Environmental Impact of Lifts

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Abstract. Lifts are active products, that is, they consume resources to fulfil their function. For this reason, their environmental impact will last their whole lifetime. In this type of product, the usage phase has traditionally been assumed to be the most relevant one from an environmental point of view. Unlike other products fulfilling the same transport function, lifts are inherently linked to the medium in which they are installed. Thus, they are tailored design to fit the needs of the population of the building where they will be operating. The fact that lifts are multi-user products conditions their performance and makes it difficult to estimate their usage, but the ISO 25745-2 current draft (for public comment) [1] provides with a quite accurate simplified method based on figures obtained from thousands of simulations. If the boundaries of the analysis are extended to cover its complete useful life down to its disposal, the results show that the usage phase is not necessarily the most relevant in all usage categories. In this paper, an overview of the distribution of the environmental impact of lifts is presented. The results are analysed to determine what the key factors are. Finally, indications on how to interpret the environmental data provided by a lift supplier are given to allow architects and lift consultants the selection of the most environmental friendly lifts during the building design phase.

1 INTRODUCTION

1.1 What is life cycle assessment (LCA)?

A Life Cycle Assessment 'LCA' (also known as life cycle analysis, eco-balance or cradle-to-grave-analysis) [2] consists of the investigation and valuation of the environmental impacts of a given product system during its useful life. This assessment is based on the input-output analysis of physical flows (materials, energy, emissions, etc.) and their relationships at all stages of this life cycle, from the raw materials phase to the transport of the final product. Once delivered to the customer, Energy-using- (EUPs) or energy related products (ERPs) [3] will, because of their nature, cause further environmental burdens or will have an influence on the impact of other product systems until the end of their estimated life period. Finally, environmental flows will be interchanged with the environment during the product disposal, valorisation and/or recycling in the corresponding treatment facilities. This holistic assessment approach, which allows detecting whether a design change is actually shifting environmental burdens from one stage to the other within the product supply chain, makes Life Cycle Assessments (LCAs) the best tool for assessing the potential environmental impacts of products currently available.

The LCA methodology is described in the Standards ISO 14040 [4] and 14044 [5] and is complemented in technical reports [6,7] Additionally, ISO 14050 [8] defines most of the terminology used in the two previously mentioned standards. All leading companies in the transport sector, including all big lift manufacturers, are promoting sustainable production and consumption and use the LCA methodology to assess their products from an environmental point of view already in the development phase [10].

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1.2 Communication of environmental data

The above mentioned ISO standards are valid for the assessment of any product or service. For this reason, they just describe the “principles and framework” [4] and the “requirements and guidelines” [5] to apply the methodology and they leave many aspects undefined and therefore subject to the choice of the practitioners. This flexibility implies that the results of two Life cycle impact assessments (LCIAs) can only be compared if they are delivered with an extensive report detailing how the assessment has been conducted and if this report has been critically reviewed. Nevertheless, this is neither an efficient business to business, nor an effective business to customer communication way. Instead, companies utilise environmental declarations [11], which can be of three different types: Type I [12], Type II [13] and Type III [14]. Their degree of credibility and transparency varies because the procedures to issue the labels and the schemas ruling them, also standardized, are different. Whereas Type II is a self-declaration, type I and III are based on the life cycle approach and shall/can be verified by third parties. Type III declarations, in contrast to type I give quantitative information of the final (or intermediate) product based on a set of specific rules, requirements and guidelines called Product Category Rules (PCRs). They are mainly used for business to business communication and are for this reason primarily launched by industry initiative. The lift sector is currently undergoing the development of these rules [15].

2 DEFINITION OF THE OBJECTIVES AND METHODOLOGY

The lift sector is highly fragmented and its supply chain is long and complex. Some components and sub-components manufacturing processes, logistic and installation works can be carried out by a medium, small or micro company different than the one selling the lift. This aspect complicates the issue of conducting a complete life cycle assessment, increasing the duration and difficulty of the data collection process and the cost involved. Additionally, the fact that there are not two identical lift products in the market, except if they are installed in the same building, makes it necessary to assess each individual lift unit apart or to create a good database that can be used to extrapolate results.

2.1 Objectives

The purpose of this research was to define a method to conduct LCAs of lifts with the less possible effort, but providing the most possible reliable results, thus allowing their publication and their use for comparison of two competing lifts products over their entire life cycle. The development of the method involved a first screening study, in which the constituting parts of the product system, as well as the elementary flows that were important with view to the final results were identified. The screening highlighted the relevance of the usage phase and lead to further investigation, the results of which are contained in the ISO 25745-2 Standard [1]. After a sensitivity analysis, the study was later completed to fill in the data gaps existing. Further details like product structure to be used, background data for the assessment, information requirements regarding the product maintenance and replacement, rules for the assessment of the use phase, end of life treatments and responsibilities in the reporting can be found in [10].

