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DEVELOPMENT OF ECODESIGN INTEGRATION TRAJECTORIES : TWO SURVEYS AND LCA CASE OF STUDY WITH A POWER DISTRIBUTION PRODUCTS

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ABSTRACT
The decision for a company to adopt an ecodesign process approach raises some difficulties highlighted by many authors. Ecodesign integration strategies, particularly in the small and medium size firms (SME), are mostly intuitive and unconscious. This situation reveals the need for a tool to help the ecodesign integration. Our research focuses on the development of a trajectory model to integrate ecodesign in the SME's. This particular strategy requires a step by step process that consists of combining and distributing specific "drivers" at the correct time. The tool proposed is a combination and the progressive leading of three elementary strategies: "Methods and tools process", "organizational management process" and "company development strategy process". To achieve this, we have conducted two surveys among the experts and the companies that are the pioneers in the area of ecodesign. Also, we have done an experimentation of a trajectory model in a power distribution products manufacturer (Transfix).

Keywords: ecodesign, drivers, trajectory model, Life Cycle Assessment, power distribution transformers

1 INTRODUCTION
During the last decade, technical progress has lead to growing production and consumption. As a Consequence, we have now global environmental problems such as resource depletion. In the present environmental context, it is necessary to go toward of "mature" industrial systems that are characterized by weaker flows of mass and energy, of raised rates of recycling, etc [1]. The environmental integration is becoming an increasingly necessary step for the evolution of companies [2]. Awareness of environmental impacts, more stringent environmental regulations, and growing environmental preoccupations of consumers leads companies to integrate environmental issues into their strategies [3]. Ecodesign appears as a solution for companies to include (assume) "human sustainability priorities together with business interrelations" [4].
Brezet and Van Hamel have defined ecodesign as a sustainable solution which implies "finding the right balance between the ecological and economic requirements while developing products" [5]. Ecodesign integrates environmental considerations into the "life cycle thinking". To be more precise, this concept means minimizing the impact in terms of economy, environment, sociability, and maximize sustainability throughout all the stages of the product development process. By adopting an ecodesign approach, companies can elaborate their products while being more respectful to the environment while keeping the objectives of competitiveness, quality, and time to market.
To facilitate the integration of environmental criteria into the product development process, strategy modification and support tools and methods are needed. Since the 80's, research has focused notably on the development of numerous methods and tools of ecodesign. Actually, there is a large "range" of ecodessign tools from relatively simple check-lists or general guidelines to more complex software-methods. Among the different types of ecodesign tools, some highlight potential environmental impacts, others support a choice regarding different sustainable aspects, also some build up the green image from customer/users. A large amount of relevant papers have been published concerning the methods and tools able to set up ecodesign. Baumann and al. [6] have studied 650 articles of those papers describing ecodesign tools. Among their work, they have established that the empiric literature

does not remain representative (it represents only 10 %) and that most of them are conceptual and normative. They present some "shortcomings" such as: little practical relevance, the development of too many tools, poor linkage between strategic intent and content, too little about the large context, and little attention to system's perspectives [6]. From those defaults the appropriation of ecodesign tools by product developers remains complex. Lindhal confirms that the concrete application of the ecodesign methods and tools in industry remains indeed limited [7]. Actually, it is not only unclear if ecodesign tools are being used but also if they have any real effect on the product development process [8]. This can be the result of the lack of cooperation between the developers and users of these methods and tools [9]. Tukker and al**.** also confirm that the researchers are more active part in the development and settings of the ecodesign methods, and that industrial involvement is very poor. Those different elements mean that the integration of ecodesign tools in the product development process has not been considered adequately. Designers are confronted by problems like the choice of tools adapted to the company's context, the appropriation of these tools in their usual design methods and the competence to use the adapted tool at the right time.
In fact, the integration of methods and tools in the design process has not been up to now considered adequately [10]. Companies confronted to stronger pressures tend to adapt their policies on an ad hoc basis, without adopting a real long term strategy of environmental integration. The environment remains a "fuzzy" constraint for the services concerned by product design [11] and the approaches of integration are "fragmentary" [12]. Then, the feed-back experience of the companies having integrated ecodesign remains "anecdotal" [13]. The object of several publications was a successful practice for big companies in several sectors (Electric - Electronic, Furnishings, Automobile, Packaging, etc.) [14] [15] [16]. Still, information about big companies of other sectors and especially about small and medium enterprises (SME's), is unusual. Then, currently ecodesign plays a small role in many companies particularly in SME's. Most of these SME's do not implement ecodesign as management issues. Some SME's have implemented ecodesign in projects, but this rarely leads them to use ecodesign systematically in product development.
The state of the art reveals the necessity to place at the companies' (notably SME's) disposal a tool to help manage the integration of ecodesign.
The research that we are developing is based on what we call "models of ecodesign integration trajectories". In fact, in the launching phase, it is necessary to get organized, to manage the "drivers", to control and to improve the ecodesign integration process. This particular strategy of the ecodesign integration trajectories requires in progressing step by step, and by combining and distributing some specific drivers at the right time. The trajectory model distinguish the different elements in which SME's could make progress in integrating ecodesign: responding to market signals; involving stakeholder concerns; increasing knowledge; internal management for improvement; using tools and directly reducing visible impacts. A trajectory model is the result of a judicious selection, an adequate combination and a progressive diffusion of elements (methods, responsibility, information systems, evaluation tools, expertise, knowledge, values….).

