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ECO-DESIGN VS ECO-INNOVATION: AN INDUSTRIAL SURVEY

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1. Introduction

The issue of eco-design integration in the design process has been the object of an in-depth research and multiple publications in the past years - see for example the CALCAS report presenting literature about Product-Oriented Environmental Management Systems – [Wuppertal Institute for Climate, Environment, Energy 2008]. The subject is not closed but it is shifting towards the transfer of eco-innovation from academia to industry. Academic works on eco-innovation more specifically deal with an economical point of view, such as the study of business model associated to eco-innovation [Boons and Lüdeke-Freund 2013], or the analysis of the eco-innovation determinant (market, technology…), according to the kind of environmental impact [Horbach et al. 2012], and a methodological and technical point of view, as the application of eco-innovation to design chemical process [Negny et al. 2012].

But do academics and industrial actors have an identical understanding of the topic? And - if one is able to define eco-innovation- is it possible to establish if companies have the means to drive it? This is the core issue of the work presented in this article.

Indeed, according to the academic viewpoint relevant terms used about *design for environment* are multiple. A literature review shows that the authors use "eco-design", "Design for Environment (DfE)", "environmentally friendly design", "green product", "sustainable product" to describe product features which are sometimes similar, sometimes different. On this base it seems difficult to clearly define the meaning of eco-innovation and of its difference with eco-design.

For the European normative approach eco-innovation is essentially defined as a sum of actions guided in the perspective of environmental impacts reduction [ISO 14006 2011]. On the other hand, the research works dealing with eco-innovation propose a most global vision of the sustainability - aiming not only to reduce environmental impacts but also social impacts - which induces a change of the functionalities required to the new product and consequently a change of its business model [Carrillo-Hermosilla et al. 2010].

In parallel to the normative and academic viewpoints, the industrial integration of eco-design in various sectors from industry worldwide has been documented for two decades. Surveys and analyses conducted demonstrate the progression of the design for environment approaches in the industrial practices, even though much more might be done to improve this integration [Bey et al. 2013], [Deutz et al. 2013]. However the word *eco-innovation* is more and more frequently used by companies to characterize their new products. Nevertheless it can be difficult to appreciate how they differentiate an eco-innovative product from an eco-designed product. Beyond this semantic interrogation the question is raised on the specific features of an eco-innovative project in terms of objectives, means and associated tools. Recent industrial surveys investigate the industrial linkage between innovation and eco-design [Santolaria et al. 2011], [Bocken et al. 2014]. Yet, both studies are based on responses of

innovation-driven companies [Santolaria et al. 2011] or eco-innovative SMEs [Bocken et al. 2014] but do not consider the perspectives of companies already engaging eco-design approaches.
As a common and clear definition of the perimeter and object of eco-innovation projects could difficultly be extracted from the academic and normative approaches, it is proposed to examine the industrial practices and reflections on the subject. The authors conducted a qualitative survey with several French enterprises already involved in eco-design in order to answer the following research question: *What is the perception of eco-innovation by French enterprises already involved in eco-design?*
Section 2 first proposes some definitions of eco-design and eco-innovation from the existing literature to identify whether clear definitions may be extracted. Section 3 is dedicated to the survey methodology. The results obtained through the survey are exposed and commented in Section 4. Section 4 aims at discussing the results, while some concluding remarks and perspectives are finally given in Section 5.