The method suggested is valid for specific and model lifts and can be used both by complete lift supplier/manufacturers and by any other actor of the supply chain: component manufacturers, installers, maintainers etc. requested to supply information about their products or processes. It can be applied to assess new and existing products and all technologies, including less energy efficient ones, like for example hydraulics. These lifts may not beat the energy consumption values of electric lifts competing with them for the same application, but they might be more advantageous in other phases of their life cycle like product manufacturing, installation and maintenance (less demanding), or even at the end of their life because they may have a higher reuse or recyclability rate, as suggested in some studies from hydraulic lift manufacturers [20,21].

2.2 Methodology

The LCAs were conducted in the four steps suggested by the standards: Goal and scope definition, life Cycle Inventory analysis (LCI), Life Cycle Impact Assessment (LCIA) and Interpretation. The definition of the goal of the study is the first and most important step, because it is aligned with the intended application of the results obtained and therefore conditions the methodology to be applied and the degree of depth and rigour requested. In this section, the definition of the goal and scope will be explained. Section 3 of this paper contains the results of the three remaining LCA phases.

2.2.1 Goal and scope definition

The methodology covered a "cradle to grave" analysis including all the life cycle phases directly related to the product until its disposal and end of life treatment. The reinstatement of reused components back in the in the same life cycle chain was excluded because of the lack of statistical data. The use of recycled material was accounted in the input materials from the databases only in those cases where the % of recycled material composition was known.

2.2.2 Functional unit

The main function of a lift is the vertical transportation of goods or passengers in buildings from floor to floor, therefore the best lift for a certain application will be the one able to transport the amount of passengers or loads in transit in the building during a certain period to their desired destination causing the least possible environmental burdens. Considering this, possible functional units are: Passenger.Floor, kg.Floor, Pkm (Passenger.km), kg.km.

2.2.3 Lift structure

For the inventory, the lift must be broken up into its major components. The information was obtained from the software application used by the lift company collaborating in the study to configure the product and from the ERP. These are in some cases linked.

The sum of the weights of the components inventoried matched with the theoretical weight of the lift. The lift structure reflected the actual supply chain, so that the responsibility regarding the provision of the inventory information was clear. In this way, double counting of parts can be avoided. In [10], a proposal for a standardized lift structure that incorporates all possible lift components according to their function and considers the economic flows in the sector is provided.

2.2.4 System limits

The system limits were established taking into account the influence that the lift suppliers have in the environmental impact caused by their products. This responsibility included the usage and maintenance phases, because the lift performance depends on the design and the quality standards adopted for their components. Processes like building a production site, infrastructure, production of manufacturing equipment and management personnel activities were left outside the boundaries because of the lack of data and because they are not expected to have a significant influence in the results used for comparison. Other data like the impact of manufacturing intermediate parts and subcomponents or their transport were also left aside because of the impossibility of collecting reliable information.

2.2.5 Processes of the Lift life cycle

The processes along the product supply chain can be classified as upstream, core or downstream processes [16] depending on the responsibility that the company conducting the assessment has on them. They can also be classified as foreground and background processes, depending on whether there is direct access to environmental information or not. Following, the processes and information on how they were considered in this study is given.

Upstream processes considered (The environmental background information was obtained from environmental databases of LCA software)**:**

- Production of raw materials (extraction and refining)
- Production of auxiliary materials (like those used for the manufacturing processes)
- Production of semi manufactured goods (not considered)
- Water supply
- Production of heat and electricity
- Transport

Core Processes: These are all relevant unit processes taking place within the organisation of the product subject of assessment.

- Lift components material composition including packaging. Upstream data were used for the inventory.
- Lift components manufacturing. Only the manufacturing processes of the first level suppliers, tier 1, were considered for the first study. Manufacturing processes of suppliers were excluded from the second study. The treatments of wastes generated within the process were considered too.
- Production of parts and subcomponents. Data of components (like electric and electronic equipment) are available in databases. Foreground data were not collected.
- Components assembly. This activity can be carried out at the components manufacturing site or during the lift installation. Its environmental impact is however negligible.
- Lift components storage (intermediate storage of components). Only transport from first level supplier to lift manufacturer considered. Intermediate transports or storage time not considered.
- Lift components distribution to the Building site[2], (upstream data used for transport activities).
- Lift installation. Mainly impact of workers displacements. Its impact is however negligible.

Downstream Processes: These processes take place after the lift is sold and installed and are no longer under the control of the manufacturing industry, but by the product owner.

- Lift use.
- Lift maintenance: Spare parts, use of consumables (e.g. lubricants), and displacement of lift workers to the lift installation. The later was left outside the system boundaries in this study, but should be considered when assessing different technologies.
- Lift modernisation. Excluded from the boundaries of an LCA because it depends on the user decision and the information is therefore unknown to the LCA practitioner
- Lift dismantling.
- Lift disposal or end-of-life. Collection and transport of the complete lift to the end-of-life treatment facilities and corresponding treatment. Conversion into recycled material was excluded.

