ECOEFFICIENCY VALUE ANALYSIS: EXERCISING AND ENVISIONING ECOEFFICIENCY

Daniel Collado-Ruiz

Salvador F. Capuz-Rizo

Integración de Diseño & Evaluación Ambiental, Universitat Politèctnica de València

Abstract

The consideration of environmental aspects when designing and marketing a product is becoming a mainstream activity in many sectors. Whilst environmental claims have been on the rise in the last decade, systematic consideration within design processes is somewhat less common. One reason for this is the unsuitability of many tools to current practices. This paper presents a variation of value analysis – one of the most commonly applied methods – targeted at both cost and environmental impact, which focuses on being integrated as seamlessly as possible in a company currently applying this method. Special attention is given to the way in which it is to be performed – factoring in the complexity of who has which information – and how to visualize the information, simplifying the assessment and leaving space for creativity. Ecoefficiency is the main driver for decision-making instead of value, interpreted as a derivation of the same: functionality of the product divided by costs, including those in environmental assessment. The paper presents the application of the method with the example of a CD case.

Keywords: *Ecoefficiency, Design for the Environment, Value Analysis*

Resumen

La consideración de los aspectos ambientales en el diseño y marketing de un producto se está convirtiendo en una actividad común en muchos sectores. No obstante, mientras que los productos cada vez dicen tener menos impacto ambiental, la consideración sistemática de los aspectos ambientales en el diseño no parece ser tan popular. Una razón de esto es la falta de adaptación de muchas de las herramientas propuestas a la práctica habitual. Esta comunicación presenta una variación del análisis de valor – uno de los métodos más usados – enfocada tanto al coste como al impacto ambiental, orientada a ser integrada lo más fácilmente posible en una compañía que utilice este método en la actualidad. De le da especial énfasis a la forma de realizarlo – considerando la complejidad que quién tiene qué información – y a la visualización de los resultados, simplificando la evaluación para dejar espacio a la creatividad. El criterio principal de decisión es la ecoeficiencia en lugar del valor, pero interpretada como una variante del mismo: la funcionalidad dividida entre los costes, incluyendo aquellos considerados por la evaluación ambiental. La comunicación presenta la aplicación del método en un ejemplo de una funda de CD.

Palabras clave: *Ecoeficiencia, Diseño para el medio ambiente, Análisis de Valor*

1. Introduction

The current political agenda includes sustainability as one of the key issues that society needs to tackle. This is no small challenge, with some experts stating that society needs to increase its resource efficiency – for the activities they are currently doing – at least ten-fold (von Weizäcker et al., 1997). This naturally requires all entities in society to take a role, and industry is one of the key stakeholders. This definition of efficiency, coined as ecoefficiency by the World Business Council on Sustainable Development (Schmidheiny, 1992), has the potential of serving as guiding indicator of the planet's current performance, and even of an industry's environmental performance. Doing more with less, maximizing the results while minimizing the planet's resource consumption, seems like the natural way to govern different processes in a company.

When it comes to design, this discipline often receives names such as ecodesign, design for the environment, design for sustainability, green desing, etc (Waage, 2007, Karlsson y Luttropp, 2006). Numerous methods have been developed since the beginning of the millennium, many of them with the purpose of increasing the acceptance of this approach in industry. However, acceptance is relatively low (Baumann et al., 2002, Mathieux et al., 2001). Many of these methods seem to have been developed based more on the concept that they were intended to deliver than on the people to which it was being delivered, and much of what has been generated does not seem to fit current processes. Additionally, many of these methods focus exclusively on the environmental impact, sometimes abandoning the complete vision that ecoefficiency provides with.

This paper presents the so-called ecoefficiency value analysis, a method developed to integrate the concept of ecoefficiency into the most popularly used method in industry: value analysis. The paper will present the approach in comparison with previous attempts of integration, and will exemplify it with a case study in which the method will be applied to a CD case for its redesign.

