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APPLICATION OF ECODESIGN METHODOLOGY IN SMEs RUN ACCORDING TO LEAN MANAGEMENT: THE CASE OF A FURNITURE PUBLISHING COMPANY

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Abstract

The aim of this paper is the adaptation of an Ecodesign methodology for product publishing SMEs that have implemented Lean Management. To obtain verification of this methodology, an eco-redesign case study of a product has been carried out from a furniture publishing SME which applies lean management to its entire production chain. Some proposed improvements resulting from this case study were: Design for dismantling, Multifunction, Dematerialisation, Increasing the material of renewable origin & Use of recycled material. The results indicate that this ecodesign proposal may be applied in a simpler procedure in companies which have already lean management criteria. Even more, lean management facilitates the development of life cycle assessment studies.

Key words: ecodesign, lean management, Life Cycle Analysis (LCA), publishing company, Small and Medium-sized Enterprise (SME), wood bases industry

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1. Introduction

The introduction of this article has been structured based on the definition of three crucial concepts which will be considered throughout the study: Ecodesign, publishing Small and Medium Enterprises (SMEs) and Lean management.

1.1. Ecodesign

Ecodesign refers to the systematic incorporation of environmental factors into product design and development (Tukker et al., 2000). Ecodesign is therefore, the design that considers actions aimed the environmental improvement of the product at all its stages, from the initial conceptual design to the end of its useful life and reprocessing (EC Directive, 2005; Karlsson and Luttropp, 2006).

According to Russo et al. (2011), ecodesign represents a challenge technicians are trying to face since the cost of products or processes has started being calculated including the total environmental cost. Moreover, the design process is oriented toward a cyclical, rather than a linear path. This cyclical consideration comprising the different stages in the life of the product: raw material extraction,

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distribution, use and disposal (AENOR, 1999), is called life cycle (Mascle and Zhao, 2008) and their analysis can be used as a tool for eco-design.

Life cycle assessment (LCA) is a suitable and valuable tool to assess the environmental impact of products and services, and should be part of the decision-making process towards sustainability (Baumann and Tillman 2004; UNE-EN ISO, 2006). Additionally, LCA provides objective and more reliable information related to the product. Finally, a series of specific alternatives to solve detected environmental problems should arise through LCA implementation.

The ISO 14062 standard was the starting point of the ecodesign (ISO/TR 14062, 2002) and several studies can be found concerning the description of this methodology and practical applications (Lewandowska and Kurczewski, 2010a; 2010b). Examples concerning the application of this methodology to different industrial sectors can be found in the packaging and packing sector (Bovea and Gallardo, 2006), the automobile sector (Muñoz et al., 2006), the leather tanning industry (Rivela et al. 2004), the furniture sector (González-García et al., 2011a; 2011b; Santolaria et al., 2011), the waste management (Todd et al., 2003) and the video/TV units (Nedermark, 1998).

1.2. Publishing SMEs

A publishing SME (EC Recommendation, 2003) is defined as an enterprise whose task is to select a design (either created by the company designers or by external designers) under pre-established criteria, comprehensively characterised and differentiated, with the objectives of producing it (usually by subcontracting a third party) and selling it. The fact that production is outsourced implies that the SME has to select a network of suppliers according to their production process, geographical location, quality and financial criteria, although not necessarily environmental criteria.

Several studies were reported concerning the application of ecodesign methodologies and only some studies can be found regarding their application to SMEs (Hernández et al., 2011; Hernández et al., 2012; Kerr, 2006; van Hemel and Cramer, 2002; Moultrie et al., 2007). Table 1 shows a comparative analysis of the strengths and weaknesses of conventional SMEs that do not outsource their production and publishing SMEs that do outsource their production. The comparative results, shown in Table 1, were obtained during the research study.

1.3. Lean Management

Lean management is based on a process management approach known as "Just in Time" (Fandel and Reese, 1991; Naylor et al., 1999). The companies that apply this management tool are those which aim to provide products or services with features that consumers value according to both quantity and quality targets and in a prefixed immediate delivery time (Gautam and Singh, 2008). Lean management considers the following principles (Cuatrecasas, 2002):

a) Products or service production with features valued by consumers. These characteristics must be clearly indicated in the product.

b) To manage processes as a whole and not as isolated operations. The activities in any process will be carried out in a chain, according to a process flow. This approach gives rise to the so-called product value chain.

c) To maintain this flow regular and constant. In this way the process is balanced.

d) To manufacture only on request (Fandel and Reese, 1991), avoiding and minimising stock.

e) To prevent waste or squandering (activity or consumption bringing no value to the product or service, for example, excessive stock or workforce time wasted due to any problem, or poor quality products).