3 LCA RESULTS, INTERPRETATION AND RECOMMENDATIONS.

As mentioned in 2.1, the purpose of the study was to identify the most significant aspects of the lift product system with view to define a suitable LCA method that supported Product Category Rules. This objective was achieved. Annex B of [10], indicates the degree of completeness of the lift inventories used. As the results were not intended to be used in comparative assertions disclosed to the public, no uncertainty analysis[3] was conducted. The results of the LCA were calculated for different impact categories and eco-indicators. Most of the results presented in the following sections

[2] This transport of the product to the consumer is a downstream process in the case of small goods.
[3] Quantification of the uncertainty introduced into the results of the analysis due to the cumulative effects of model imprecision, uncertainty of the inputs and the variability of the data.

are expressed in units of Eco-Indicator 99 [17], because this end-point indicator aggregates different environmental categories in a single value and makes it easier to see general tendencies. Although no official critical review was arranged, the doctoral thesis in which this complete study has been published was reviewed by several renowned international experts [10]. This section summarizes the conclusions reached after the sensitivity analysis performed. These are the aspects, architects and lift consultants need to pay attention to when interpreting the environmental data provided by a lift supplier for selecting the most environmental friendly option for an application.

3.1 Lifts materials composition and manufacturing processes

Table 1 and Table 2 show the lift composition of a 630 kg geared traction lift in weight. The highest percentage corresponds to metal parts, which are recyclable or contain recycled materials, however the impact of electric and electronic components, which average for less than 2% in weight, represent a much higher % of the total impact of the materials phase. For eco-indicators/impact categories that consider more aspects than the consumption of fossil resources or global warming potential, components like the control cabinet are among, or even the most relevant (see Table 3).

Table 1: Distribution by material

Type of material	% weight
Ferrous Metals	85,72%
Non Ferrous Metals	2,10%
Polymers	1,52%
Elastomers	0,12%
Gases and fluids	0,05%
Modified organic natural materials	0,34%
Paintings and superficial Coatings	0,30%
Electronic components	1,93%
Inorganic materials	0,30%
Adhesives	0,04%
Packaging	7,58%

Table 2: Distribution by functional group

Components	% weight
Traction unit (Electric Driver)	6,02%
Anti-fall safety devices	1,18%
Controller cabinet	2,32%
Components of the elect. installation	2,28%
Landing doors	10,54%
Car doors	1,58%
Car frame (sling)	7,72%
Counterweight frame (sling)	23,10%
Car	8,12%
Car guide rails	17,56%
Counterweight guide rails	10,23%
Suspension and compensation ropes	1,52%
Fixing elements	0,18%
Packaging	7,59%
Well components	0,05%

Table 3: Environmental impacts of the materials phase depending on the functional group

		EcoIndicator 99 (E/E)		Global Warming Potential		Ozone Depletion Potential		Acidification Potential		Eutrophication Potential		Photochemical Ozone Creation Potential	
		Pts	%	Kg CO2 -eq	%	Kg CFC- 11-eq	%	Kg SO2 -eq	%	Kg PO4-eq	%	Kg C2H4-eq	%
GROUP 1	Traction Unit (Electric Driver)	118,77	12,25%	553,35	8,09%	5,23E-05	9,74%	4,25	11,97%	3,47	13,45%	3,12E-01	8,97%
GROUP 2	Overspeed Governor	4,88	0,50%	58,90	0,86%	2,54E-06	0,47%	0,22	0,62%	0,12	0,47%	3,30E-02	0,95%
GROUP 3	Controller cabinet	155,28	**16,01%**	544,49	7,96%	4,86E-05	9,06%	4,84	13,63%	5,70	**22,13%**	2,41E-01	6,93%
GROUP 4	Travelling cables	146,30	**15,09%**	225,87	3,30%	1,14E-05	2,12%	4,36	12,26%	4,57	**17,76%**	1,94E-01	5,58%
GROUP 5	Car operator panel	23,33	**2,41%**	74,15	1,08%	6,53E-06	1,22%	0,59	1,67%	0,53	**2,07%**	3,17E-02	0,91%
GROUP 6	Landing operator panel / Call indicator board	4,80	0,50%	26,02	0,38%	2,19E-06	0,41%	0,15	0,42%	0,10	0,37%	8,68E-03	0,25%
GROUP 7	Door front/frame/liner (sheets)	3,82	0,39%	13,54	0,20%	9,24E-07	0,17%	0,07	0,20%	0,02	0,10%	4,23E-03	0,12%
GROUP 8	Landing Doors	72,07	7,43%	884,20	12,93%	1,54E-04	28,73%	3,44	9,67%	1,79	6,94%	4,31E-01	12,41%
GROUP 9	Doors operators	36,47	3,76%	256,65	3,75%	2,20E-05	4,09%	1,30	3,66%	1,39	**5,41%**	1,02E-01	2,94%
GROUP 10	Car doors	34,85	3,59%	123,44	1,80%	8,25E-06	1,54%	0,64	1,80%	0,22	0,87%	3,84E-02	1,11%
GROUP 11	Car Frame + Counterweight frame + Fixing Parts + Bed Plate + Well components	72,74	7,50%	862,34	12,61%	4,31E-05	8,04%	3,14	8,85%	1,70	6,58%	4,52E-01	13,02%
GROUP 12	Car	108,44	11,18%	954,07	13,95%	6,89E-05	12,84%	4,44	12,48%	1,59	6,18%	4,09E-01	11,79%
GROUP 13	Guide Rails	148,17	15,28%	1.856,23	27,14%	8,97E-05	16,71%	6,40	18,00%	3,92	15,24%	1,02E+00	29,27%
GROUP 14	Mechanical parts (Accessories + Fixing Parts + Other Components)	18,26	1,88%	193,82	2,83%	1,14E-05	2,12%	0,73	2,04%	0,31	1,21%	1,04E-01	2,99%
GROUP 15	Suspension Ropes	12,19	1,26%	134,08	1,96%	7,53E-06	1,40%	0,51	1,44%	0,12	0,46%	7,21E-02	2,08%
GROUP 16	Governor Ropes	0,91	0,09%	10,00	0,15%	5,62E-07	0,10%	0,04	0,11%	0,01	0,03%	5,38E-03	0,16%
GROUP 17	Counterweigh Weights	8,46	0,87%	69,32	1,01%	6,71E-06	1,25%	0,43	1,20%	0,19	0,73%	1,74E-02	0,50%
Total		969,75		6.840,45		5,37E-04		35,54		25,76		3,47	