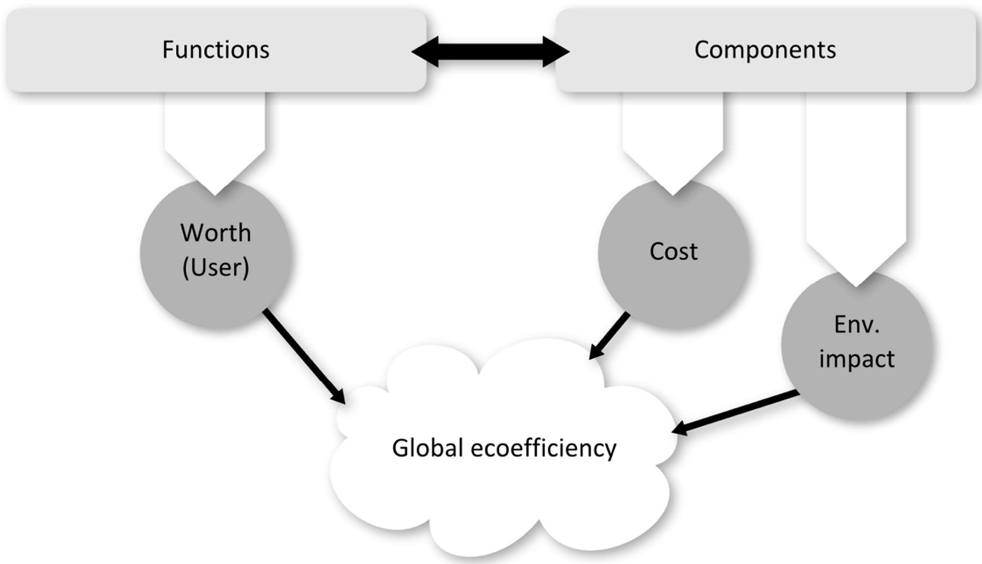
2. State of the art

Schneider and Birkhofer (2000) introduced a study done by Berliner Kreis in 1997, about the most commonly used design methods in industry. Value Analysis turned out to be the most applied method, with almost 40% of the companies applying it continuously and 90% having used it, although it not being common. The next methods described were intuitive methods and assessments – not strictly speaking guiding the process – followed by Failure Mode and Effect Analysis (FMEA) with 20% and 85% respectively. It can be seen that focusing on Value Analysis the percentage of method-using companies that can gain access to this method is considerably high.

There are several ways in which Value Analysis, as first presented by Miles (1989), is analogous to the concept of ecoefficiency. In Miles' publications, value was used as a guiding parameter, with the additional structure depending only on the workflow and style of the applicant. Other approaches such as those presented by Mudge (1989) or by the European Standard on Value Management (AENOR, 2000), present a more structured approach, although this way of dealing with the problem did not appear until some time later, when the whole concept was more mature. One could see a parallelism on Ecoefficiency, invented a few decades later, and only more recently starting to be applied in a systematic and procedural way.

Another parallelism comes from the terms that both of them employ, and even on the use they make of such terms. Value Analysis, and most particularly the concept of value, deals with two concepts, one to maximize and one to minimize. On the numerator of the equation we can find the product's worth or functionality. It is linked to the product's performance rather than to its physical parts, and the way to assess it is through the user. On the other hand, the denominator includes resource consumption, most commonly related to cost. These costs may be production costs, market price or life cycle costs, and constitute the economic sphere in value analysis. If one is to compare those concepts with those in Ecoefficiency, we can see that the numerator is common to both. The denominator is to some extent as well, although in Value Analysis resources are interpreted as a cost, and in ecoefficiency they are one of the categories considered in the environmental assessment that would take the place of the denominator.

Figure 1: Domains in Ecoefficiency, similar to those in Value Analysis



Even with this clear distinction between domains, as depicted in Figure 1, integrating them into a clear formula for ecoefficiency promises to be challenging. The most common approach, with no attempt to integrate it with Value Analysis, disregards costs and focuses solely on environmental impacts. Some authors interpret the numerator as value from the Value Analysis point of view. A simple calculation would deliver a formula for ecoefficiency as worth divided by the multiplication of costs and environmental impact (Park & Tahara, 2007, Hur et al., 2004). Kondoh et al. (2006) assimilate this as a geometric average, calculating the square root of the previously mentioned denominator. However, Collado-Ruiz (2007) showed that this multiplicative approach is oversensitive to double counting, and can sometimes deliver results that do not reflect the product's performance. Another approach is the additive approach as first proposed by Bastante-Ceca (2006), assessing environmental impact as a cost, to be added to the rest of the costs in the product. This allows for a more similar analysis to that in conventional Value Analysis. Conceptually, this approach is similar to assessing environmental impact as external costs (Silva & Fernandez, 2006, Vidal & Bovea, 2003).