2. Eco-design and eco-innovation

This section clarifies the eco-innovation concepts and its differences with eco-design, and proposes to conclude on an academic position on eco-innovation. These concepts are then put into perspective with the industrial vision of a panel of French companies.
Eco-design is a well-established concept and the most accepted definition is the ISO 14006:2011 one [ISO 14006:2011] that defines eco-design as follows: *"integration of environmental aspects into product design and development, with the aim of reducing adverse environmental impacts throughout a product's life cycle."* The European Commission gives the same definition but nevertheless underlines some differences with DfE methodologies only which focus on single life cycle stage [Kemp and Pearson 2007]. One can observe than in this definition environmental criteria are of the same level than technical feasibility, cost or quality criteria.
Eco-innovation may reveal quite a similar definition than eco-design. Fussler and James [1996] defined eco-innovation as a new product, process or service, development (NPD) process that provides significant environmental performances. The European Commission in 2007 augmented this definition introducing the term "innovation" instead of NPD [European Commission 2007]. This position is developed in the definition given by OECD which is *"eco-innovation can be understood and analyzed according to its targets (the main focus), its mechanisms (methods for introducing changes in the target) and its impacts (the effects on environmental conditions)"*. The OECD [2009] viewpoint underlines a more holistic understanding of eco-innovation as an enterprise practice, which integrates an array of characteristics ranging from modifications to innovation across products, processes, organizations and institutions.
Academic position reveals the same heterogeneity about the definition of eco-innovation. The concept remains ill-understood with many theoretical uncertainties [Andersen 2008]. Tyl [2011] stated that *"contrary to eco-design, eco-innovation does not have a standardized and 'referenced' definition […], which results in the use of heterogeneous denomination, such as eco-innovation, green innovation, environmental innovation, or innovative eco-design and sustainable innovation"*. Carrillo-Hermosilla et al. [2010] provided an inventory of 16 definitions related to eco-innovation and sustainable innovation. These different definitions show divergent viewpoints about eco-innovation: (1) Regarding the intensity of the eco-innovation, some authors consider that eco-innovation must be radical and others explain that an eco-innovation may as well be incremental. This last vision is shared by Cluzel [2012] in the case of complex systems with a limited ability to innovate. (2) Some authors discuss the intention of the innovation, in their perspective the environmental performance has to be motivated. (3) The last point of divergence is the possible integration of the social aspect in the scope of the eco-innovation. Indeed, several definitions consider social aspects. As an example, O'Hare [2010] considers eco-innovation as an extension of eco-design into the early stages of innovation. In Charter and Chick's [1997] model, eco-innovation appears to be situated on a higher level than eco-design. Through this model, eco-design is associated to a more incremental improvement whereas eco-innovation is more radical. Given these different works, the boundaries seem to differ according to the type of product or company's sector.

To conclude the normative as well as the research approaches show an identical difficulty to clarify the similarities and differences between eco-design and eco-innovation. It thus seems difficult to draw a clear boundary between these two concepts.

3. Method: construction of the industrial survey

This empirical survey is part of a research project on eco-innovation practices funded by the French network EcoSD (Ecodesign of Sustainable Systems). A survey was conducted during 2013 (may to july) with industrial or industry-linked French organizations from various sectors. These were selected among the industrial partners of the network on a volunteering initiative. Table 1 below gives an overview of these organizations with their industrial sector and their business type. Names of the companies are not given because of confidentiality.
12 French organizations were involved through semi-structured in–depth interviews. From the 12 organizations, 18 persons were met (from one to three persons per organization) during one to one and a half hour in average. All surveyed organizations have at least a recent experience in eco-design, while most of them have more than ten years' experience.

Table 1. Overview of the 12 interviewed French organizations

Company name	Industrial sector	Type	Business
A	Urban mobility	Industry	BtoB
B	Building	Industry	BtoB
C	Energy	Industrial association	BtoB/BtoC
D	Energy	Industry	BtoB
E	Metal industry	Industry	BtoB
F	Automotive	Industry	BtoC
G	Automotive	Industry	BtoB
H	Environmental management	Consultancy	NA
I	Environmental management	Consultancy	NA
J	Environmental management	Consultancy	NA
K	Postal sector	Industry	BtoB
L	Furnishing	Technological center	BtoB/BtoC

Organizations are mainly large companies (up to 260,000 employees), but also small consultancies with less than ten employees. The organizations that are not companies are C an L (see Table 1). C is an industrial association of companies in the energy sector, representing at once SMEs and large companies, and L, a technological center with 350 employees. This panel was chosen in order to reflect multiple viewpoints in the French industry.
Starting from the main research question proposed in Section 1, the purpose of these interviews was to answer the following derived questions:

- *How is eco-innovation perceived and defined in reference to eco-design by French industrial practitioners?*
- *What are the expected outcomes of eco-innovation?*
- *Has the company/organization already experienced eco-innovation projects?*

Semi-directed interviews were conducted thanks to guidelines with closed and opened questions, which were audio-recorded. Data collection deals with the following topics:

- Eco-design vs. eco-innovation: definitions, differences and maturity in the company
- Innovation process and organization in the company
- Sustainable and environmental considerations in projects
- Eco-design, eco-innovation or innovation tools used in the company
- Experience feedbacks concerning eco-design, eco-innovation or innovation projects

A first version of the interview guide was tested with pilot companies. The interviews were conducted and transcribed. Transcriptions were then validated by the interviewees. Each audio recording and

transcription was finally analyzed independently by two researchers to identify outstanding items related to eco-innovation topics. A last phase of clustering was operated by a third researcher.
Transcriptions from organizations A to F were particularly examined as they gave the most accurate and exploitable results. Figure 1 below presents the positioning of these companies according to their size (number of employees) and their years of experience in eco-design: they are large companies from 1,000 to 260,000 employees with at least 15 years' experience in eco-design. Next part of the paper focuses on these 6 organizations answers to the three questions raised in this section.