Although the completeness of the inventory data regarding the manufacturing processes is far from being ideal, the screening studies showed that their ecological relevance is low (see Figure 1).

🕮 Attention shall be paid to the fact that electronic components introduced to improve the lift performance during the usage phase may significantly worsen the materials phase.

🕮 The cut-off rules applied for the inventory shall be declared by the practitioner to avoid that materials with a high environmental relevance be excluded.

3.2 Relevance of the usage phase

This is the most critical phase in the LCA of a lift because of the difficulty to predict it. The results are therefore highly sensitive to the method selected for the estimation of the energy consumption and the assumptions made regarding the usage of the equipment, which determine the time distribution of the running and non-running periods. Figure 1 shows the results of the complete LCA of one of the lifts described in Annex B of [10]. The different columns show the environmental impact of the lift system during its whole life (estimated as 20 years) measured in units of Eco-indicator 99 for the five usage categories defined in VDI 4701-Part 1 [18] and the 5 first categories of ISO 25745-2 [1]. Whereas VDI usage categories are based on building characteristics that may be ambiguous and in the practical application cause that two different usage categories can be possible for the same application, ISO 25745-2 [1] defines the usage categories according to the daily number of starts (a parameter, which is already used in the sector as a measure of the intensity of travel for selecting the best equipment) and gives average values, based on thousands of simulations, for the distance travelled, the weight transported and the time spent in the different operational modes.

The German guideline was before ISO 25745-2 the only document providing usage tables with data of average time spent by the lift in the different operating conditions and has been, for this reason, the reference document used by LCA practitioners in the lift industry till now. Although VDI is a good guideline for comparison of products, its approach is not adequate for LCA because it considers the ISO 25745-1 reference cycle (a lift travelling with rated load over the full building height). Thus, if these data (load and distance) are multiplied by the number of starts, it will result in the lift travelling longer and carrying a higher load than it actually does. This might not have a high impact in the average energy consumption (in some cases; in others it does), but when calculating the environmental performance of the lift system per functional unit Pkm (see 2.2.2), the higher denominator will reduce the environmental impact. Another flaw of VDI-Part 1 is that energy consumption in idle is not considered (Part 2 [19] does), what results in an important underestimation of the total standing energy consumption (idle power is always higher than standby) for the highest usage categories, as in these cases the lift has not time to switch into standby$_{5min}$ (5 minutes have elapsed since the last trip) during the normal operation period [9,10].

As per the results shown in Figure 1, the environmental impact associated to the use phase of this lift only exceeds the impact of the lift materials in categories 3 (for VDI), 4 and 5, while it is lower for categories 1, 2 and 3 (for ISO). Both for the VDI and ISO usage categories, the energy consumption travelling generates a greater environmental impact than the standby phase in categories 3, 4 and 5, but not in the low demand case. It is important to remark here, that due to the absence of measured data, the same value has been used for the idle and standby$_{5min}$ power and that this lift does not have a further saving mode (standby$_{30min}$). The spare parts have been estimated according to the preventive maintenance plan. Thus, the conclusions for Usage category 3 could change if the actual idle power and more accurate data of the spare parts were considered. In Table 4, the results of Figure 1 are grouped in the two most relevant aspects: Lift composition (Materials + spare parts) and usage (aggregating running, idle = Standby$_{5min}$ and Standby$_{5min}$). The Nr. of starts for the VDI usage categories have been obtained from the travelling time given in the tables, considering that each cycle is the ISO 25745-1 ref cycle (full rise).