This integration has been attempted in the past, following very different strategies. The Value Management standard itself points out subtly other considerations such as environmental impacts, leaving the door open for considering ecoefficiency (AENOR, 2000). Yamaji (1999) first presented Life Cycle Value Engineering, considering not only traditional value (in-house considerations) but also other life cycle costs. This includes costs for the user, and of course social value – the cost out of creating inequalities and unjust circumpstances in the world.

Ferrer (2004) proposed Partial Environmental Value Analysis, in which costs would be substituted by environmental impact. Combining an analysis of environmental value and economic (tradicitional) value, one could select a strategy that focuses both in the economic and ecologic strategies. A similar approach is presented by Oberender and Birkhofer (2004), and further developed by Sakao et al. (2006) with the name of Eco-Value Analysis. In this case, strict calculation of value figures is ommited, and assessment is done with all figures together. The matrix is duplicated (triplicated even) not only including costs, but also environmental impact. Assessment is later done based on two different graphs, making the final result almost analogous to that of Ferrer (2004).

With a considerably different approach, the Instituto Andaluz de Tecnología developed, together with the Technical University of Vaasa and CEV, developed Environmental Value Analysis (EVA). In this case, instead of assessing the environmental impact of components, the method sets what they call environmental functions. Even if these functions fail to meet the general definition normally used in Functional Analysis (Collado-Ruiz, 2007), it is possible to presume them as functions of the design team. The main advantages of this method are its systematicity and the tools developed to ease its interpretation of environmental and economic terms

As can be seen, there have been numerous efforts in integrating ecoefficiencty – or at least environmental assessment – into Value Analysis. Hoever, the concept of Ecoefficiency still remains as difficult to visualize and calculate. The following paper will present an integration of the previously mentioned approaches, together with novel interpretations of the concept of ecoefficiency.

3. Description of the method

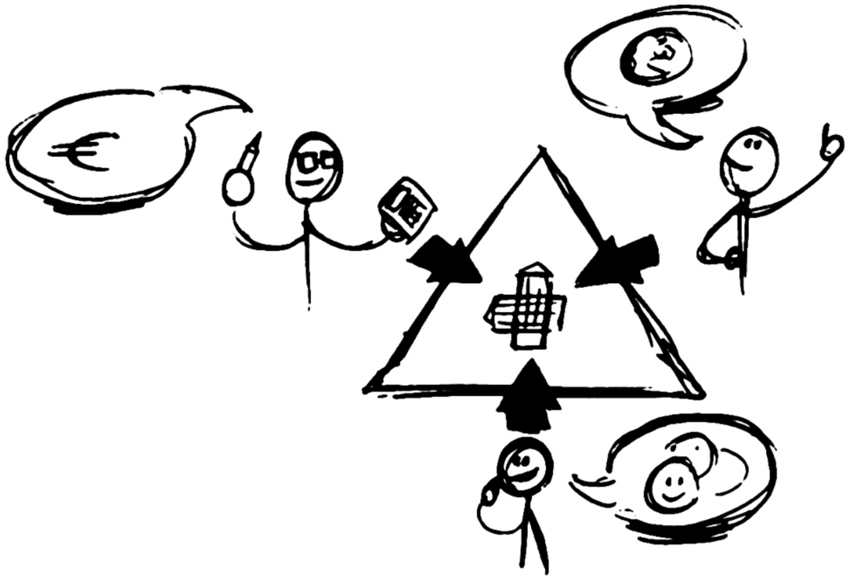
Lindahl (2005) states that the three goals of a method are:

1. Facilitate communication
2. Encapsulate experience and knowledge
3. Structure part of the design process

The proposed method aims at fulfilling all three of them in the best way possible. The method's structure is very closely related to the standardized structure of Value Analysis. The terminology that is used is mainly related to Value Analysis, so in a company in which it is already applied it should be the common communication language already. Additionally number 3 is ensured due to the standards for Value Analysis mentioned above. Special attention shall be put to number 2, in particular related to number 1. The method should encapsulate not only the knowledge about ecoefficiency in the company, but also the different knowledge items that are necessary for its calculation.

Knowledge about environmental impacts tends to be centralized in some departments in the company, if any, or externalized. Many ecodesign methods require assessments to be done by the design team or interpreted by it. However, surveys performed by Erzner et al. (2001) show that it is much more common, when possible, to have a group of experts in the company reporting to each one of those teams. This method should be capable of integrating this reality into the way the method proceeds, making the environmental assessment independent of the rest of the assessments. Stretching this yet a bit further, since there are three domains to be analyzed, the method proposes the separation of all three, so different people in the company can specialize in the part that they have more knowledge on. Additionally, since the timeframe may be different, this makes the whole process more flexible. Image 2 shows how this can perform in a distributed environment, in which each employee in the company has parceled knowledge about his specialization, and does not require considering the rest of the parts – which may well be overwhelming for them.