More particularly, this article tries to answer the following questions:

- What are the necessary key resources and "drivers" to succeed?
- How to manage the different drivers of the environmental integration in a company?
- How to implement a specific trajectory of ecodesign integration in a French SME company?

In this article, we will present our research that intends to define which mechanisms are best suited to integrate ecodesign. First, we are going to present our research methodology. In the second section of this paper, we will present the empirical results of our first survey. This survey is based on 48 samples and reflects the point of view of the French ecodesign experts including consultants, researchers, institutions and associations. Our contribution talks mostly of identified parameters influencing ecodesign integration in French companies. From this survey, we have defined a first list including the companies' motivations to adopt an ecodesign approach. Then, we have identified the "drivers" which could be used to build relevant and coherent strategies of integration in SME. Afterwards, we have established a trajectory model of ecodesign integration. In the third section of this paper, we are also going to present the results of our second survey based on the first research survey. Feedback was transmitted to French companies' pioneers in the ecodesign field. In the last section of the paper, we will present the trajectory model implementation strategy in a French SME. The main goal of the project is to establishing the life cycle thinking in the company Transfix. This company develops,

manufactures and distributes a wide range of products, systems and services for power distribution. In this research, we will develop the ecodesign strategy integration used in this company. The trajectory model used is based on the progressive enrichment of ecodesign tools and the development of commercial arguments concerning environment. As part of the strategy, it was decided to do a comparative Life Cycle Assessment and implement ecodesign tools. So, first, we are going to present the results of the LCA research. An environmental single-score based on a life-cycle approach, was allocated to each studied transformer technology. Second, we are going to show the "drivers" which are mobilized in the company: internal management for improvement, increasing selling offers of environmental conscious products, improving internal functional coordination and involving stakeholder concerns. At the same time, we are going to present the metrics and elaboration methodology allowing for the sustainable awareness of the product development process in Transfix.

2 METHODOLOGY OF RESEARCH

The piloting tool must help a company to identify the most adapted trajectory of integration depending on its context. This tool will be nourished by the feed-back of the experts and the companies that are the pioneers in the area of ecodesign in France.

Our research program includes 4 stages that are essentially based on:

- Quantitative interviews of French experts,
- Quantitative interviews conducted on a large population of French and foreign companies,
- Implementation of a integration trajectory model in a SME company,
- Qualitative interviews achieved in a small number of French companies.

In this article, we will firstly present the preliminary results of our program. While basin ourselves us on a bibliographic study, we made up feedback form (Q1) intended for ecodesign experts (consultants, researchers, institutional and professional associations). The survey was tested while interviewing seven French experts. The improved form was distributed to 150 French experts. The survey's results allowed us to establish validated lists of "integration parameters" (motivations, obstacles and "drivers"). Second, we created a second questionnaire (Q2) based on the results of our first survey. This feedback has been transmitted by the French ecology and sustainable development ministry to 735 persons concerned by ecodesign. The analysis of the earliest answers made by the French companies' pioneers in this field, allows us to develop "trajectory model of integration" associating the integration parameters. To match up with the second stage, we will conduct some interviews with several representative companies concerned with the environment. Other interviews will be carried out all along the year 2007. These real integration "stories" will permit us to illustrate our model of trajectory and will nourish an integration guide intended for SMEs. At the same time as we work on this survey, we will test our process of ecodesign integration in a SME's. The aim is to confirm the aptness of the integration trajectory model which we think is adapted to the company's context. Also, the idea of this field of application is to apprehend the imperfections of our tool with the aim to improving our tool by iteration.

3 MAIN PARAMETERS OF INTEGRATION APPROVED BY RESEARCH

In this section the motivations, "drivers" and obstacles influencing ecodesign integration are presented. These parameters have been determined from a bibliographic study and confirmed by our first survey intended for the experts of ecodesign. This survey assessment is based on 48 actors contributions (32% of answers) collected in November 2005 and reflects the point of view of each of the four categories of experts: 27 consultants (56%), 12 researchers (25%), 6 institutional actors (13%) and 3 associations (6%). The majority of the experts taken into account have three major provisions of services in companies: monitoring ecodesign projects (71%), training staff (75%) and environmental evaluations of products (50%). A smaller part did some research into strategies of valorization and communication around the ecodesign approach (40%). Also, some experts followed up the distribution of ecodesign software and brought a technical support to help companies to use these tools. The monitoring of the ecodesign approach in companies was supported by experts using a large variety of tools and methods. The tools used are mainly: training tools, communication tools, environmental assessment tools, proposal tools and organizational tools. Among those tools, some were developed by experts to help companies to integrate the ecodesign approach.