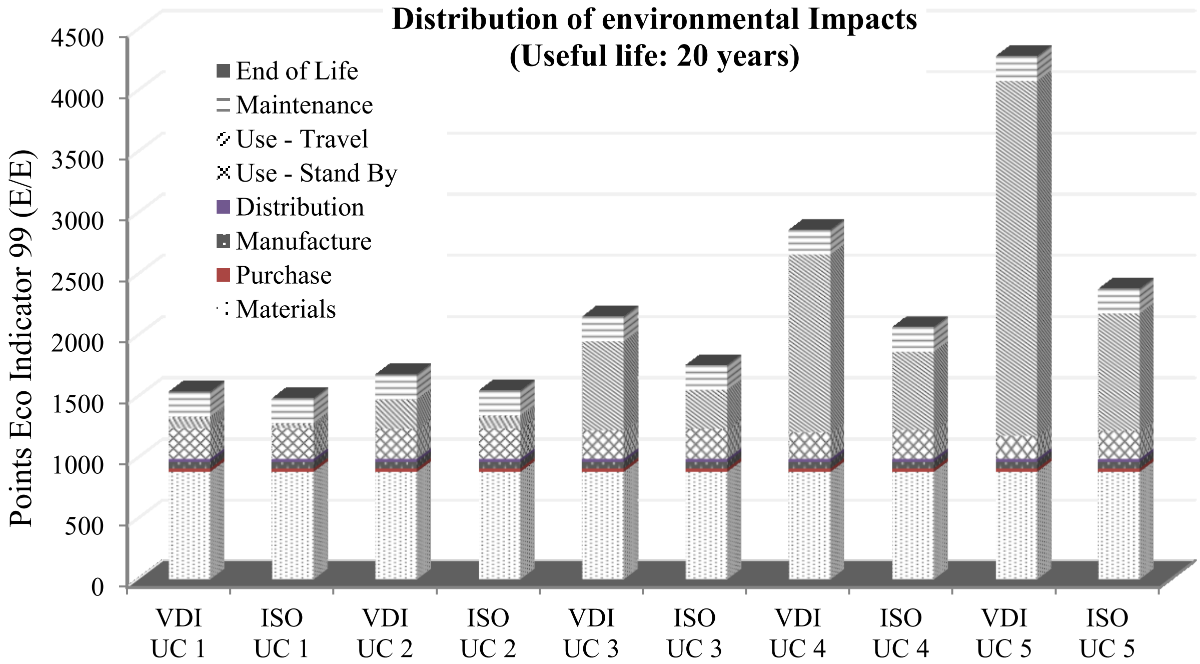


Figure 1: Environmental Impact results 630 Kg gearless traction based on usage of the facility

Table 4: Impacts in different life cycle phases (grouped). Travelling times and Nr. of Starts

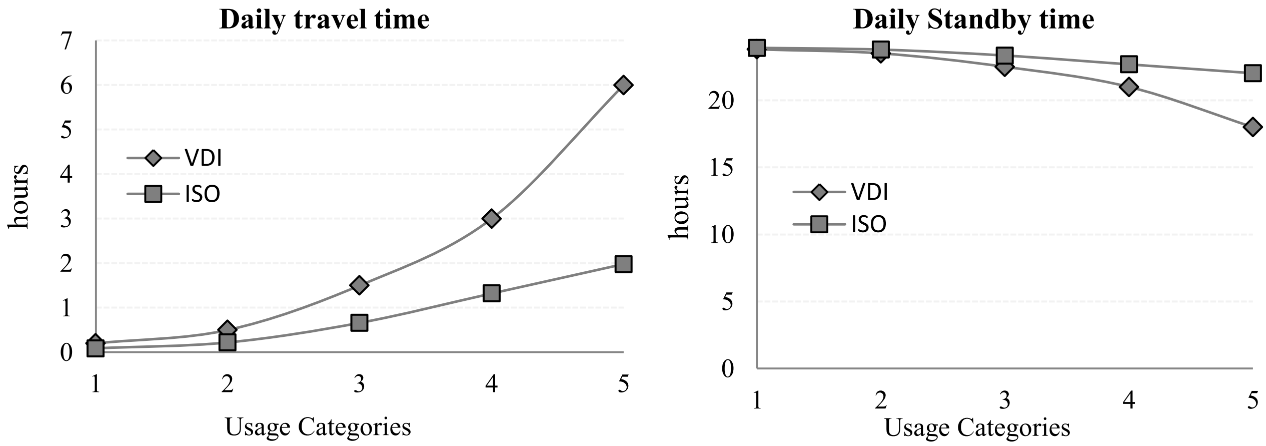
	Eco Indicator 99 (E/E)									
Usage Cat.	**1**		**2**		**3**		**4**		**5**	
Method	VDI	ISO	VDI	ISO	VDI	ISO	VDI	ISO	VDI	ISO[4]
Materials + Spare parts	**70,48%**	**73,00%**	**64,53%**	**70,05%**	**50,36%**	**61,75%**	**37,89%**	**52,44%**	**25,33%**	**45,56%**
Use (Travel + Standby)	**22,55%**	**19,79%**	**29,09%**	**23,02%**	**44,66%**	**32,14%**	**58,37%**	**42,38%**	**72,16%**	**49,93%**
Manufacture	3,52%	3,65%	3,23%	3,50%	2,52%	3,09%	1,89%	2,62%	1,27%	2,28%
Purchase	1,84%	1,90%	1,68%	1,82%	1,31%	1,61%	0,99%	1,37%	0,66%	1,19%
Distribution	1,61%	1,66%	1,47%	1,60%	1,15%	1,41%	0,86%	1,19%	0,58%	1,04%
End of Life	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Travel time (h)	0,20	0,09	0,50	0,22	1,50	0,66	3,00	1,32	6,00	1,98
Standby time (h)	23,80	23,91	23,50	23,78	22,50	23,34	21,00	22,68	18,00	22,02
Starts/day	77		192		576		1152		2304	