Figure 2: Interaction between different disciplines



The proposed method assesses functionality in the same way that conventional Value Analysis does – as a percentage, either defined by the design team or by users themselves. Environmental impact is assessed in one of the existing methods that calculate the final value in economic figures, out of the environmental costs. Examples of such methods are EPS 2000 (Steen, 1999), Tellus (Zuckerman & Ackerman, 1994) or LIME (Itsubo & Inaba, 2003). In other cases, costs may also be used as an assessment of environmental impacts, whenever they have been internalized by laws or company activities. For this case of Ecoefficiency Value Analysis, and since costs will be measured in euros, EPS 2000 will be used.

The proposed method follows very closely the steps for Value Analysis, with the same preparation and information phases before the assessment, and creation, evaluation, investigation and realization phases afterwards. Only the analysis changes, and each discipline from Figure 2 would take a different role in this process. The assessments are preformed as mentioned previously, and calculations are done based on the additive formula. Transformations from functions to subsystems and viceversa are done according to formulas 1 and 2, and calculation of ecoefficiency of element (function or subsystem) *i* follows Equation 3. Figure 3 shows the matrix used in this assessment, to gather all the information that is handled along the process.

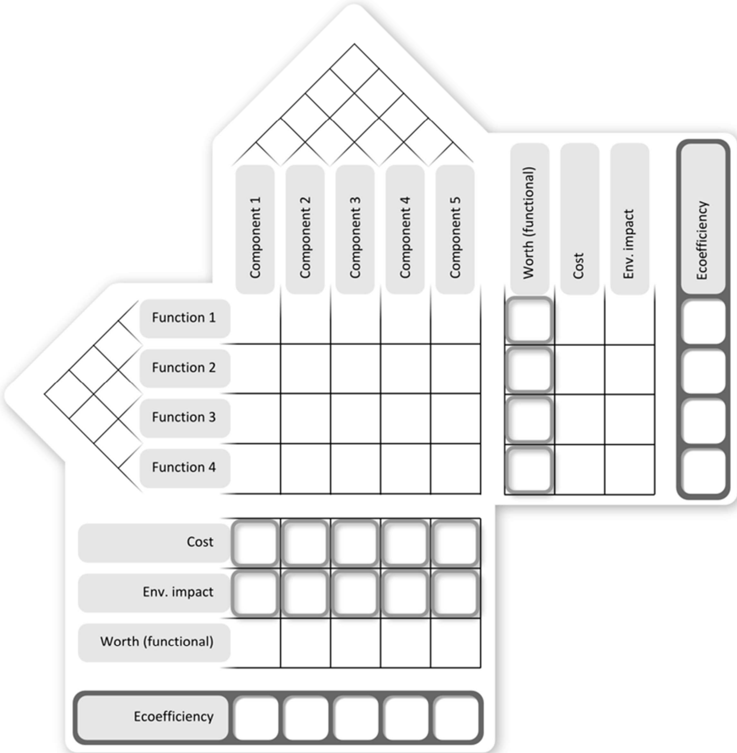
$$Cost_i = \sum_j (a_{ij} / \sum_i a_{ij}) \cdot Cost_j \quad (1)$$

$$Importance_j = \sum_i (a_{ij} / \sum_j a_{ij}) \cdot Importance_i \quad (2)$$

$$Ecoefficiency_k = Importance_k / Cost_k \quad (3)$$

Where *i* are functions, *j* are subsystems, and *k* include both *i* and *j*.

Figure 3: Ecoefficiency Value Analysis matrix



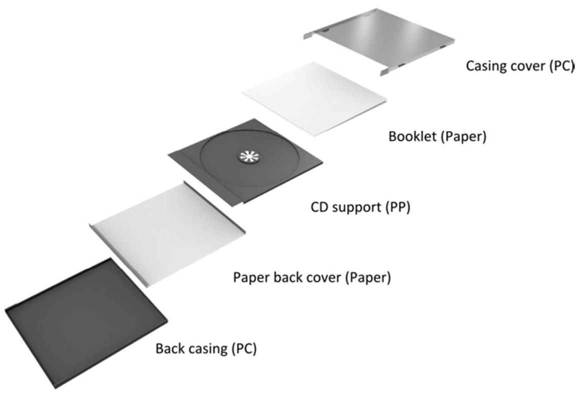
From that point elements with a lower ecoefficiency need to be reconsidered and redesigned.