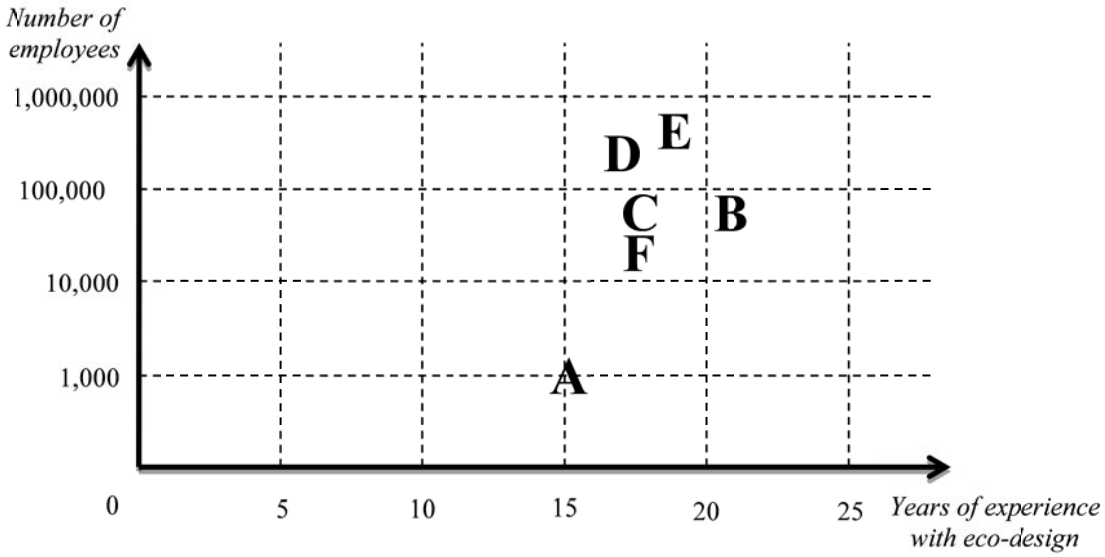

Figure 1. Positioning of the 6 organizations particularly examined in this paper

4. Results: Industrial viewpoints on eco-innovation

The aim of the sub-section is to present the key notions on eco-innovation emphasized by the surveyed industrial practitioners. Each respondent was asked to define eco-innovation in reference to eco-design. This characterization is done in a qualitative and narrative way in coherence with the investigation mode, i.e. in-depth interviews with a small sample of enterprises. The research approach was to cluster verbatim into meaningful polarities or topics.

4.1 Defining eco-innovation, its motivations and its goals

The word *eco-innovation* made its appearance while eco-design was gaining momentum in industries. The approach and objectives of eco-design are therefore more explicitly present than those of eco-innovation. Eco-design has become a reference framework to define eco-innovation through the goals to achieve, the expected outcomes and the obstacles to its implementation.
Eco-design is often characterized as a practice of regulatory compliance by surveyed organizations (respondents C, J, K, F). Consultant I adds that eco-design simply meets customers' needs "as usual", but with a reduced environmental impacts. Eco-design is also perceived a *"vector of eco-innovation"* (companies B - building and E - metal industry). For company C (energy), eco-design is defined as the integration of environmental aspects on a classical design process at a product level, whereas eco-innovation is perceived as the use and the transposition of existing technologies or products for innovative applications. This last point is shared with company F (automotive).
For most respondents, eco-innovation is "innovation-driven", that is an innovation oriented by the environmental dimension. As pointed out by company E (metal industry): *"Eco-innovation is an innovation driven by the need to decrease environmental impacts. It potentially results from an eco-design process"*. However, the opposite vision is also expressed, the eco-innovation process alternatively being *"an eco-design process with a specific upstream creativity stage"* (company A - urban mobility, and D - energy). The two different visions are presented in Figure 2: environmental

criteria are added to a traditional innovation process in the first viewpoint (on the left), while creative stimulation mechanisms are additional inputs to the eco-design process in the second vision (on the right).