🕮 These results show that, unlike often believed in the lift industry, the usage phase is not always the most relevant, in line with some statements made by some hydraulic lift manufacturers [20] and [21].

🕮 The estimation of spare parts and preventive maintenance operations (which will affect the transportation of lift workers) shall be in accordance with the different categories of usage, as the life of the components depends on the lift activity (Nr. of starts) and lift technology considered.

Table 5 shows the difference between running and non-running times considered by VDI-1 and ISO 25745-2, which are the source of the big differences in the highest usage categories.

Table 5: Time spent travelling and standing (ISO includes idle, $Stby_{5min}$ and $Stby_{30min}$)



3.3 Influence of the energy mix

The environmental impact of the different power generation technologies (hydropower, nuclear, coal, gas and other fuels, combined cycle, wind, solar, cogeneration, biomass, bio-fuels, etc.) vary substantially. Eco-Indicator 99, for example, strongly penalizes electricity generation technologies

4 ISO 25745-2 considers a 6th usage category not represented in the graph to be coherent with VDI.

which are very natural resource-intensive and produce air emissions, but ignores the high risk of a worst case scenario and the existence of waste for which treatment is not yet possible, in the case of nuclear energy. Thus, countries or companies using a higher proportion of renewable or clean production technologies will reduce the impact generated by their energy-consuming processes and products. In the same way, lifts installed in countries with a good energy mix will be more environmentally friendly. Figure 2 below shows possible environmental impact scenarios for a traction lift installed in different countries. The energy mix assumed corresponds to year 2008.

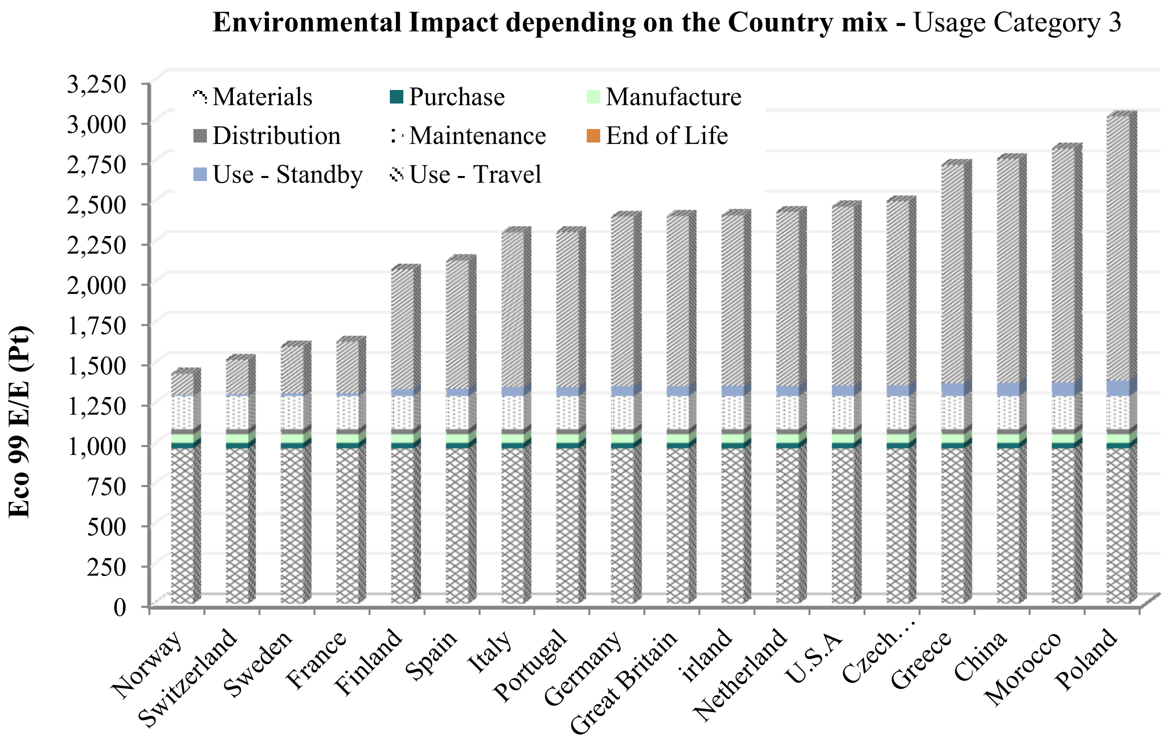


Figure 2: Environmental Impact results (630kg gearless traction) for the usage category 3, installed in different countries

🕮 The strong influence of the energy mix in the results of LCAs suggests that it might be reasonable to consider the kWh as unit for assessment of energy consumption for lift comparison purposes. In any case, LCA data for publication should clearly indicate what mix has been used for the assessment.