The following section will present a case study in which all the concepts are applied, and section 5 discusses the advantages, disadvantages and potential improvements of this method.

4. Case study: application to a CD case

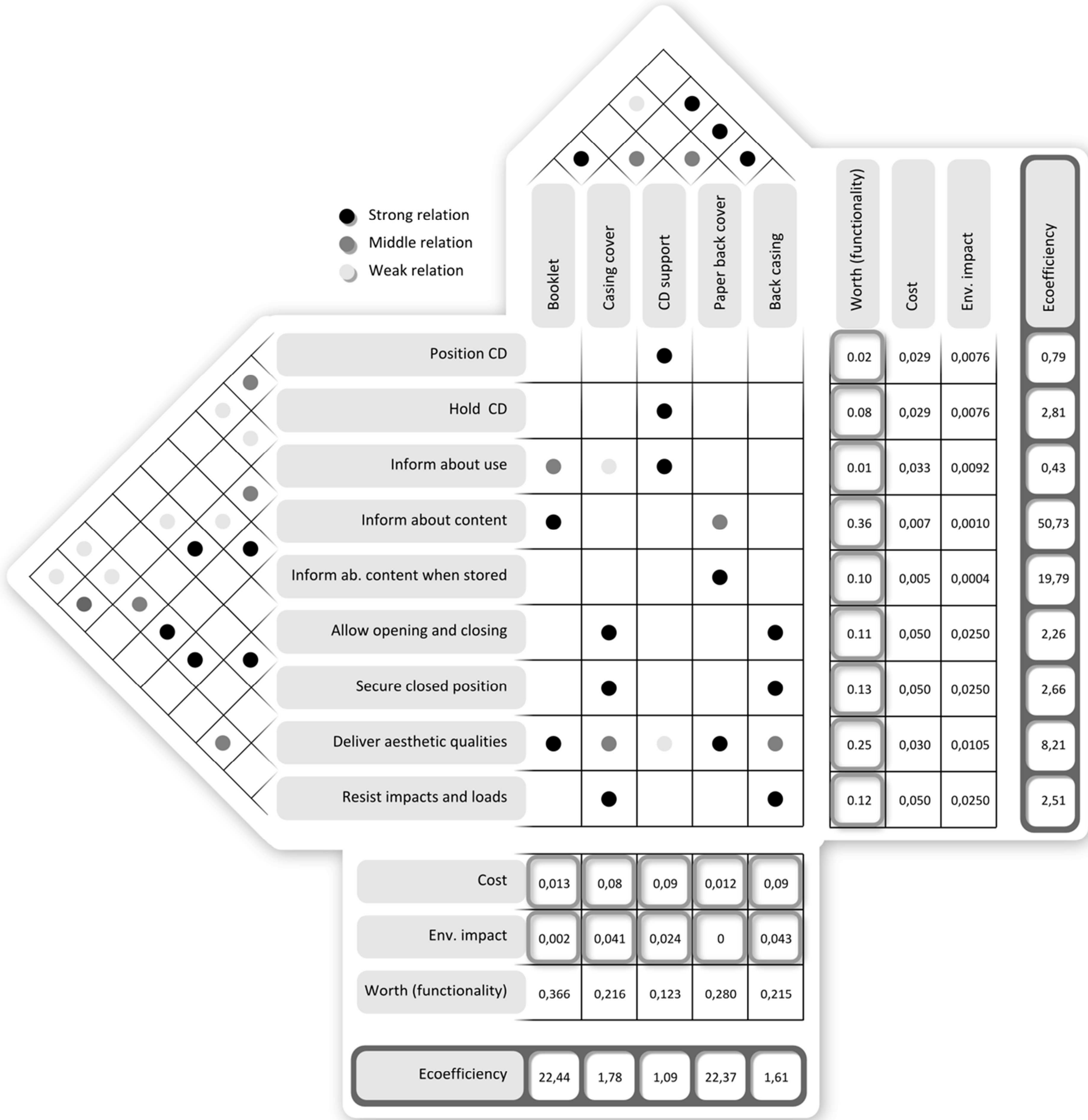
The presented method is applied to a simple CD case, model Jewel, as can be seen in Figure 4.