We chose to evaluate our parameters on 3 levels: very important, fairly important, and slightly important. The results of out interview to a sample of seven experts permitted us to find out that the step "not important at all" was useless.
Companies have been integrating the ecodesign approach in industrialized countries since 90's. Some authors have studied companies' projects using the ecodesign approach. From this work some motivations, "drivers" and obstacles can be identified. In this section, we are going to present, with empirical results, the main parameters identified in literature and confirmed by our first survey.
First of all, we have defined the motivations like a set of factors determining how to improve the environmental performance of the enterprise. Van Hemel tests the approach taken in the ecodesign diffusion projects in 77 Netherlands SMEs. He found the top-three internal and top-three external motivations for starting up ecodesign [17]. Zutshi and Sohal studied 286 organizations in Australia and New Zealand on their experiences with environmental system management [18]. They identified a thorough list of motivations to implement EMS.
The majority of experts, all mixed categories, considered that the five main motivation factors are:

- To respect regulations pressures,
- The internal strategy of the group,
- The economic and commercial profits,
- The satisfaction of stakeholder requirements,
- The initiative of the industrial sector.

Motivations depend on the behavior of the companies. Therefore, it is necessary to make a distinction between the two categories of behavior from the companies that consider the environment. The eco-defensive behavior privileges the economic output, this considers the environment as a cost, and obeys the rules without going any further. The eco-offensive behavior is articulated around a preventive logic and voluntary commitment, the environment being considered as a key element for the enterprise.
Moreover we define "a driver" as an action that favors the integration process. The action drivers are how the catalysts act, orient and reinforce the power of diffusion of ecodesign.
Based on a large literature review, Johansson identified twenty drivers for ecodesign integration [19]. The works of a certain number of authors ([10][7][9][11][20][21][22][23]) confirm and sustain the drivers associated with the ecodesign process identified by Johansson.
In the literature, action drivers that companies are able to mobilize on ecodesign integration are multiples. According to our research positioning, results of our research will allow us to complete the list of "drivers" and to keep six categories of these factors. In the table 1 we will present the most important "drivers".

		Results of Q1		
Action drivers		**Very**	**Fairly**	**Slightly**
Related to the	**Drivers outcome of the literature**	**Importing**		
Management	To establish an explicit ecodesign policy	47.9 %	35.4 %	16.7 %
	To support the leaders	**85.4** %	14.6 %	0 %
	To define and to specify the responsibilities of actors	35.4 %	**52.1** %	10.4 %
	To elaborate an internal flux of information	33.3 %	**54.2** %	12.5 %
Relations with stakeholders	To adopt a synergy with the stakeholders	37.5 %	45.8 %	16.7 %
	To encourage external communication	25 %	47.9 %	25 %
Development process	To encourage inter - function coordination	**64.6** %	22.9 %	12.5 %
	To use, to master and to update the specific documents /standards	16.7 %	**58.3** %	25 %
	To define and to adopt adapted tools	27.1 %	**62.5** %	10.4 %
Competence	To train and to make the staff aware	**68.8** %	27.1 %	2.1 %
	To choose a dynamic ecodesign "leader"	**70.8** %	29.2 %	0 %
Motivation	To involve the team design	**68.8** %	27.1 %	4.2 %
	To involve the staff	43.8 %	45.8 %	8.3 %
Market and competition	To orientate the market toward the more respectful products	**50** %	45.8 %	4.2 %
	To differentiate from the competition	47.6 %	41.4 %	10.3 %

Table 1. Drivers of ecodesign integration

By empirical analysis, if we add the percentage who qualified "drivers" as very or fairly important, we noted that most of these proposed factors are considered as important by a majority of canvassed experts. Those drivers play a determining role for the integration of an ecodesign process. They are

likely to influence the general strategy of the company. In the launching phase, it is necessary to get organized, to manage the actions, to control and to improve the ecodesign integration process. It is essential to progress step by step. It means selecting a strategy and coordinate actions to mobilize success factors at the right moment. Consequently, it is indispensable, before to the launching process, to select eminent drivers. From another point of view we think it is necessary to guide the integration process according to the verified successful experiences. Following this logic our research's objective is to propose a model of trajectory for integrated ecodesign.

