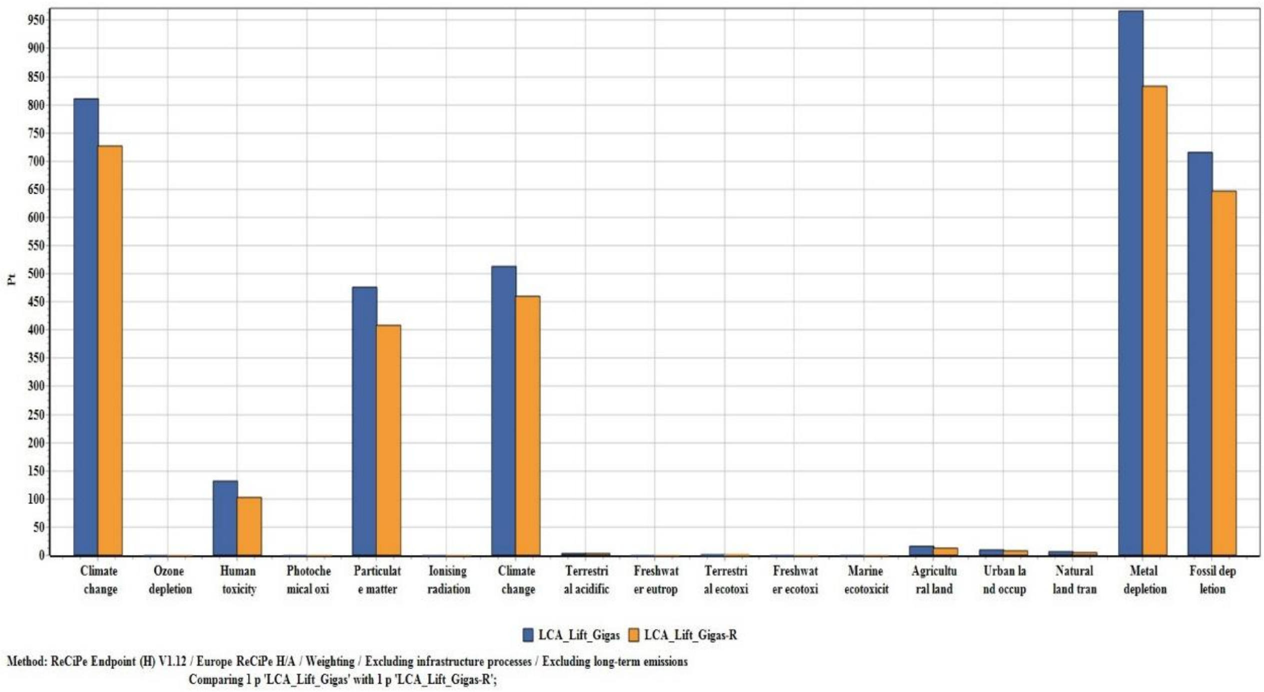
Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Normalization / Excluding infrastructure processes / Excluding long-term emissions
Comparing 1 p 'LCA_Lift_Gigas' with 1 p 'LCA_Lift_Gigas-R';

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 harmonised category indicators at the midpoint and the endpoint level.

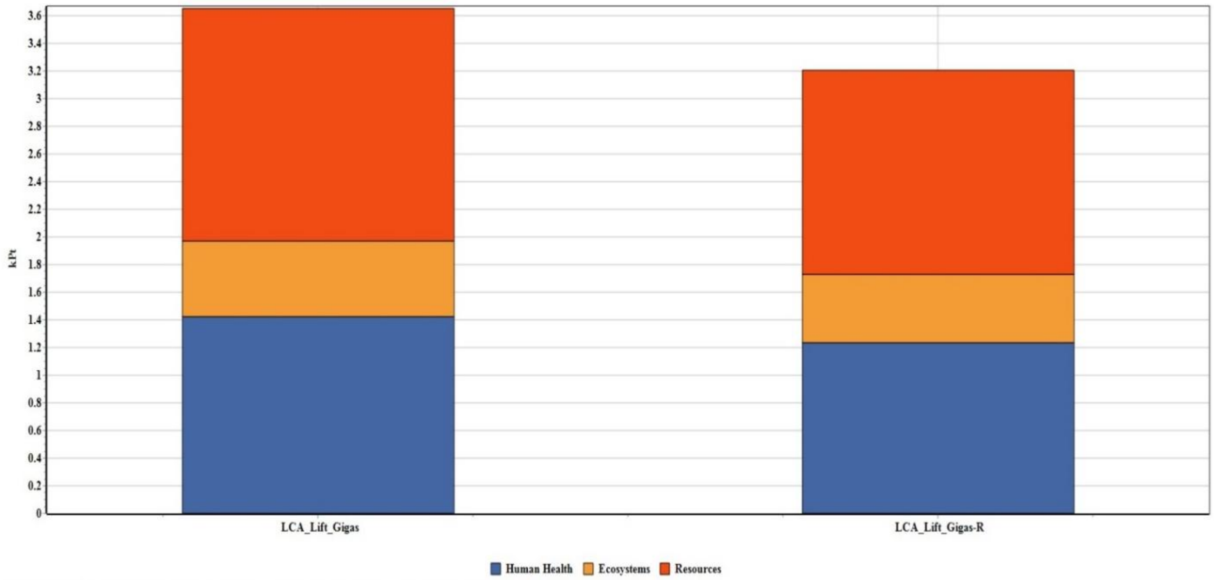
.


