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PROXI INDICATORS USED FOR PRODUCT ENVIRONMENTAL ASSESSMENT

Abstract: *The paper is focusing on the necessity of assessing the products in order to evaluate their negative environmental impact. This activity is part of the design strategy meant to identify the existing products' weak points in order to optimise the future designs. The environmental assessment can be performed using a large range of instruments, among which the category of Proxy Indicators covers an important area. The Eco-indicators are Proxy Indicators used mainly for comparing solutions. This paper shows how this instrument can be successfully used to compare existing products with the new designs.*

Key words: *assessment tools, ecodesign, life cycle, proxy indicators.*

1. INTRODUCTION

The human – environment relationship is one of the problems we are confronting with today. It is a complex subject that involves numerous factors, designers included. Designers and design can do a lot because they are responsible for all the products we use every day. It is well-known that any human activity, therefore all the products and service we use and have a benefit from, have an environmental negative impact. Design can contribute to reducing this impact during each step of the design process. Moreover, designers have the power to influence the customers, the users of their products, indirectly contributing to their ecologic education, by designing environmentally safer products.

The design process requires intense and strict monitoring. The monitoring process is extended on several steps, the most important one being the evaluation of the product environmental impact during the entire life cycle, known as LCA [1]. The whole life cycle evaluation is essential because it gives complete information on the product 'behaviour' from the materials perspective, "from cradle to grave" [2].

A product life is extended on five stages [3], as follows: materials obtaining, processing, transportation, use and disposal. Obviously this sequence follows the material flows. Moreover, during its life stages, some energy is consumed. Consequently, a complete evaluation of the environmental impact should include material and energy flows.

2. EVALUATION INSTRUMENTS

The tools used in the assessing activities are of two types: analytical and creative. Each of them needs to be used iteratively in the search for solutions or new directions. The instruments used for assessing the environmental impact are, usually, analytical.

The main objective of the analytical tools is to gain insights into environmental impacts throughout the life cycle of a product. Analysis of the life cycle of a product involves looking upstream processes (raw materials, processes, transportation), and looking downstream, to the future use and end of life options (reuse, recycling, landfilling).

One main analytical tool for assessing the environmental impact of a product is life cycle analysis, or assessment (LCA). LCA provides a statistical inventory of the total impacts made during the complete life of a product, "from cradle to grave" from the material acquisition to the final disposal.

As a concept, LCA attempts to attribute the environmental loads from all stages of the life cycle of a product or product system, back to the "functional unit" of the product. This allows the product designer to consider and design around the broader environmental implications of a product. Although LCA can be seen as a concept or an approach, the term has stricter application as a specific and internationally standardised methodology for assessing environmental footprint from product systems.

Through the LCA, "the system" is evaluated, that includes all the operations along the material and energy supply chains, including transport between them, to obtain a complete "cradle to grave" assessment of the environmental impact. Where the product is not controlled following sale to the user, the analysis may be on a "cradle to gate" basis, including the supply chain, only up to the point of sale. In either case, analysis of the life cycle avoids the risk of apparently improving the process to reduce the impact, but actually transferring it to some other point in the material or energy supply chain. However, the use stage represents an unknown because even when the final user is known, the way the product will be exploited, is difficult to define.

Other assessment tools are the so called Proxy Indicators. Proxy Indicators are single values that are used to reflect the environmental impact of a product or material [4]. Examples of Proxy Indicators are: Embodied energy, Material input per unit of service (MIPS), Ecological rucksack, Ecological footprint, Eco-indicators. All of them are designed to reflect into a single numeric value the extremely wide range of environmental impacts, e.g. air emissions, global warming, ozone layer depletion, species extinction, acid rains, desertification.

Eco-indicators are generally recognised as Proxy Indicators as they are an attempt to model a wide range of impacts that are then weighted against each other and summed into a single value.

Because the limitations in measuring the environmental impacts and because the uncertainties in weighting the different impact categories, it is more useful to see these values as indicators/*proxies* for the environmental impact than as a measure of any actual environmental impact. This might be the reason for naming them so.

Some of the Eco-indicators are: Eco-points, Environmental priority strategies in product development (EPS) and Eco-indicator 95/99 [1].

The Eco-indicator method was developed by the company PRE Consultants, at the Dutch government request. The data bases were built together with a large range of companies and research institutions. The impacts are grouped into the categories: *human health, ecosystem quality and resources* [6]. These categories cover (almost) all the possible environmental impacts, previously mentioned. The indicators are calculated based on the best available scientific knowledge. The three areas are then weighted against each other on the distance-to-target principle.