Among the most important "drivers" determined by this survey, we have determined six relevant particular strategies to support ecodesign integration. We distinguish six different elements in which our trajectory model can be based on: responding to market signals; involving stakeholder concerns; increasing knowledge; internal management for improvement; using tools and directly reducing visible impact on PDP [29].

Most authors not only studied ecodesign "drivers", but also they identified obstacles. From those works we have been able to distinguish most internal and external obstacles for ecodesign. Among these obstacles, the totality was qualified by the majority of experts as constraining. The twenty barriers were classified in the categories as follows: weakness of internal organization, economical constraints, lack of knowledge/experience, problems bound to the tools, lack of company commitment, problems in the product development process, lack of feed-back, lack of information on profits, external pressure weakness.

Ecodesign integration process has for objective to go around these obstacles. In our research, we focused on studying these obstacles because they have allowed us to stress on the difficult it will be necessary to act on before the integration process.

4 MODEL OF ECODESIGN INTEGRATION TRAJECTORY

In this section we will present one of our "models of the integration trajectories" associated to the integration parameters. The trajectory model which we are going to describe, will allow us to build the strategy of ecodesign integration in company's chosen for the case of study. The different models of trajectories have been determined from the results of our fist survey and confirmed by our second survey intended for French companies' pioneers in ecodesign. For this survey form we elected to evaluate our parameters on 5 levels: not at all important, slightly important, important, very important, and extremely important. On the same way we have opt to draw our parameters in a scale of time every 3 years since 1992. This survey assessment is based on 66 French companies contributions collected in December 2006. We will continue to distribute the questionnaire to the other French companies concerned with ecodesign. 37 SME's (number of employees: 1 to 249), 11 big companies (250 to 2500) and 18 very big companies (2500 and more) answered the internet survey form. 6.1% of the replies came from primary industry sector (agriculture and conversion of natural resources), 77.3% from secondary sector (construction and manufacturing) and 16.7% from the tertiary sector (service). These companies come from diverse industrial sectors like automobile, electronic/electric, textile, building, chemistry… 54.5 % of the companies have extended in the national market and 36.4% in the international market. 58.4 % of the companies define the environmental issue in their companies as extremely or very important compared to other strategic issues.

On the last section we distinguish six different elements in which our trajectory models can be relied on (enrichment of methods and tools, formalization of knowledge, evolution of management systems, integration of stakeholders and their requirements, operational application, development of commercial arguments). The results of the first survey confirm the relevance and importance of these strategy processes. The results of this second survey show that successful ecodesign integration is the result of a combination of different elementary strategies. Because of the above, we have defined a trajectory model as a combination for progressively leading to three processes. The three processes interact between them. The results of the survey intended for companies have helped us to develop the three following strategic processes:

- *Methods and tools process* based on the progressive enrichment of the ecodesign instruments,
- *Organizational process* based on the progressive involvement of workforces and allocation of specific responsibilities concerning environment,
- *Development strategy* process based on the progressive involvement of stakeholders and development of marketability (development of commercial arguments concerning environment).

According to Lindhal we consider that knowledge and experience is built into the methods and tools [24]. In fact, ecodesign methods and tools contribute when structured in product development, facilitates communication, promotes the knowledge of the user, supports improvement and some times also supports cooperation in teamwork. On one hand companies differ in their products, organization, culture and size. All of these differences influence the efficiency and effectiveness to using these tools. On the other hand, tools differ in complexity and structure. Among the large range of ecodesign tools, some highlight potential environmental impacts, others support a choice regarding different sustainable aspects... Also some tools provide support in trade-off situations [25], for example the ten golden rules proposed by Luttropp and Karlsson which present set design rules using guidelines and check-lists adapted to various design tasks [8], product types and persons. Moreover an eco-efficiency indicator is considered an efficient communication tool [26]. Our trajectory model proposes which are there to show which tools are most efficient for use and when they should be used during the process of ecodesign integration. The goal is developing appropriate and useful standards ecodesign tools to increase their use in the regular activities of PDP. At the beginning a company can involve simplified tools (MET matrix, checklists,…) in the early phases for more efficiency. Next the company can integrate gradually specific tools (LCA, LCC, eco-TRIZ…), thus making tools more efficient by customizing some depending on their internal needs. Results of the second survey show that 53 % of companies consider the utilization of methods and tools as a necessary factor to integrate ecodesign. Tools specified by the companies were categorized in assessment (strategic decision-making, design decision-making,…), improvement and innovation. Companies use usual ecodesign tools like LCA, standards, design for X… But for the most part, they develop customized ecodesign tools like guidelines, check-lists, internal standards…

Baumman et al. state that management and organization seem more important than tools [6]. In the same way, Boks affirm that communication and cooperation is the key to disseminate ecodesign thinking [27]. Also in literature, research show that a successful environmental management system (EMS) or a total quality system can facilitate ecodesign implementation [18]. According to literature, we noted that the performances of some factors are also keys to the process of ecodesign integration. Communications, cooperation, management, organization, creation of knowledge are the factors which can support ecodesign integration. The results of this second survey show that the following drivers were used by the majority of interviewed companies: to define ecodesign responsibilities (60.6%), to manage an internal information system (57.6%), to involve design team (78.8%), to create cross-functional teams (69.7%). Consequently, to promote a more effective ecodesign learning spiral, SMEs has to mobilize “drivers” of trajectory model as much as drivers who can support the organizational management.