Lean management optimises the total value chain, value understood as that which finally reaches the user or customer (Gautam and Singh, 2008); for example, the value of an office desk to provide a working surface. To achieve this, the different segments of the value chain must be analysed from the point of view of the final customer, evaluating all the potential problems**.** In this way, more streamlined, better quality and lower cost flows can be obtained with a holistic perspective, an aspect that lean management has in common with the ecodesign methodology.

Another way of ensuring the fluidity of product orders is by improving the performance of the entire process, reducing simultaneously costs related to stock and production operations (Bullinger et al., 1999). Therefore, the production of each stage will take place according to the demand of the subsequent stages, and so on to the end of the chain, where the customer makes the order.

2. Description of the study: SME (external production)

2.1. Objective

The objective of this research is to assess from an environmental perspective a publishing SME with outsourced production using suitable design criteria for its eco-design and considering lean management as the production management system. Therefore, both the methodology including the specific ecodesign requirements and the adaptation of the criteria of the lean management has been proposed. This approach attempts to evaluate all the stages of the product life cycle equally, to implement practices compatible with the environment.

The final improvements proposed and derived from this study will permit to improve market competitiveness of products and processes

(Handfield et al., 1996), and the cost-effectiveness of the ecodesign methodology (Naylor et al., 1996).

2.2 Publishing SME case study

The case study corresponds to a furniture publishing SME. In this context, the application of lean management mainly comes about through:

- Customised products for customers, based on a standard product.
- Manufacture only on request, to avoid and minimise stock.
- Local suppliers.

The company under study (Mobles 114, 2010) was founded by industrial designers with the prospective of developing products from the concept stage, carefully selecting materials and processes, while paying attention to functionality and aesthetics characteristics.

These concepts have led the company to actively participate in the study in order to incorporate environmental improvements. Moreover, significant impulses in the process have arisen not only through the company's own initiative, but also through demands from customers to fulfil environmental requirements according to environmental management systems (O'Brien, 1999), Spanish ecodesign standards (AENOR, 2003) and international environmental management standards (Guinee et al., 2001; UNE-EN ISO 14040, 2006).

Both ecodesign and lean management approaches present a series of points applicable to the different product stages. These two methodologies can therefore be subject to comparison, as illustrated in Table 2. One of the principal divergences between eco design and the lean management is that the former is cyclical and the other is essentially a linear process.A key point dealt with in this article is the existence of points in common between the two methodologies, which may facilitate the easier application of the combined methodology in small and medium-sized enterprises.

2.3. Methodology

Based on the ecodesign methodology of the United Nations Programme for the Environment (Brezet and van Hemel, 1997), the different phases of the methodology proposed will now be described. The principal adaptation was in the "Drawing up the eco briefing" (phase VI description, 2.3.6), including the principles of the the lean management system in this phase (Table 2). In order to achieve adaptation, a case study has been carried out with a specific product from a design publishing SME with outsourced production.

Table 1. Differences between own and outsourced production for SMEs. Strengths and weaknesses

Indicators	***Publishing SME (external production)***	***Conventional SME (own production)***
Own area	Small: offices only	High: offices and facilities for production and stock
Machinery	Basic: office equipment	Complex: production equipment
Energy/Water	Low consumption per product unit and contracting SME	Medium-high consumption with respect to smaller production
Waste generation related to product	Greater quantity and variety, but lower per product unit	Office and production waste
Waste management	Difficult to monitor, not all suppliers manage it	Greater control and lower total quantity
Human resources	Small: only office and publishing staff	High: office and production plant staff
Product delivery times to customer	Longer delivery times. Delocation of suppliers leads to higher complexity	Shorter delivery times. Stricter control on production
Distances covered	Various transport journeys for different components from different suppliers	Reduction of km covered before final delivery to the customer
Product quality control	Difficult to unify; each supplier applies it differently	Constant and unified, easier to apply
Incidents	Difficult to react. Contact with suppliers	Rapid reaction
Product diversity	Greater variety of products range	Specialisation and simplification of catalogue

Table 2. Points in common and divergences between ecodesign and lean management at the different product stages

Consideration of Product	***Ecodesign***	***Lean***
Extraction of raw material	Yes	No
Production process	Differentiated operations	Flow of operations, from beginning to end
Useful life	**Use and consumption of product** resources	**Value desired by the product** user
Waste generation	**Prevention and minimisation** of waste and environmental impacts	**Optimisation of operations and waste;** lower resource consumption and occupation of area
Waste management	**Identification, management and treatment**	**Identification**
Product process	**Cradle to Cradle** (McDonough and Braungart, 2002; Karlsson and Luttropp, 2006)	**Cradle to Gate** (McDonough and Braungart, 2002)
Improvements to the product	Environmental, **social** and **economic**	**Economic**, productive, delivery times and **customer perception**

Firstly, the phases of the ecodesign methodology have been considered and the principles of the lean management as a production management system have been included into these.