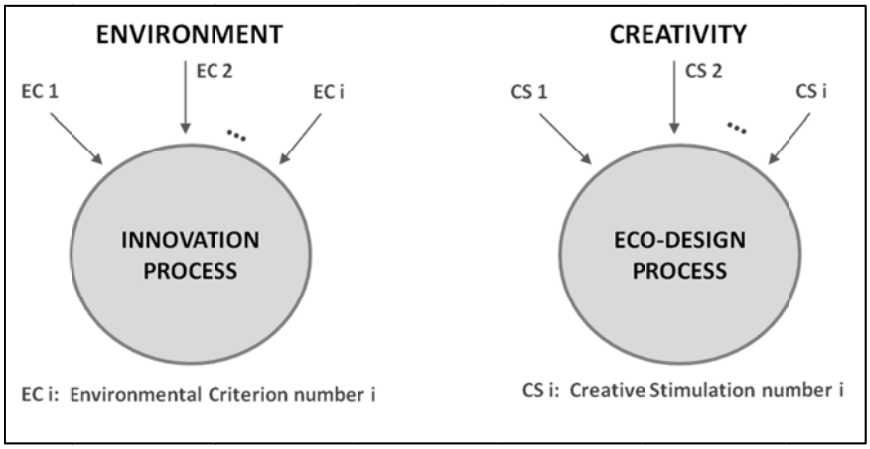

Figure 2. Industrial representations of the eco-innovation process

Compared to eco-design, eco-innovation takes into account environmental criteria in early stage of the innovation process (company G, automotive sector). It is also wider than a traditional eco-design process in the sense that it relies on the three pillars of sustainable development (company A, urban mobility). It is also interesting to stress the perceived relationship of eco-innovation to the design space: "*Eco-innovation broadens the design space through the environmental dimension, which allows value creation*" (consultant I).

In company A (urban mobility), an eco-design expert accompanies projects teams on their request. This expert (1) contributes to the methodologies of functional analysis and eco-design; (2) informs projects teams about the regulatory requirements that have to consider; (3) strives to achieve the inclusion of environmental aspects in the creative steps of the design process. In this company, although projects are never initiated by an environmental brief, environmental aspects are integrated in the form of constraints (regulatory) or opportunity (considered as a favorable aspect by the customer). Company D (energy) has recently developed a more pro-active approach through eco-design to go beyond legislation, and to sell cleaner solutions than the competitors. The objective is to have a more strategic view, through an earlier integration of environmental criteria in the design process.

In a broad sense, industrial eco-innovation goals can be defined in reference to eco-design and to factors related to traditional innovation: "*Eco-innovation goes beyond regulations and standard requirements. It aims at meeting increasing client expectations and at positioning ahead of competitors*" (consultant J).

These first results show the real difficulty to identify a consensual eco-innovation definition from the industrial point of view. Goals for eco-design and eco-innovation are not really distinguished. Companies aim at developing responses to particular triggers that may bring them serendipitously to eco-innovation. These triggers are developed in the next sentences.

This part of the interviews firstly deals with the events and requirements which motivate enterprises to develop an innovative and sustainable design approach. The main points are the following: crises; standardization, regulation and anticipation, Corporate Social Responsibility (CSR), competitiveness, clients' expectations and health of the consumer.

Energetic and economic crises - From the early 70's, economic crises have been forcing companies (in particular energy-intensive companies such E) to reduce costs. A first step towards cleaner production was taken (cut in process costs, resources optimization, reuse of waste) followed by product design (material reduction). Nowadays strategies are somehow different for some companies. For it seems impossible to replace all existing products, the objective is to "rethink" the current solutions beyond the product towards new ways of usage.