Ecodesign integration in the company strategy requires involving stakeholders in the decision making. This participative strategy aims to satisfy the demands of the customers, to consulate the suppliers and partnerships, and to develop relations with the institutional services [21] [23]. It’s crucial to consider that market is a link between customer’s needs and products development. In fact, according to Luttropp and Lagerstedt, we accept as true that the goal of companies is not just to perform functional needs but also, to build up an image. Actually, label/brand/trademark has been moved into the foreground. Product is more and more a part of a life style and design (integrating ecodesign as one aspect of design). Suit must relate to more than a relational function of a product or service. The creation of market demand is more important than design and production [8]. In fact, we have noted that green communication contributes to increasing a positive market appreciation. Then, our third model axis proposes to strengthen ecodesign marketability (by integrating environmental demands in harmony with the other usual elements) and to involve stakeholders in the ecodesign approach decision making. The first objective is to progressively communicate the environmental performance. This communication can rely on systems of environmental product declaration (EPD), ecolabel… The strategic role is to transform the market towards more refined products that can also contribute to sustainable consumption and production. The majority of interviewed companies consider that the creation of market opportunities for green products (53%) and the differentiation from their competitors (53%) was very or extremely important for the implementation of their ecodesign approach. Then, in the specific case of company strategy, the second objective is also to build, increasingly, bridges and linkages with stakeholders in a way that creates synergy between the ecodesign optimizations. Furthermore, synergies in the relations are very influential on the innovation processes. Therefore, companies are dependent on collaboration and knowledge sharing within the

actors of life cycle products. The results of the second survey reveal that involvement of stakeholders is important for the majority (69.7%) of the companies surveyed.

The results of two surveys allowed us to propose a tool to help ecodesign integration based in trajectory models. Each trajectory model depends on the progressive drivers' mobilization issue from three dimensions: ecodesign methods and tools axis, organizational axis and development strategy axis. The objective being to attain the maximal point by a progressive evolution of each of three dimensions (cf. figure 1).

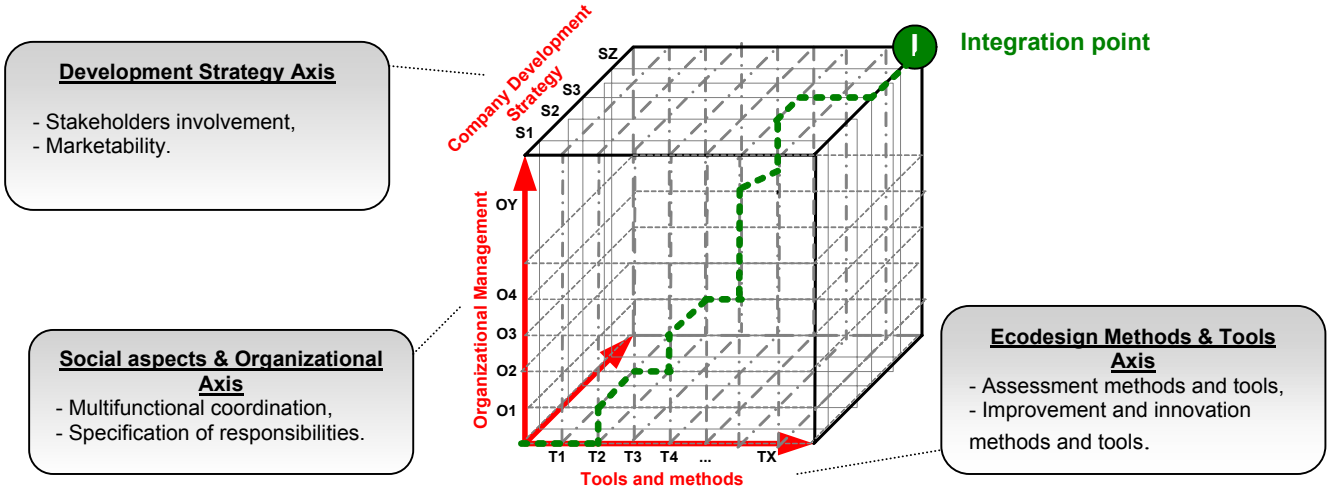


Figure 1: Trajectory model

5 CASE STUDY OF TRANSFIX

Due to the limited time allowed for this study, we chose to concentrate on only one trajectory model. Therefore, the objective of our involvement at Transfix is to validate and to enrich the trajectory model described before. The preliminary study, subject of this paper, was carried out in the course of 2006 by Supmeca in close collaboration with Transfix and its suppliers.
In this section, we will describe the methodology, framework, goal and inventory analysis of the LCA study. Next, we are going to present LCA results of comparing the systems. Finally, we will give the conclusions from the preliminary study, the methodology used to improve the product's environmental performance and the main steps to disseminate the ecodesign approach by means of a trajectory model.