2.3.1. Phase I: Knowledge of the structure of the company and its operation scheme

In this phase, it is necessary to develop a map of the SME itself and all those providers contracted to carry out the production, distribution and marketing of each and every one of their products. Therefore, the different elements of the product system (and therefore, all the processes and potential problems involved) associated with the company will be established (Bonney et al., 1999; Melton, 2005). Lean management will affect the resulting map or diagram, as the company takes account of its principles. If any of the information that is needed within the SME itself cannot be obtained, it will have to be requested directly to suppliers.

2.3.2. Phase II: Selection of the multidisciplinary working team

The agents and parties involved in ecodesign tasks are usually the designer and the environmental expert (Rieradevall and Vinyets, 1999). It is also advisable to include in the working group staff from the departments of product development and technical office so they can participate in these tasks. If the SME has no experience or specialised professionals in the design field, subcontracting is recommended.

The choice of the person responsible for communication and coordination between the parties will also be very important. Therefore, it is essential for the chosen responsible to have deep knowledge of suppliers, as well as of the lean management implemented at the SME. As required by lean management, statistical data on customer preferences must also be considered.

2.3.3. Phase III: Identification of the product to be eco-redesigned and its value

In this stage, an exhaustive definition of the product to be eco-redesigned must be carried out (Gertsakis et al., 1997). The methodology is applied to a company which already designs, but does not use ecodesign criteria. According to lean management, the value/s demanded by customers will have to be identified: the meaning of value is the feature that finally reaches the user or customer (for example, the value of an office desk would be to provide a certain working area). This value, which must be permanent once the product has been eco-redesigned, aims to indicate that the feature that users consider essential must be maintained in the eco-designed product. It is also important to differentiate between two concepts: value and waste (activity or consumption that does not add value to the product) and thereby strengthen the former and discard the latter (Melton, 2005). The identification of waste will be carried out in Phase IV. Additionally, the profile of the customer the product is aimed at will have to be defined.

2.3.4. Phase IV: Making the Environmental Inventory

This phase comprises the inventory of the input/output data (material and energy flows and environmental emissions) for a given product throughout its life cycle (UNE-EN ISO 14040, 2006). The information collected must be as complete as possible; however, typically it will be dispersed among the different suppliers. At this point it is highly recommended to have the map/diagram resulting from Phase I prepared, in order to define and consider the system boundaries for data collection. At the end of this phase, the waste flow (waste defined as the activity in a product and service with no value -see Phase III-) must be identified and removed or translated into values demanded by the customer (Abdulmalek and Rajgopal, 2007; Melton, 2005).

2.3.5. Phase V: Application and results of the Life Cycle Assessment

Quantitative environmental tools offer full reliable results (UNE-EN ISO 14040, 2006). Nevertheless, the application of this type of tools is troublesome and they typically remain off the economic and human resources in the context of an SME. Therefore, the subcontracting of experts is once again advisable to carry out the quantitative analysis.

The environmental tool recommended due to the reliability of results is LCA, a technique for determining the environmental aspects and potential impacts associated with a product, service or process by compiling an inventory of the relevant input and output of the system defined (UNE-EN ISO 14040, 2006). The results of this phase will reveal the environmental problems associated with the product, making it possible to propose improvement actions.

2.3.6. Phase VI: Drawing up the ecobriefing, including the adaptation of the lean management system

This phase will be carried out based on the previous phases and the interpretation of results obtained in Phase V. The adaptation of a methodology which facilitates the communication of environmental factors among environmental experts and designers employing basic information about the product to be designed and defining the product with the environmental objectives to be achieved is defined as eco-briefing (Smith and Wyatt, 2006).

The briefing (Gilbertson, 2006) includes environmental aims that should be considered in the development of eco-design. Based on this definition, the term ‘eco-briefing’ arises, which is the practice of informing designers of the environmental goals to be achieved by means of ecodesign. The preparation of the eco-briefing should favour the creativity of the design team and guide them through the eco-redesign

process (Gertsakis et al., 1997). The alternatives which eco-briefing addresses, with the aim of improving the current environmental conditions of a product, are known as strategies of eco-design (Bhamra, 2004; Ferrao et al., 2006). Eco-design strategies analyse the technological, social and financial aspects, which will be evaluated by the participating technical team.