Figure 4: Depiction of the product and the different parts it is composed of



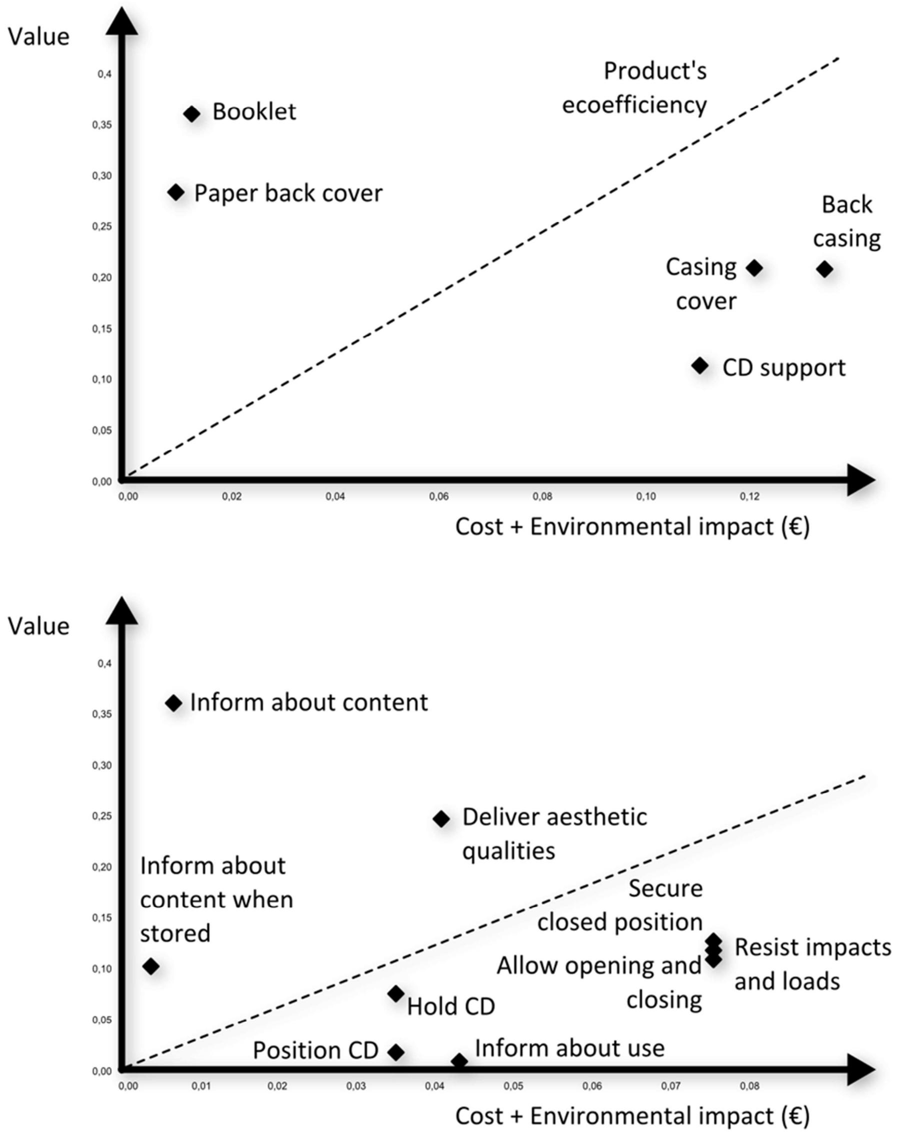
The figure shows the different materials. Injection processes assume big or mid production quantities, and 4 parts injected per mold. The environmental impacts were calculated using different databases included in software SimaPro, and the method EPS 2000. Cost were also calculated, out of estimators and material costs. The final figures are represented in Figure 5, calculations were done using Equations 1 to 3. A functional analysis was also performed, to define which functions the CD case would have. The importance of each function was calculated through Analytic Hierarchy Process (AHP), with the results shown also in Figure 5.

Figure 5: Ecoefficiency Value Analysis matrix with results for CD case



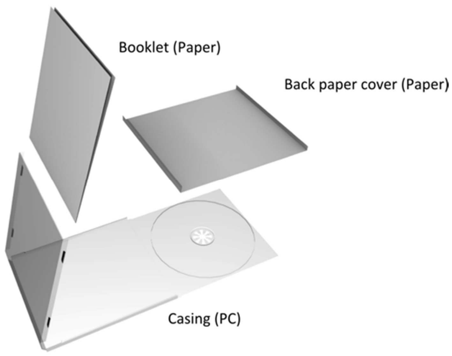
Functions and components were compared with a logarithmic scale of 1, 3 and 9 (low, mid and high relation). The results of comparing worth and cost+environmental impact are shown in Figure 6.