5.1 Framework, goal, methodology and inventory analysis

Transfix, develops, manufactures and distributes a range of products, systems and services for power transmission. In fact, in almost every place you will find transformers (in every neighborhood, in every industry,..) and the expected life span of a transformer is about 30 years. This is why being environmentally aware seems relevant. Also, the electric and electronic industry is particularly affected by the product related environmental legislation of the EU such as the directive 2005/32/EC on the eco-design of Energy-using products and the directive 2002/96/EC relating to waste electrical and electronic equipment. Transfix is not yet concerned by this legislation, but they understand the company will have to conduct a Life Cycle Assessment (LCA) of their products and will have to integrate ecodesign. Moreover, some competitors of the company are more advanced in the environmental field. Some communicate on their ecodesign approach by means of environmental reports, Environmental Product Declaration, labeling… That's the reason why these SMEs were particularly interested in analyzing the environmental aspects of the existing products and the prospect of newly developed products. The interest of the company is to monitor the environmental impacts of their own products.
Today Transfix implements an environmental management system (EMS). In this framework the company plans to introduce an ecodesign approach in the same way as EMS. As part of an environmental life cycle management, it was decided to make a comparison with LCA.

To capitalize on the knowledge and the variety of the contacts of each, a workgroup was created, the "ecodesign committee". This committee team involved four functions of the company (R&D manager, Marketing manager, QSE manager, Substations manager) and two experts involved in ecodesign research.
An environmental single-score based on a life-cycle approach, was allocated to each of the studied transformers technologies through the use of SimaPro software and Eco-indicator 99 life cycle impact assessment method. The LCA study resulted in the comparison of two different systems for transmission and distribution, two types of power transformer posts with mechanism of cut off in the event of grid default. The allocation of a single-score determines which system is preferably to be used and to indicate how to further improve in the future. The LCA study is performed in accordance with the ISO 14040 standards. All the stages of the life cycle were analyzed. All data reflected the specific real production, distribution, installation, use, and end-of-life situation of the systems for transmission and distribution of electric power in 2006. It includes consumption of material and energy resources as well as emissions and waste generation. The systems that were studied in the LCA are described in the table 2.

	SYSTEM 1	SYSTEM 2
General description (Posts is composed by transformer and casing)	5 power transformer posts C + 1 switch and isolating equipment put on the electric line S	4 power transformer posts A + 1 power transformer posts B integrating a switch
Description of transformers	100 KVA / unit	100 KVA/ unit
Nature of post casing (package to protect transformer)	Steel	Reinforced concrete + steel
Nature of switch casing	Steel	-
Weight of posts	1420 kg/unit	A : 2750 kg/ unit; B : 3880 kg/unit

Table 2. Definition of studied systems

The functional unit has been defined as a system that can transform voltage with a power of 100KVA, taking into account the protection of the network in case of the system failing as well as protecting the technicians and the general public thanks to the reassured structures. The calculations are based upon an estimated lifetime of 30 years and an average assumed load at 40% (application within suburban areas). French energy has been used for calculating energy consumption during manufacturing and losses during use.

5.2 Life cycle results

The difference of environmental impacts for both systems is not representative. The gap is 0,25 kPt for a global impact on the environment of 7,1 kPt for system 2. Among the most considerable impacts for both systems is the use of fossil fuels, ecotoxicity and effects due to inorganic substances. This data can be explained notably by the use of copper and the processes necessary for the production of electricity.

- Production phase

The material contents of a transformer are: core steel ; transformer oil ,steel ,cooper , insulation material.
Modeling shows that copper, core steel and transformer oil are the most significant sources of pollution in the manufacturing phase.
Component assessment of both systems allowed us to show that the use of reinforced concrete for the post casing and the tub is more favorable in environmental terms rather than steel.