2.3.7. Phase VII: Proposal and choice of environmental improvement actions

The purpose of this phase is to make a series of proposals (for example, in the areas of design, selection of materials, transport, etc.) to improve the environmental impact of the product and provide a response to the ecobrief requirements. These actions will be evaluated and chosen by the SME considering their eco-efficiency; that is, the level of accomplishment from a multifactorial perspective: technical, financial, social and environmental point of views (Yao and Carlson, 2003).

Certain environmental objectives must be set for a proper conceptual development, based on which, and by means of a critical review by a panel of expert participants, the process of eco-design is started. By establishing these initial criteria, which relate to various stages of the life cycle, global environmental improvements in the new product are obtained. The ecobrief requirements from the previous phase must be fulfilled; the industrial designer will always take charge of the product design part (Lofthouse, 2004). Table 3 provides a summary in which, for each of the phases of the proposed methodology, the main contributions of the ecodesign methodology and lean management methodology can be identified.

3. Results and discussion

This section presents the results of the application of the ecodesign methodology developed by Brezet and Van Hemel (1997) at a publishing SME which has lean management implemented. Fig. 1 shows the product selected to be submitted for eco-redesign.

It is an office desk measuring 1.6x1.6 m (the most representative size from the catalogue), consisting of an aluminium structure and high pressure laminate (HPL) envelope together with a dividing panel made of a steel structure covered with polyester material. Fig. 2 describes the flow followed by the product, as required by lean management.

Fig. 1. Image of selected product in the furniture publishing SME case study

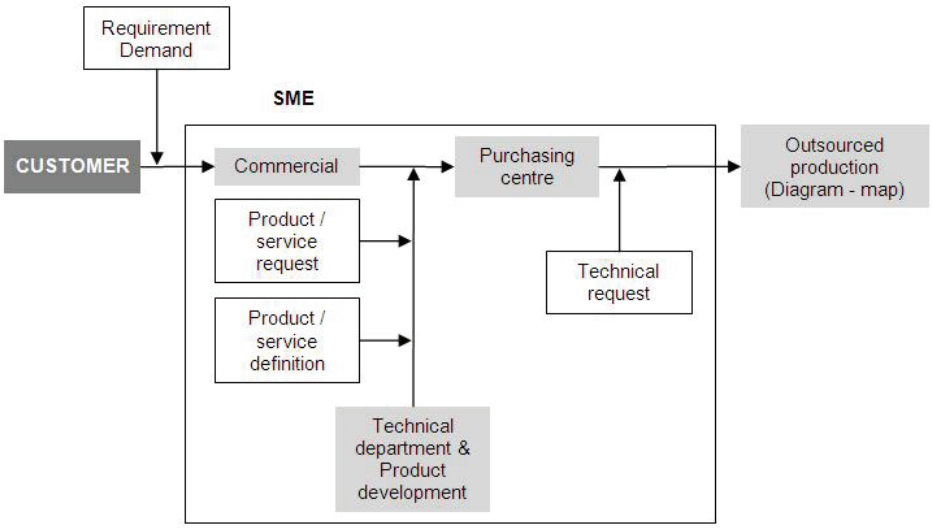

Fig. 2. Flow diagram for the product selected for the case study at the publishing SME according to lean management methodology

3.1. Phase I: Knowledge of the operation and structure of the company

According to Fig. 3, in this case study there is a diversity of suppliers from different production sectors and also from different geographical locations. In the "Transformation" and "Manipulation/Finish" stages, the participating suppliers, all of them subcontracted by the publishing SMEs, are listed. The pointed box shows the part of the system out of the scope of the LCA study (Phase V). This map/diagram is a dynamic document as it will vary depending on potential changes in suppliers. It should be highlighted that the more comprehensive information collected to complement the map/diagram, the better the result for the subsequent phases and the detection of possible concerns in the product value and environmental chains.

To draw up both diagrams, it was necessary to monitor and analyse the orders for the selected product from the sales department to the relevant suppliers, including the purchasing department.