3. USING THE ECO-INDICATOR

The Eco-indicator represents quite a good instrument when comparing alternative solutions to a given problem. It can be successfully used to assess products in use when designers intend to perform a redesign. The optimisation should have multiple constrictions and when the environmental issues are prevailing, the process might turn into ecodesign with the objective of reducing the environmental impact of the new product.

The redesign process should start with a functions structure rethinking. Questions like: 'Are all the existing functions necessary?' or 'Are the functions carrier rationally designed?' should look for an answer. Consequently, a new 'black box' scheme should be built, based on the new identified inputs and outputs (Figure 1). The example given is for a coffee machine. The yellow square represents the 'black box' and outside are presented the identified flows for material, energy and information/signal.

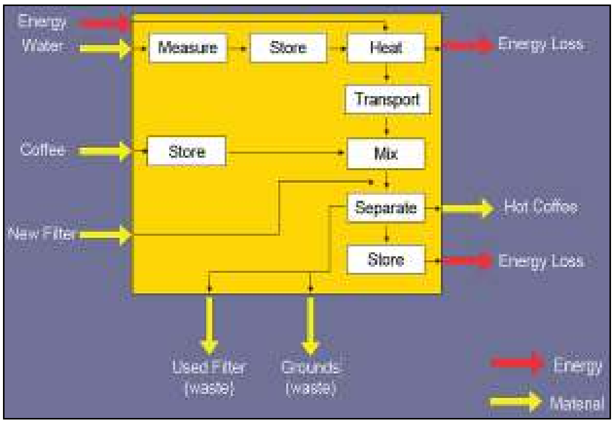

Figure 1 The product structure of functions.

After the new structure of functions was built, a value analysis should be performed for the existing product. Each component should be assessed as dimensions – mass, volume, shape – material and its processing.

The results of the primary evaluation should be synthesised into a scheme like in Figure 2. This should contain detailed information on each component, like material, mass, and a sequence of processes designed to transform the raw materials into each component. If information is available, the scheme might include the down-stream stages, 'Use' and 'End of life'. If completed, the scheme should be a model of the product entire life cycle (cradle to grave model).

Figure 2 The product life cycle modelling

This model should present all the materials involved in product manufacturing (the first column). If the material supply chain can be identified, the second column should contain the transportation system used from the raw materials obtaining (mining, harvesting) or/and primary processing (e.g. bauxite turned into aluminium ingots). Then, considering that all components are produced in the same factory location, in column three should be presented into a unique box the necessary processes to transform the materials into product components. When components are produced in different locations, they should be presented in separate boxes, with transportation to the assembly location included.

Once the product is assembled, it should follow the distribution chain to the final user. The model presented includes two transportation systems, by rail and by truck. This must be specified because the environmental impact varies from one transportation system to another.

The example in Figure 3 is the life cycle modelling for a lamp. During use, some supplementary inputs are required and should be included into the model. The lamp requires a bulb and energy for functioning. The impact determined by these factors will be present in the final evaluation.

When out-of-use, the product becomes a waste. Even if the product can be reused, eventually it will become a useless object. Several options are available. The product can be collected, disassembled and then the components sorted by their material. In this way, some materials will be recycled, other will not. For the last ones the options are landfilling (e.g. organic matters) or incineration (e.g. some non-recyclable plastics). In the example (Figure 2), the components of the product can be disassembled, and materials properly sorted, therefore the only option is recycling. This means that the materials will return to processing stage closing the circle. This represents an ideal scenario when all the materials from an out-of-use product return 100% to production. The reality is a bit different, because even the product is entirely made from recyclable materials, some parts might be lost or destroyed, or only partially recycled.

The information collected and synthetized in Figure 2 represents the starting point for the product assessment using Eco-indicator 99. A data base built by PRE Consultants [6] provides information regarding the environmental impact of materials, processes, energy and so on, using a unique measuring unit: *the point*. For example, the data base shows the environmental impact of producing 1kg of aluminium, or 1kW of energy, or rolling 1m^2 of steel sheet, or recycling 1kg of paper, or landfilling 1kg of glass.

The product environmental assessment involves building tables and graphs reflecting each component (material) impact for the stages like production, processing and end-of-life (Figure 3). If the end-of-life option is recycling, the impact will reflect the saving of an equivalent mass of raw material. For these stages, the evaluation is performed for product components, because of the variety of materials. The impact values are expressed in *points (Pt),* or *milipoints (mPt)*. The graphs permit observing each component impact weighting. This might be the starting point for the components redesign, choosing alternative materials and/or processes.