3.4 Maintenance phase: replacements and repairs

The results of the LCA are very sensitive to the amount of spare parts that, according to the estimation of the lift designer will be consumed during the useful life of the product for ensuring a good performance. This can be a deciding argument for selecting a certain lift technology

🕮 The lift user shall be informed about the necessary preventive maintenance operations and replacements necessary to guarantee the best product performance. These replacements shall be accounted as material inputs for the LCA. The preventive maintenance operations will depend on the lift usage and its expected life and may therefore differ between usage categories and technologies.

3.5 Modernisation

Modernisation operations are quite common in the lift sector. They increase the environmental burden of the lifts components phase, making their contribution to the total impact become more relevant. If the substitution implies a technological improvement which optimizes the energy consumption, the use phase will also be affected.

🕮 Although lift modernisations are excluded from life cycle assessments because they are not under the control of the lift company selling the product and are not predictable; from an environmental perspective it is advisable that the impact caused by the upgraded components be checked against the environmental improvement achieved.

3.6 Lift logistics

The influence of logistic processes in the environmental impact is sensitive to changes related to the lift supply chain (components set up) and to the transportation method selected (the environmental impact of transporting 1 ton of material along 1 km is very different depending on whether the product travels by rail, truck, ship or a cargo plane). For this reason, logistics are usually only analysed in LCAs for companies' internal use [10]. In the case of LCAs for public assertions, it is common to use average logistic values. Obviously, the distribution phase will be more relevant for companies serving international markets.

3.7 Influence of end of life treatments

As explained before, at the time of conducting the first study no detailed information about the lift waste management was available, for which reason it was estimated that the lift was disposed in the landfill. However, this seems not reasonable, as by judicious management of recyclable materials a significant improvement in the environmental performance of the components can be achieved. In general, the end of life phase is very sensitive to the end of life scenario assumed; i.e., to whether materials are reused, recovered or recycled and to which phase of the life cycle these impacts are allocated. In the first study, a possible configuration of municipal waste management was modelled in Simapro [22]. Environmental credits were given to all recycled materials obtained. This resulted in a reduction of 20% of the environmental impact. In the second study, the recyclability of the lift was analysed following the standards of the rail industry [23]. The results revealed that in a lift, whose components could be 100% disassembled, 99% (weight) of the materials could be recycled, 0,5 % valorised (for energy recovery) and approximately other 0,5% would be waste.

🕮 In order to improve the lifts end of life management, lift owners should be provided with indications regarding how to conduct the dismantling operations and with information about the best possible treatment options for each component and their potential recycling and recovery rate.

3.8 Influence of the estimated useful life

Being the lift a EuP (Energy using Product), the duration of its useful life will determine the amount of energy consumed and maintenance operations necessary. There is currently no consensus in the lift sector about an average useful life of lifts, mainly because of the continuous modernisations works that are undertaken to improve their performance. It would be interesting to count with some statistics from the sector. Till then, the lift user shall pay attention to the useful life guaranteed by the lift manufacturer and estimated in the LCA. A reduction of the useful life increases the relevance of the materials phase whereas the opposite decreases it. The estimation of spare parts and maintenance operations shall be recalculated accordingly.

🕮 The life expected for the lift and/or their components plays a decisive role in the final environmental impact of the lift. Especially in the materials phase, but indirectly affecting also the usage phase (maintenance and energy consumption). Wear of the installation may lead to higher consumption. Better quality may imply lower environmental impact.

3.9 Influence of data bases used

For all background processes, the selection of the databases and processes of the databases is of decisive relevance, because not all of them have the same level of quality and accuracy.

🕮 Common databases for background data should be provided by the lift industry to enhance the transparency with view to comparison.

3.10 Influence of the environmental categories considered or the eco-indicators used

The environmental impact categories considered for the assessment can change the distribution of environmental loads attributable to the different components or phases of the life cycle. Some materials or processes, which are not responsible for a high amount of emissions, can however cause other damages to the health. For this reason, it is always recommended to use more than one environmental categories and assessment methods for a right interpretation of the results of an LCA.

🕮 The uncertainty of the results associated to the databases, environmental categories considered or assessment methods employed can be avoided if these are fixed in the Product Category rules.

3.11 Important remarks

An environmental declaration can be used to select the best lift product or the best lift supplier, installer, etc., for a particular application, where more technologies and/or manufacturers are competing. In this case, the LCA practitioner shall use all actual data available directly applicable to the particular case considered: from suppliers, manufacturing processes, energy mix in the production facilities, etc., as well as the circumstances of the location where the product will be used. Generic data should only be used when some of this information is not available, unless otherwise stated.