3.2. Phase II: Selection of the multidisciplinary working team

The agents taking part and the activities assigned to them are shown in Table 4. In this case study, the agents belonging to the SME who took part, according to lean management requirements, were representing the departments of product and marketing. The working team for the methodology proposed would be:

- Inventory specialist: internal. Good knowledge of suppliers and continuous contact with them is required.
- Environmental specialist: external, with specific expertise on the application of environmental analysis tools.
- Industrial Designer: internal, preferably with environmental training. This person must know the company management system and the suppliers, as well as working together with the commissioners.
- Other members of the company: members from the departments of product and marketing, experts on supplier and customer profiles, respectively.

3.3. Phase III: Identification of the product to be eco-redesigned and its value

The customer values identified were:

- The desk is intended as equipment for facilities and offices, so the main customers would be companies and groups equipping areas of buildings requiring public or private use of desks (such as libraries, airports etc.).

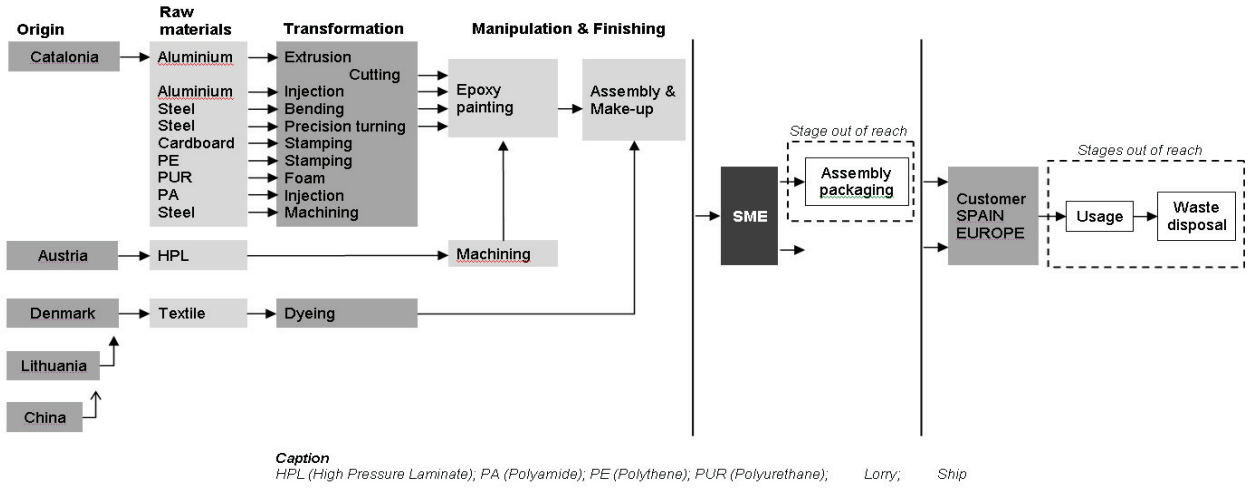

Fig. 3. Case study publishing SME map/diagram for the specific product selected (office desk with dividing panel)

Table 3. Contribution of ecodesign and lean management at the different stages of the proposed methodology

Phase	*Ecodesign*	*Lean*
I	Cradle to Gradle	Cradle to Gate (Fig. 3)
II	Staff taking part with knowledge of ecodesign.	Staff with knowledge of lean management and the user.
III	Definition of the product to be eco-redesigned	Definition of the product value most appreciated/demanded by the customer
IV	Collection of elemental data flows (inputs/outputs) of the system under study	The map/diagram and product order flow diagram help in compiling information and detecting stages with problems.
V	Application of LCA by outside expert.	Knowledge of lean management, equivalent to product knowledge
VI	Ecobrief with design, environmental, social and economic requirements.	Incorporation of lean management requirements into the ecobrief.
VII	Proposals according to ecodesign requirements. Assessment of environmental, economic and social viability.	Contribution of lean management criteria to ecodesign proposals. Assessment of viability according to lean management criteria.

Table 4. Agents involved in the case study and their assigned tasks

Agent	*Activity assigned*
SME (Person responsible for product and head of marketing)	• Furniture publishing SME with outsourced production. Company subject to the eco-redesign process • Drawing up the environmental inventory. • Application of eco-redesign.
Outside environmental experts	• Carrying out LCA. • Product selection, ecobrief, product eco-redesign proposals.

- The value or values of the desk identified as principal ones are, in order of preference: level of functionality (or effectiveness), versatility of use, compliance with standards (strength, environmental, ergonomic), easy assembly, durability, appearance and price.