Figure 6: Results for Ecoefficiency of functions and systems



According to figure 6, the back casing, casing cover and CD support need redesigning, since they have low ecoefficient. Paper parts, on the contrary, seem highly ecoefficient. Regarding functions, positioning CD, informing about use, allowing opening and closing and resisting impacts and loads are the least ecoefficient, followed by securing a closed position and holding the CD. It can be seen that most of them refer to the structural part of having the CD in a particular position, since it currently requires different parts with different characteristics. The proposed improvement idea would be to unify elements in the case, creating a mono-plastic part that folds over itself, as shown in Figure 7.

Figure 7: Depiction of the redesign of the CD case.



This model would have a lesser environmental impact in the manufacturing process due to its higher simplicity. Additionally, it uses slightly less material for positioning and holding the CD in its place.

5. Discussion, conclusions and outlook

The present paper has presented the method called Ecoefficiency Value Analysis. This method integrates concepts from different approaches and disciplines preoviously partly dissociated:

1. Value Analysis, particularly the distiction of different domains and the systematic procedures.
2. The works in integrating environmental performance into Value Analysis, mainly from Oberender and Birhofer (2004), Sakao et al. (2006), Ferrer (2004) and Ajbejule (2004).
3. The concept of ecoefficiency applied to product development, mainly out of the works of Bastante-Ceca (2006) and Collado-Ruiz (2007).

It can be seen that the proposed approach is both systematic and delivers a clear output: a strategy on what parts require improvement from an ecoefficiency point of view. It also presents the advantage of being integrated seamlesly with cost analysis, so the team can swap from focusing on Value Analysis to Ecoefficiency Value Analysis without further developments.

Additionally, one of the advantages seen is the independence on assessing each one of the domains, and of each one of the required disciplines. Environmental engineers can focus on the environmental impact assessment without requiring knowledge on the rest of the process, as cost specialist can with economic figures. Designers or marketers may focus on user requirements, functions and performance independently as well. It is only at the end when the figures of each one of the teams get to be integrated, and they can serve as a starting point for the team’s discussions. This method thus has the potential of creating a common language for discussion if the company expects ot focus their strategy on ecoefficiency. It can also serve as a quick tool to integrate information that is already developed in the company. The entry barriers are seeminly smaller than for other methods with steeper learning curves.

However, this research line is far from exhausted. It is important from a research point of view to test this approach in a complex environment, such as a company. Methods in enclosed environments have more potential for working, but exposure to real-life cases is the path for further development.

As well, this method can benefit with integration to other systematic-oriented studies both from an environmental and functional point of view, such as those presented by Collado-Ruiz and Ostad-Ahmad-Ghorabi (2010). Companies envisioning their future products in this way could benefit from further focusing their results with ecoefficiency value analysis, although both approaches need to be developed in order for them to be applicable in practice.

Finally, much of the information used in the aforementioned processes is reused time after time, especially that of material costs, impacts, use patterns, or energy and resource allocation. Probably the improvement with the most potential for this method would be a way in which to manage this knowledge, so that the company benefits from those estimations and can feed back future projects out of it. Further research is needed to ensure that this potential is capitalized, since the benefits could cosniderably outweight the application of the method itself.

6.References

AENOR (Asocicación Española de Normalización y Certificación) (2000) Norma UNE EN 12973. Gestión del Valor. AENOR.

Ajbejule, A., Fernández, M. and d'Espiney, S. (2004) Approaches to environmental value analysis of productso, processes and services. Management of Environmental Quality. An International Journal, 15(2), p111-130. Emerald.

Bastante-Ceca, M.J. (2006) Propuesta metodológica para la cuantificación de la ecoeficiencia de los productos industriales a partir de la evaluación del valor funcional y de los impactso económico y ambiental. PhD thesis in the Universitat Politècnica de València.

Baumann, H., Boons, F., & Bragd, A. (2002). Mapping the green product development field: engineering, policy and business perspectives. Journal of Cleaner Production, 10(5), 409-425.