kPt
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Human Health
Ecosystems
Resources
LCA_Lift_Gigas
LCA_Lift_Gigas-R
Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Weighting / Excluding infrastructure processes / Excluding long-term emissions
Comparing 1 p 'LCA_Lift_Gigas' with 1 p 'LCA_Lift_Gigas-R';

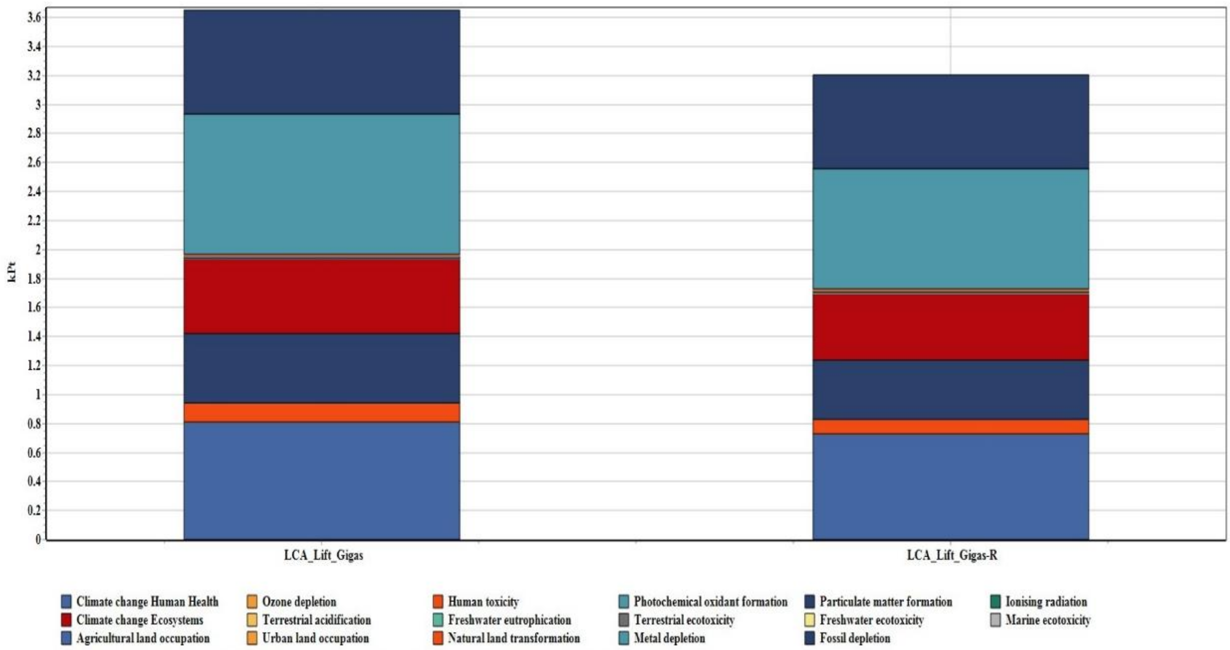

Pt
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Climate change
Ozone depletion
Human toxicity
Photochemical oxi
Particulate matter
Ionising radiation
Climate change
Terrestrial acidific
Freshwater eutrop
Terrestrial ecotoxi
Freshwater ecotoxi
Marine ecotoxicit
Agricultural land
Urban land occup
Natural land tran
Metal depletion
Fossil depletion
LCA_Lift_Gigas
LCA_Lift_Gigas-R
Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Weighting / Excluding infrastructure processes / Excluding long-term emissions
Comparing 1 p 'LCA_Lift_Gigas' with 1 p 'LCA_Lift_Gigas-R';

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 / Excluding infrastructure processes / Excluding long-term emissions
Comparing 1 p 'LCA_Lift_Gigas' with 1 p 'LCA_Lift_Gigas-R';



Method: ReCiPe Endpoint (H) V1.12 / Europe ReCiPe H/A / Single score / Excluding infrastructure processes / Excluding long-term emissions
Comparing 1 p 'LCA_Lift_Gigas' with 1 p 'LCA_Lift_Gigas-R';

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 appears 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	
		Atlas Gigas	Atlas Gigas-R	Atlas Gigas	Atlas Gigas-R	Atlas Gigas	Atlas Gigas-R
Acidification	kg SO2 eq	253,39	222,89			280,86	245,64
Eutrophication	kg PO4--- eq	25,87	23,26			25,87	23,26
Global warming (GWP100a)	kg CO2 eq	29271	27716	29574	28051	29271	27716
Photochemical oxidation	kg C2H4 eq	14,65	13,14			14,65	13,14
Ozone layer depletion (ODP)	kg CFC-11 eq	0,001133	0,00107			0,00113	0,00107
Abiotic depletion	kg Sb eq	0,6357	0,63166			0,63575	0,63166
Abiotic depletion (fossil fuels)	MJ					298059	274796

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.

G.E.MI. 14486435000

KLEEMANN
Your 1st Choice in Lifts