3.4. Phase IV: Drawing up the Environmental Inventory

The most effort consuming step in the execution of LCA and ecodesign studies is the collection of inventory data in order to build the life cycle inventory. Moreover, high quality data is essential to make a reliable evaluation. In the case study, the limits of the system considered were from the extraction of the raw material to the delivery of the end product to the customer. The variety of suppliers with different management systems located in different places, with different production processes, different departments, human resources, etc. meant that the compilation of information was a complex task.

The low quality or low precision of some data is associated with the fact that suppliers do not exclusively dedicate their production to the publishing SME. Given the lack of direct data, in drawing up the inventory and in order to be able to reach the elemental flows, it was necessary to make some indirect calculations based on the data provided by the suppliers. Therefore, it was necessary to estimate water and energy consumption, generated waste and transport consumption per product unit. Fig. 3 shows the list of suppliers and the productive sectors they work in.

A total of 14 suppliers were asked to fill in information for the environmental inventory (most of them were also SMEs). Those that had some kind of management system implemented filled in the survey in more detail. In general, all suppliers took part and showed willingness to cooperate. Once again, the presence of lean management helps with the ecodesign methodology.

The main wastes detected in the flow, according to lean management are:

- large transport distance (e.g. suppliers from China/Lithuania/Denmark for the dividing panel fabric);
- excessive residues from raw material (e.g. in the case of the desk envelope, this is 25-30% of the raw material used);
- oversized dividing panels.

The inventory Table of the global process under assessment is shown in Table 5.

3.5. Phase V: Application and results of the Life Cycle Assessment

The results of the LCA in the case study were provided by an environmental expert. It was very important to have the map/diagram from Phase I before applying LCA, as well as the Environmental Inventory, as both help to delimit the system under study and its scope, necessary for applying LCA.

The LCA analysis was done under a "cradle to gate" perspective; that is, the product life cycle analysis was applied to the point where it is delivered to the customer. For the analysis, the characterisation factors defined by the Centre of Environmental Science at Leiden University were considered: CML 2 baseline 2000 V2.1 method (Guinee et al., 2001), using real data from the SME (Phase IV) and data from the Ecoinvent Database 2.0 (Dones et al., 2007; Hischier, 2007; Kellenberger et al., 2007; Spielmann et al., 2007) and from IDEMAT Database (2001). The impact categories analysed were: abiotic resource depletion (AD), acidification (AC), eutrophication (EP), global warming (GW), ozone layer depletion (ODP), human toxicity (HT), freshwater ecotoxicity (FE), marine ecotoxicity (ME), terrestrial ecotoxicity (TE) and formation of photochemical oxidants (PO). The results of the LCA analysis can be briefly described as follows:

- Regardless the impact category under assessment, the main environmental hot spot is associated with processes taking place in the product system corresponded to metals production with contributions near 70%, specifically extruded aluminium for the desk structure. This was followed by far by the transport stage, textile production (that is, polyester of the dividing panel cover) and packaging (Fig. 4).
- Regarding the impact associated with the parts of the final product, the structure and dividing panel accounted for the greatest impact of this product/system (Fig. 5), which is mainly due to the materials used in these parts (metal and polyester).

Table 5. Global inventory data for the production of the office desk (1.6 m x1.6 m)

Inputs from the Technosphere		*Outputs to Technosphere*	
Materials		**Products**	
Wooden materials		Table (kg)	54.85
High Pressure Laminate board (kg)	28.67	Packaging material (kg)	9.58
Metal pieces		**Waste to treatment**	
Extruded aluminium (kg)	21.59	Metal waste (kg)	0.74
Injected aluminium (kg)	0.64	Cardboard waste (kg)	0.054
Zinc – stainless steel (kg)	0.45		
Iron tubes (kg)	2.55		
Stainless steel (kg)	0.50		
Plastic pieces			
Polyamide (kg)	0.12		
Textiles			
Polyester (kg)	0.46		
Polyurethane foam (kg)	0.38		
Zipper (kg)	0.04		
Packaging materials			
Cardboard (kg)	7.05		
Polyethylene foam (kg)	0.13		
Polypropylene (kg)	0.24		
Chemicals			
Paints (kg)	0.23		
Fossil fuels			
Natural gas (m^3)	3.71		
Energy			
Electricity from grid (kWh)	21.55		
Transport			
Truck 16-32t (t·km)	93.93		
Truck 3.5-7.5t (t·km)	35.45		
Truck 7.5-16t (t·km)	0.147		
Van (t·km)	1.18		

3.6. Phase VI: Drawing up the ecobrief, including the adaptation of lean management

When drawing up the ecobrief, two new features were detected, to be included into the methodology:

- Lean management must also meet environmental requirements. This is possible thanks to the points in common detected for both methodologies.
- It is necessary to consider the waste produced according to lean management in Phase IV and the customer profile and product value in Phase III to propose improvement actions.