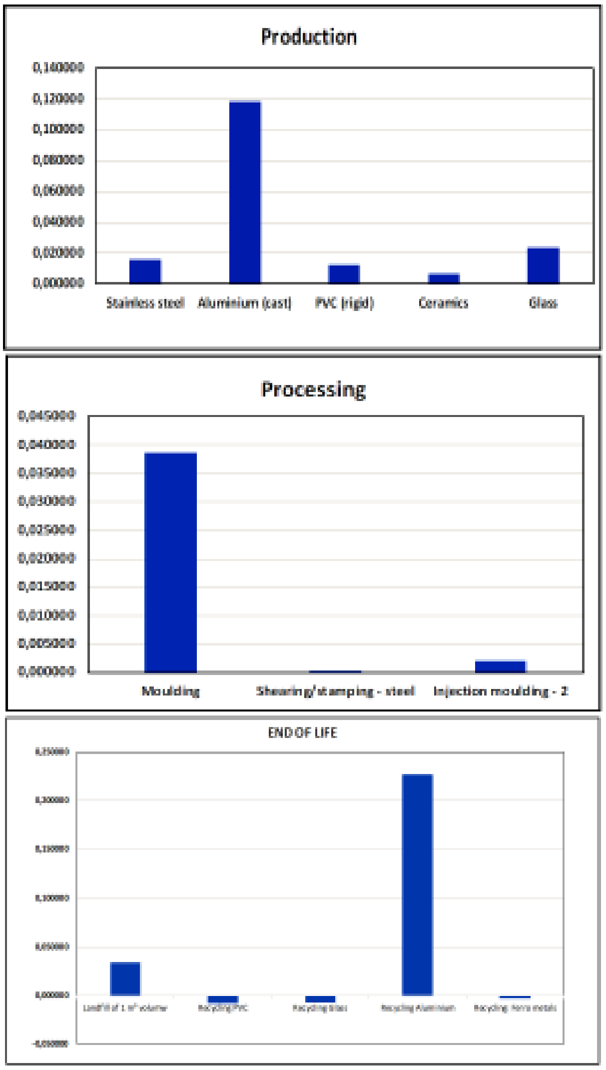

Figure 3 Environmental impacts for production, processing and end-of-life stages.

For the use and transportation stages, the evaluation is performed for the assembled product.

Containing less information, the results for these two stages can be placed on the same graph (Figure 4). The necessary energy should be estimated by anticipating how many hours the product will be in use. The data base contains indicators for each European country and the values may vary depending on the energy sources weight (e.g. hydro, wind, solar, fossil fuels).

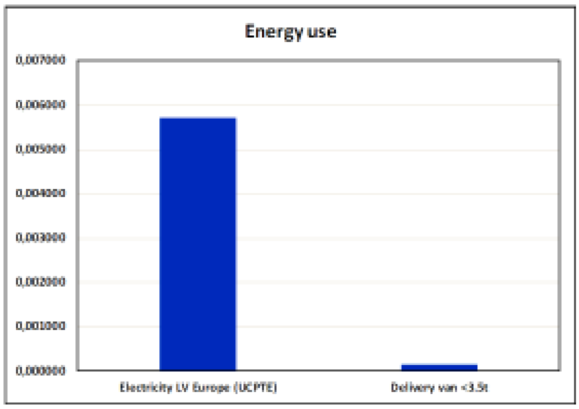

Figure 4 Environmental impacts for the using stage

For the transport, the indicators are expressed in points per ton·km *[Pt/t·km]*. Therefore, it is necessary to know where the product is fabricated and which transportation system is used.