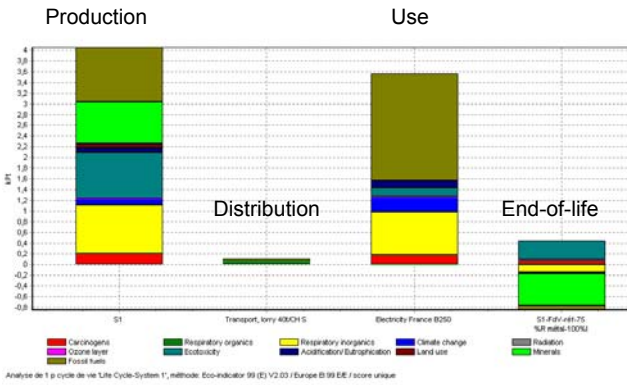
- Use phase

We noted that the use phase has the most impact during the whole life cycle. This result is explained by electric consumptions due to losses (no load losses and load losses) over period of 30 years. The global impact due to the consumption of the losses corresponds to 3,8 kilos point (KPt) against 3.4 kPt global impacts due to the production phase. (Figure 2)

- End of life phase

The reference "scenario" for the end of life considers 75% recycling of major materials (cooper, steel, and aluminum) and 100% incineration of transformer oil. The second scenario considers the recycling of 100 % of major materials and transformer oil. The third scenario takes into account the remanufacturing of some components. The comparison of three scenarios for the end of life shows that

the remanufacturing of some components is the most favorable. The transformers consist of large metals parts relatively easy to dismantle and recover. That is why the remanufacturing of parts was a solution to develop in the long term. (Figure 3)



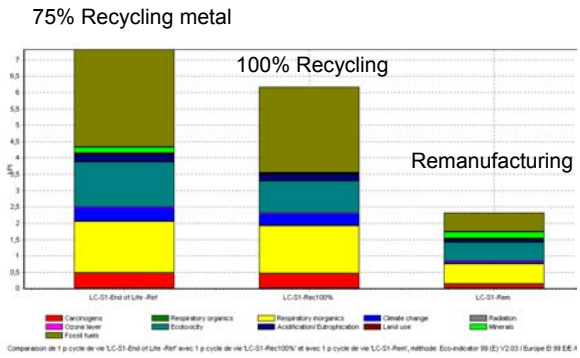


Figure 3 : End-of-Life scenarios –System 1

Figure 2 : Life cycle –System 1

The environmental impacts of the products varied according to alternative scenarios such as lifetimes, materials, processing and disposal. In this logic, various scenarios were analyzed. The results of these assessments show that the most favorable solutions are to use coils in aluminum, to reduce 30% of non load losses of electricity, and/or to modify recycling and disposal processes.
Based on these analyses, the "ecodesign committee" has generated improvement options. In the next step, they will select the most suitable improvement options and will draw up the feasibility study.
This article presents the results of the study carried out since June 2006. These analyses have allowed us to direct the study to be able to refine it afterwards. For example, according to the first results, the "ecodesign committee" decided to enrich the study by making others comparative ACVs. These LCA results are the first step to develop the ecodesign approach adapted to the context of Transfix. The next step is to redesign the power transformer post "C". Then, the "ecodesign committee" plans to carry out LCA on a new product development.

5.3 Process of ecodesign integration into Transfix

In a short while the main goal of the project is to communicate the LCA results also to Transfix customers. The long term goal is to establish in the life cycle thinking a sustainable ecodesign process in the company. Certainly has been a huge help on trajectory model of ecodesign integration proposed by our research. In this way, we have selected implement our trajectory model into Transfix. The model of trajectory has been developed to help the company to integrate sustainable ecodesign process. The objective of this trajectory is to describe a step-by-step process that combines eminent ecodesign drivers. The strategy selected by Transfix is based on the progressive enrichment of ecodesign tools, the implementation of multifunctional coordination and the development of commercial arguments concerning the environment. In fact, we use the results supported by our survey's analysis to postulate that: the use of tools, the gradual environmental communication to the stakeholders and the mobilization of drivers facilitating the organizational management play a main role in the integration of the ecodesign process in Transfix at long term.
The implementation of the ecodesign approach on which the "ecodesign committee" decided to experiment has for objective to integrate the three strategic processes defined in the trajectory model.
The first strategy is to use a number of ecodesign tools. There is a variety of tools which should help company to set up studies, assessments and improve the environmental performance of their products. All of the proposed tools will constitute the base of an ecodesign approach in Transfix. Here below are the tools that could be gradually developed and integrated in the product development process:

- Table of equivalences of environmental impacts (designer can make an environmental simplified assessment by material)
- Simplified LCA include in Transfix usual design tool,
- Guide of end of life specifications (instruction to cleanup pollution, indications facilitating the dismantling, recyclability of components..)

- List of substances with legislation constraints (hazardous substances…),
- List of recommended substances,
- Performance monitoring tool (assessment of sustainable development criteria in design by means of eight indicators),
- Guide of ecodesign.

The second strategy is to develop green marketing using different external communications and to build up opportunities for stakeholders to participate in the company ecodesign approach. Transfix labeling is an effective way of bringing transparency to the market. So the labeling strategy should re-enforce their market. In this way we will clearly define eco-efficiency, a transparent internal measurement procedure and a labeling strategy. A key objective for this strategy will be to increase the transformer eco-efficiency to communicate progressively with Transfix's stakeholders.