A clear specific example of this is the large number of kilometres covered:

- According to lean management, manufacturing is only carried out on request. Each order is sent to the publishing SME by the suppliers every time an order is made. However, according to environmental criteria, this large number of kilometres covered has a high impact and must be avoided. Therefore, it could be proposed sending an order produced each time, covering the minimum possible number of kilometres. The revision of the logistics for product delivery should be then revised to increase the efficiency of product transport and to reduce its environmental impact and costs associated.

3.7. Phase VII: Proposal and Choice of Environmental Improvement Actions

After the ecobriefing, specific improvement actions were proposed concerning the critical points detected in Phase V. Their level of viability and projection over time (short-, medium- and long-term viability) were then assessed. The following new features were established to be incorporated into the methodology:

- The consideration of viability considering compliance with the quality valued by the customer or product user, a criterion highlighted in lean management. These measures or actions referring to materials and processes must be considered a value chain from start to finish in which there are continuous flows and where waste does not exist or is avoided.
- Referring to the example already given concerning the kilometres covered, a specific action complying with economic, social and environmental viability, and also with lean management, as it minimises the time between production stages and provides a better flow in the overall product process, would be.
- Doing away with the supplier-SME transport stage and implementing direct supplier-customer transport. In this way, the quantity of kilometres covered is minimised and the operation of the product value flow marked by lean management is optimised. This

measure could be improved if there are various suppliers (carrying out the same process) at different geographical points, so that minimum distances to the customer could always be covered.

Some examples of proposed improvements resulting from this phase, which were also assessed as viable by the SME, were:

- Design for dismantling
- Multifunction
- Dematerialisation (reducing the amount of aluminium in the desk structure)
- Increasing the material of renewable origin (in the Table top and dividing panel)
- Use of recycled material

3.8. Future prospects

Some strategies to be analysed in future studies that could facilitate the proposed application of ecodesign methodology are described below:

- Chosing ecodesign strategies that are adapted to the situation of SMEs, which do not involve great investment and promote cheaper improvement actions (such as design for dismantling, use of single materials, use of recycled material etc.) as well as which do not involve great changes for suppliers or in processes.
- Designing the product as a sum of sub-components so that different combinations can meet customer requirements.
- This product concept facilitates order flows (Gautam and Singh, 2008) and reduces the participation of the technical office. This cuts out feedback in the process that halts the proper operation and linear flow of processes, affecting the company itself and outside suppliers (new design, manufacture and checking of prototypes, generation of documentation etc.). The flow is therefore continuous but segmented into two spheres with minimal interaction, as can be seen in Fig. 6.

At the initial stage of product conceptualisation, all these possible combinations must be foreseen, and the combinable sub-products perfectly defined. Promotion of a good flow of information between departments and the development of wider capabilities in the company personnel (lean management) in turn, will improve product flow. Selection of transport and suppliers depend on distance to the customer, always minimising both delivery times and environmental impacts.

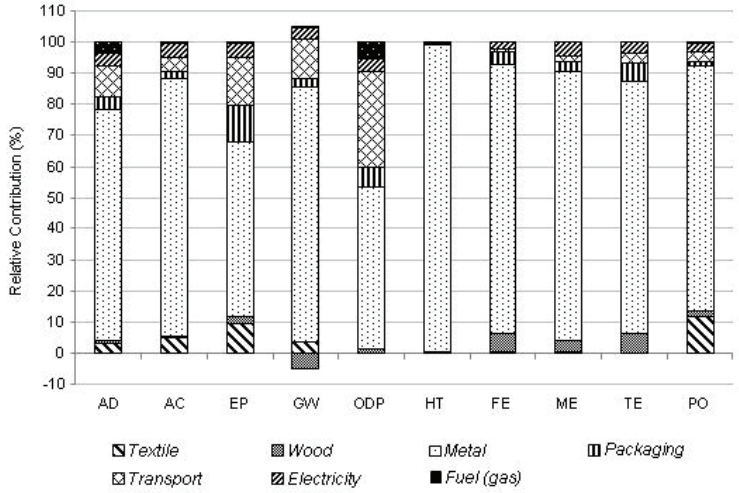

Fig. 4. LCA results: Relative contribution (%) to the different impact categories of the different processes included in the system