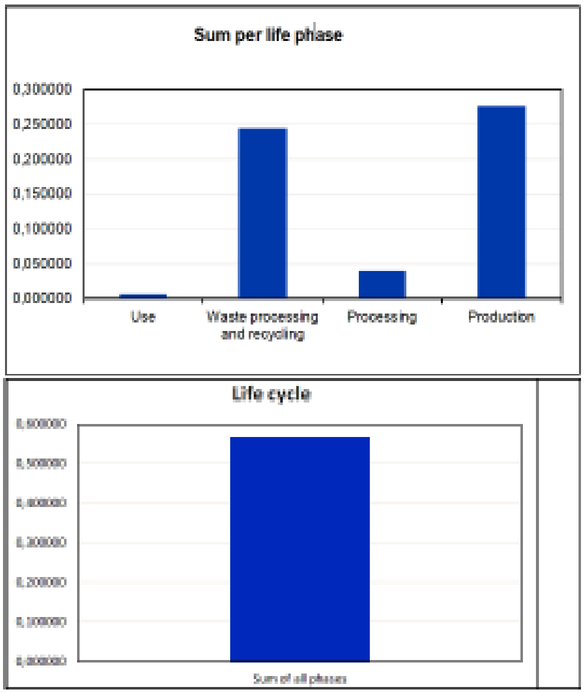

Figure 5 Total environmental impact for each stage and as sum.

Figure 5 presents a graphic representation of the product impact as a share for each stage. It is relevant because helps identifying the spots where the product has the highest environmental impact. This could be another starting point for a redesign process. Corroborated with the value analysis, the information provided by the Eco-indicator evaluation, can show designers where they can focus the changes for optimising the new product.

4. ECO-REDESIGN

As we previously assumed, an evaluation performed using Proxy Indicators gives as results some numbers, values expressed in a neutral measuring unit, the point. It is difficult to impossible to appreciate weather this value is large or small in a simple subjective evaluation. That is why these instruments are used for comparing solutions not for individual evaluation.

Knowing where the “weak spots” of the existing product are, designers can find solutions to improve it. Changes can be made in choosing the materials, for example. The components with high impact might be built from several alternative materials.

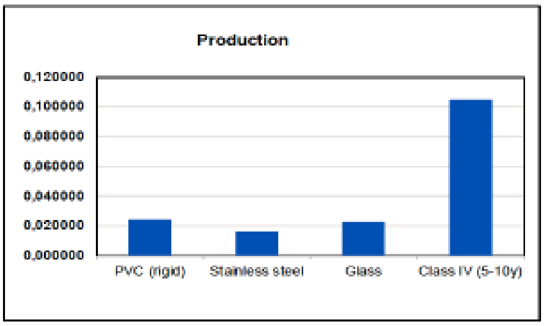

Figure 6 Environmental impacts for alternative materials

For comparing the materials, an evaluation should be performed, using again the Eco-indicator instrument. The result of such an evaluation (Figure 6) can be the base on which the new product should be built.

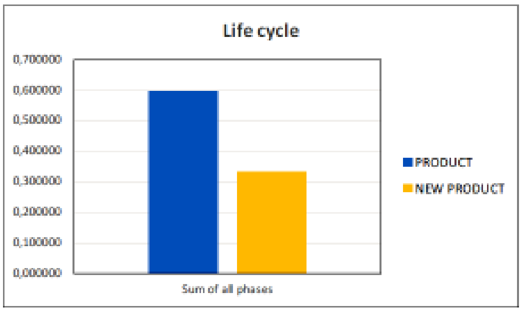

Figure 7 Comparison between the environmental impact of the existing and the new product

A similar comparison can be performed for other aspects regarding the product optimization, with repercussions on life cycle stages. Same material can be processed differently, only reshaped, so optimisation can be performed changing the process with one having a smaller footprint. Different materials may have a different impact; also they can present a different behaviour as waste. A non-recyclable material might have a high footprint. Replacing it with a recyclable material should considerably reduce the environmental impact. An increased consume of energy might be the cause of a higher impact so redesign should go deeper down to the conceptual design phase when the working principles and the working structure are established [4].

Once the new design is established, it can be evaluated in a similar way to the existing products. Data can be compared for each stage, or global (Figure 7). In case the new design has a lower impact, can consider the objective fulfilled.

5. CONCLUSION

Evaluating the environmental impact of a product or service represents an important step towards the objective of contributing through design, to a sustainable development for the human society. The product evaluation represents a complex activity because of the large variety of impacts which need to be reduced to a single measure, called “the environmental impact”. The Eco-indicator is an instrument that uses the comparison method between two or more products, technological routes, or provided services. It is a simple instrument which can help designers to improve their designs by evaluating the environmental impact.

The evaluation is performed over the entire life of the product, i.e. from the materials choice, continuing with materials processing, product distribution and use, and ending with finding friendlier solutions for the out-of-use products. The evaluation can be performed for the entire product, or for each component, separately.

In this way can be identified the impact for each component, in any stage of the product life cycle, a good basis for an optimal solution for the EcoReDesign process.

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