To complete optimization from the integration of the ecodesign process we will develop organizational management by increasing responsibilities and involving different departments. So, the Transfix ecodesign trajectory deals in the mobilization of a combination of "drivers" links to use tools, to create organizational management and to develop environmental values in the company strategy. All the drivers must be mobilized by different departments such as product development, marketing, quality-security-environment, production and purchasing.

The level of environmental integration will be measured by way of indicator defining multi-functional coordination (including environmental manager with staff from marketing and sales, purchasing, product development, production and operations, accounting and finances, public relations and legal …) [28]. Based on the results of our second survey, we confirm that the companies' pioneers in ecodesign use the majority of these functions but also others like ergonomics, suppliers, top management.... In fact, the dissemination of ecodesign thinking in the different departments of Transfix is coherent with their level of integration. We will assess the level of Transfix ecodesign integration with the aid of a questionnaire which will be forwarded to the whole staff. The same questionnaire will be forwarded in six months and in one year. The validity of this trajectory model will be according to the level of integration determined by these questionnaires. Some others indicators for measuring the integration level may be: using tools frequency, number of actors taken into account in the ecodesign approach, number of eco-products developed …We defined four levels of ecodesign integration in the company: environmental value was unconscious, environmental value was assimilate like a criteria, environmental value was considerate like a constraint, environmental value was considerate like a major company value.

In this case of study, the ecodesign committee was composed by multi-functions and it organizes once reunion for month. These reunions allow to train every department and to increase competence of the work team.

Sustainable ecodesign process is a comprehensive trajectory within Transfix's plan. In order to gain successful integration, a careful selection process and conscious implementation will be applied. This process covers a several year time period. The trajectory model clearly identifies the objectives and how they will be achieved. The starting point is to mobilize progressively selected drivers until end of 2007.

CONCLUSION

In this article we describe our research aiming at designing a tool for piloting the ecodesign integration in SME's. This tool is based on what we call "models of ecodesign integration trajectories". This particular strategy of the ecodesign integration trajectories requires a step by step progress, and that requires the combination and the distribution of some specific drivers at the right time. The trajectory models are essentially based on the feed-back of two surveys's leaded among the experts and the companies that are the pioneers in the area of ecodesign in France. The main objective of this article has been to show our program of research to dress up a trajectory model adapted at the context of Transfix.

First, the results of our survey based on 48 contributions of ecodesign experts (consultants, researchers and intuitional actors) allowed to highlight the main parameters of an ecodesign integration process (motivations, barriers and drivers). Those results revealed the main action drivers that could be mobilized for building coherent and relevant integration strategies. Among the most important "drivers" determined by this survey, we have determined six relevant strategies to support ecodesign integration. We distinguish six different elements in which the trajectory model (intended to

implement in the case of study) can be based on: responding to market signals; involving stakeholder concerns; increasing knowledge; internal management for improvement; using tools and directly reducing visible impact on PDP.
Secondly, the results of the 66 answers made by the French companies' pioneers in this field, allowed us to develop "trajectory model of integration" associating "drivers". The tool for piloting ecodesign integration that was proposed is based on three dimensions:

- *Methods and tools process* based on the progressive enrichment of the ecodesign instruments,
- *Organizational process* based on the progressive involvement of workforces and allocation of specific responsibilities concerning environment,
- *Company development strategy* process based on the progressive involvement of stakeholders and development of marketability (development of commercial arguments concerning environment).

The objective of the trajectory model is to attain the maximal point by a progressive evolution of each of three dimensions. Assisted by the trajectory models, we propose a tool for SME's allowing to pilot sustainable ecodesign integration. This tool bases itself on trajectory models was built aid of drivers, identified in feedbacks realized in companies. Every SME can become identified with one trajectory model and can engage an approach adapted to its context and to its expectations, in a perspective of long term.
Therefore, the objective of our involvement at Transfix is to implement and to enrich the trajectory model previously described. In the last section of this article, we have shown the first steps implemented in this SME's following our trajectory model. The company has started using ecodesign tools as a LCA for making-decision to improve a range of products. Afterwards the aim is to generalize use of a variety of tools which should help companies to set up studies, assessments and improve the environmental performance of their products. More recently "ecodesign committee" has developed a customized tool that allows to measure level of sustainability of products using eight indicators. The results of this tool will be communicated to the customers. In the same way, "ecodesign committee" continues to train and to involve the staff during the monthly meeting. Until august 2007, our research aim is to confirm the aptness of the integration trajectory model in Transfix. Also, the idea of this case of study is to apprehend the imperfections of our tool and to improve it by iteration.

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