However, when the results of a LCA are used in another context, for example in the design phase of a model lift or to check what technology (hydraulic/electrical, regenerative/non-regenerative, etc.) is more suitable for a certain application (big/small residential or office buildings, hospitals, etc.), generic data shall be preferably used for the assessment, so as to minimise the risk that aspects not related to the technology affect the results.

Some examples of foreground data which can make a significant difference in the results are:

- Company specific energy mix used in the manufacturing phase.
- Use of fresh water resources.
- information on local/site-specific impacts (acidification, eutrophication and biodiversity),
- self-production of components or concentration of suppliers customers etc., affecting logistic data
- the use of materials or processes not included in common databases
- the use different secondary materials with respect to the ones listed in in common databases
- much higher or much lower environmental impact than reported in background databases due to the application of green purchasing policies (environmental friendly suppliers),
- a better end of life treatment

In general, better environmental performance than average of the sector or the figures given in a standard, guideline or future Product category rules.

4 CONCLUSIONS AND FURTHER WORK

LCA Practitioners and users are often concerned about the quality of the environmental results provided in public assertions. The absence of information regarding the application of the LCA methodology, the imprecision of the system boundaries used in the analysis, the use of background data from different sources, different assessment methods or indicators, etc. cause that equally credible analyses can produce qualitatively different results, thus leading to varying interpretations. This undermines the reliability of environmental assessments from a scientific point of view, and renders them ill-suited for eco-labelling. In this paper, the LCA results of an example lift have been used to illustrate what the key aspects to be considered in the assessment are, but as already suggested in [10], a harmonisation process is needed in the lift industry. Some efforts have already started. It is important, that all relevant stakeholders are involved in the consultation phase of the Product category rules that are been developed [15].

5 LITERATURE REFERENCES

1. ISO/DIS 25745-2: 2013 *Energy performance of lifts, escalators and moving walks Part 2: Energy calculation and classification for lifts (elevators)*
2. "Defining Life Cycle Assessment (LCA)." US Environmental Protection Agency. 17 October 2010. Web (http://www.gdrc.org/uem/lca/lca-define.html)
3. DIRECTIVE 2009/125/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for the setting of Eco design requirements for energy-related products (recast)
4. ISO 14040:2006 Environmental management -- Life cycle assessment -- Principles and framework
5. ISO 14044:2006 Environmental management -- Life cycle assessment -- Requirements and guidelines
6. ISO/TR 14047:2003 Environmental management -- Life cycle impact assessment -- Examples of application of ISO 14042
7. ISO/TR 14049:2000 Environmental management -- Life cycle assessment -- Examples of application of ISO 14041 to goal and scope definition and inventory analysis
8. ISO 14050:2009. Environmental management – Vocabulary
9. Lorente, A-M., Núñez, J.L. & Barney, G.C. - *Energy Models for Lifts: Determination of average car load, average travel distance and standby/running time ratios*. 2nd Symposium on Lift and Escalator Technology 2012.
10. Lorente Lafuente, A-M, doctorate thesis deposited at EINA, University of Zaragoza entitled: *Life Cycle Analysis and Energy Modelling of Lifts*. September 2013
11. ISO 14020:2000 Environmental labels and declarations -- General principles
12. ISO 14024:1999 Environmental labels and declarations -- Type I environmental labelling -- Principles and procedures
13. ISO 14021:1999 Environmental labels and declarations -- Self-declared environmental claims (Type II environmental labelling)
14. ISO 14025:2006 Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures
15. http://www.environdec.com/en/PCR/Detail/?Pcr=9211#.U-87TWNz89Q
16. The International EPD cooperation (IEC). Supporting Annexes for environmental product declarations, EPD. Version 1.0 dated 2008-02-29
17. Frischknecht R., Jungbluth N. Implementation of Life Cycle Impact Assessment Methods. Ecoinvent Report 3. Swiss Centre for Life Cycle Inventories Data v2.0 (2007)
18. Verein Deutscher Ingenieure - VDI Guideline: VDI 4707 Blatt 1, Aufzüge – Energieeffizienz. 2009
19. Verein Deutscher Ingenieure - VDI Guideline: VDI 4707 Blatt 2, Lifts - Energy efficiency - Components. 2012
20. Spyropoulos, N., Asvestopoulos, L., *Hydraulic vs. Traction Lifts: Environmental Friendliness and Quality of Service to the User*. Elevcon 2008
21. Jost C., *Analysis of the ecological footprint of different drive systems for lifts*. http://www.lift-journal.de
22. http://www.pre-sustainability.com/simapro
23. ISO 22628:2002. Road vehicles - Recyclability and recoverability. Calculation method

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[5] http://www.ita.es/

[6] Life Cycle Analysis and Energy Modelling of Lifts. Including.

- New methodological approach for the assessment of the lifts usage phase based on the influence of traffic
- Proposed summary tables for regulatory use fitting existing building classification systems
- Product Category Rules proposal for conducting comparable LCAs and issue of Type III environmental Statements

[7] http://www.mplifts.com/portal/web/guest/inicio