Collado-Ruiz, D. (2007) Propuesta prescriptiva para impulsar la integración del ecodiseño y el diseño para el reciclaje en el proceso de desarrollo de productos. PhD thesis by the Universitat Politènica de València.

Collado-Ruiz, D., Ostad-Ahmad-Ghorabi, H. (2010) Fuon theory: standardizing functional units for product design. Resources, Conservation and Recycling, 54 (10), p. 683-691. Elsevier.

Erzner, M., Grüner, C. and Birkhofer, H. (2001) Implementation of DFE in the daily design work - An approach derived from surveys. Proceedings of the 2001 ASME Design Engineering Technical Conference (DETC 2001). Pittsburg, September 2001.

Ferrer, P. (2004) Propuesta metodológica para la aplicación del ecodiseño mediante la integración de las consideraciones ambientales en las técnicas de desarrollo de producto, en el marco sistémico. PhD thesis in the Universitat Pôlitècnica de València.

Hur, T., Kim, I., Tamamoto, R. (2004) Measurement of green productivity and its improvement. Journal of Cleaner Production, 12 (7), p 673-683. Elsevier.

Itsubo, N, and Inaba, A. (2003) A new LCIA method: LIME has been completed. International Journal of Life Cycle Assessment, 8(5), p 305. Springer.

Karlsson, R., & Luttropp, C. (2006). Ecodesign: what’s happening? an overview of the subject area of ecodesign and of the papers in this special issue. Journal of Cleaner Production, 14(15-16), 1291-1298.

Kondoh, S., Masui, K., Hattori, M. (2006) Proposal of the index to measure total performance through product life cycle. Proceedigns of the 13th CIRP International Conference on Life Cycle Engineering. Leuven.

Lindahl, M. (2005) Engineering designer's requirements on design for environmentl methods and tools. PhD thesis in the Royal Institute of TEchnology (KTH) Industrial Engineering and Management.

Mathieux, F., Rebitzer, G., Ferrendier, S., Simon, M., & Froelich, D. (2001). Ecodesign in the European electr(on)ics industry: an analysis of the current practices based on cases studies. The Journal of Sustainable Product Design, 1(4), 233-245.

Miles, L.D. (1989) Techniques of Value Analysis and Engineering. 3rd Edition. Eleanor Miles Walker.

Mudge, A.E. (1989) Value Engineering. A systematic approach. J. Pohl Associates.

Park, T.J. and Tahara, K. (2007) Quantifying producer and consumer-based eco-efficiencies for the identification of key ecodesign issues. Journal of Cleaner Production, Elsevier.

Sakao, T., Oberender, C., Krone, N., Shimomura, Y., Borkhofer, H. and Reichl, H. (2006) Evaluating customer requirements in Eco-VA. Proceedings of the 13th CIRP International Conference on Life Cycle Engineering. Leuven, may-june 2006.

Schmidheiny, S. (1992) Changing Course. A global Buisness Perspective on Development and the Environment. World Business Council for Sustainable Development.

Silva, A.P. and Fernandez, A.A. (2006) Integrating life cycle costs analysis into the decision making process in new product development. Proceedings of the International DESIGN conference – DESIGN 2006. Dubrovnik.

Steen, B. (1999) A systematic approach to environmental strategies in product development (EPS). Verson 2000 - General System characteristics. CPM REport 1999:4.

Vidal, R. and Bovea, M.D. (2003) The customer's value in sustainable design. Proceedings of the 14th International Conference on Engineering Design. stockholm, august 2003.

Von Weizsäcker, E., Lovins, A. B., & Lovins, L. H. (1997). Factor four: Doubling wealth-halving resource use: the new report to the Club of Rome. London, UK: Earthscan.

Waage, S. (2007). Re-considering product design: a practical “road-map” for integration of sustainability issues. Journal of Cleaner Production, 15(7), 638-649.

Yamaji, K. (1999) A trial on comprehensive value judgement of insutrial product. Proceedings of Ecodesign'99: First International Syumposium on Environmentally Conscious Design and Inverse Manufacturing. Tokyo, february 1999.

Zuckerman, B. and Ackerman, F (1994) The 1994 update of the Tellus Institute Packaging Sutdy Impact AssessmentMethod. Tellus Institute.

Correspondencia (Para más información contacte con):

Dr. Daniel Collado-Ruiz
Phone: + 34 96 387 70 07 Ext. 75650 / 15652
Fax: + + 34 96 387 98 69
E-mail: daniel@collado-ruiz.es
URL: www.upv.es