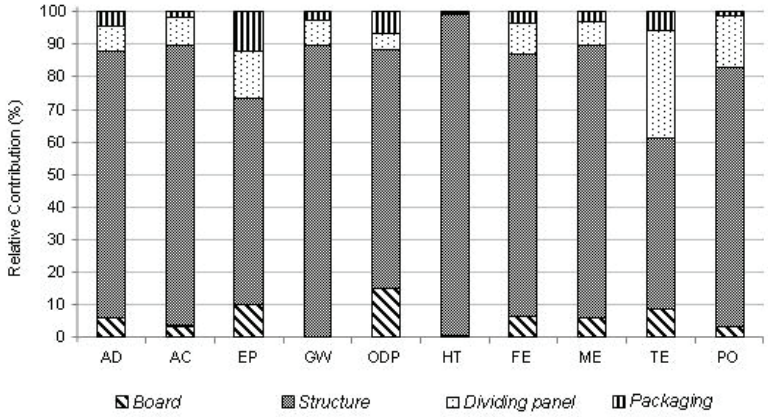

Fig. 5. LCA results: Relative contribution (%) of the different parts of the product and the packaging in the different impact categories

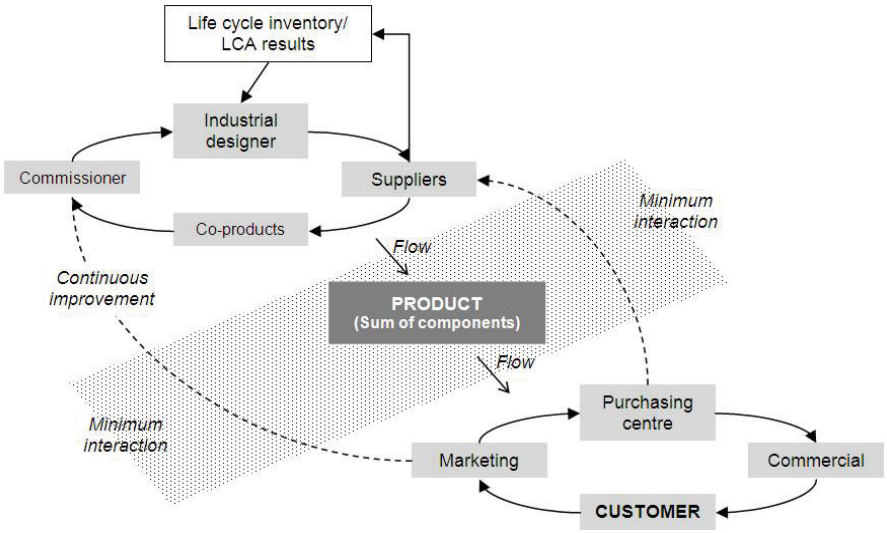

Fig. 6. Proposal for the SME's future internal organisation

4. Conclusions

The implementation of ecodesign in SMEs implies the use of a series of environmental analysis tools and the application of improvement actions for environmental prevention. If it is a publishing SME, with subcontracted or outsourced production, implementation is more complex, both at the environmental inventory phase and in the detection of the stages where the main impacts and problems exist. An advantage associated with outsourcing is the reduction in resource consumption (water and energy) and the reduction of waste, both at the publishing SME and at the suppliers, due to the optimisation involved in simultaneous production for various contracting companies.

In the case study, lean management applied at the furniture publishing SME has simplified the implementation of an adaptation of an ecodesign methodology. This facility is the result of points in common between both methodologies such as the reduction or minimisation of waste, according to lean management nomenclature, equivalent in ecodesign to environmental impacts or the use of resources.

LCA has shown to fit in easily in the context of lean management, given the need required by the management system to document and define all processes, making it easier to obtain environmental inventory data and to define the system under study. Therefore, lean management facilitates the application of LCA.

Nevertheless, the fact that the SME outsources all its production to a network of different suppliers (different structures and geographical locations, etc.) is considered to be a difficulty when it comes to applying ecodesign. Hence, special attention is paid to drawing up a meticulous study of the supplier map/diagram and the product order flow.

In the case study, it has been observed that the SME places greatest importance on requirements concerned with financial factors directly related to sales, costs – ultimately, financial viability. One way of making it easier for an SME to apply ecodesign is to translate the environmental indicators into economic language; it is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution. In the proposed methodology, as well as considering financial, environmental and social viability, included in ecodesign, viability according to lean management criteria is incorporated into the consideration.

This article therefore incorporated lean management criteria in the ecodesign strategy in order to facilitate the implementation of ecodesign at publishing companys outsourcing their production, which would also involve continuous improvement.

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