Standardization – Through norms in constant and rapid evolution, companies are encouraged to justify the environmental footprints of their products and services, and hence to print an evolution on designs.
Current regulations and anticipation of future regulations – Regulations are not yet affecting all sectors of activity. The most cited regulations through the interviews are RoHS [European Commission 2011] and REACH [European Commission 2006] directives. Regulations also develop in a sense of an increased pressure on enterprises. Notably there is a development of regulations about communication of environmental impacts to the consumer. In order to deal with this requirement, companies have to implement an eco-design approach to gain knowledge on impacts of components and products. They may consequently have to redesign some of their products. Also, there is a recognized industrial need to know whether new substances (in replacement of banned ones) might not be forbidden in a very near future. That is why anticipation approaches are conducted (company D, energy).
Corporate Social Responsibility (CSR) – Shareholders and rating agencies also encourage sustainable development approaches. This might be done through CSR requirements (company B, building sector).
Competitiveness – Since it is more and more frequently evaluated by clients and emphasized by competitors, the environmental performance has become a key challenge for companies. The motivation to keep up with competitors can be twofold: either become a leader or follow the evolution of markets. The first objective requires heading towards deeper and deeper environmental commitments, whereas the second one implies to implement an eco-design approach (or an environmental "catch up").
Pressure of clients – More and more clients insist on getting environmental data related to products, for example in the building sector (company B). On top of this kind of information, others call for environmental approaches in order to anticipate the evolution of normative and regulatory requirements. Lastly, some clients have to specify environmental criteria in response to call for tenders. Depending on the level of the input demand, the response is either an eco-design or an eco-innovation approach.
Health of consumers – Some substances may be harmful or even toxic for consumers in the use phase of products. Such kinds of emissions have to be measured in order to be handled, reduced or suppressed through the investigation of alternative solutions. This concerns for instance company F (automotive).
In summary, it can be noticed that:

- Although eco-innovation does not benefit from a normative framework (as eco-design does), there is a shared position among surveyed industrials to define eco-innovation as an innovation affected at least by the environmental dimension.
- Expressed goals of eco-innovation are in line with acknowledged eco-design goals, although emphasizing the influence of CSR and health of consumers. Moreover, the normative and regulatory insights are clearly put forward by respondents regarding eco-innovation.

4.2 Expected outcomes of eco-innovation

Eco-innovation arguably goes beyond expected outcomes of eco-design. Although it may lead to the development of brand new technologies, it is more likely to foster innovations in usage of products and development of new services (companies A - urban mobility and C - energy).
As the company offers combined products and services, it brings new systems to the market which may also influence the consumer behavior. But currently this kind of "social innovation" is only a consequence, and not an objective described in the initial brief of the innovative project (company A - urban mobility).
Moreover, where a radical technical shift is difficult to implement, it seems easier to create new services on the basis of existing technologies. To this extent, eco-innovation has two main objectives: designing new technologies and revising or combining existing technologies in particular to develop new services. A typical example concerns smart grids, which consists in using existing sensor technologies to measure the electric consumption of a working space (company C - energy).

For companies B (building) and D (energy), the search for eco-innovation is not related to a single product, but rather to a set of parameterized and adaptable solutions. The design process relies on the upstream development of new technologies of material substitution, which are disseminated into several solutions in later stages. For instance, company B considers that eco-innovation deals more with building components and systems, to be then integrated in the whole building in a "classical" optimization process. There is a clear willingness to switch from specific environmental solutions to more integrated ones.
In summary, surveyed companies seem to envisage the relationship of eco-innovation outcomes to technology in two different ways: (1) develop new technologies to disseminate into a portfolio of several solutions; (2) revise or combine existing technologies to develop new usage scenarios, services or business models.

4.3 Implementation of eco-innovation projects, processes and tools

Responses to the question *"Has the company/organization already experienced eco-innovation projects?"* reveal two types of approaches to the effective implementation of eco-innovation.
For the first category of companies, no real eco-innovation process was observed. So called innovative programs may conduct to eco-innovation, however, they are essentially driven by the need to be compliant with regulations (companies D – energy, F – automotive). These projects are thus conducted with traditional innovation tools. Other companies assume not to perform eco-innovation (company B – building).
Finally, only company A (urban mobility) stated the existence of eco-innovative programs. Traditionally, such programs are launched to overcome technical issues involving more or less environmental aspects. Nevertheless, the development process is still unreproducible since it highly depends on the project manager. So eco-innovation cannot be considered as fully integrated in the company.
Only few elements were given by the interviewees concerning the implementation of eco-innovation practices, processes and tools. For instance no particular eco-innovation tool (see next section) was mentioned. These results are discussed in the next section.

5. Discussion of the survey results

As mentioned in Section 2, it is hard to draw clear boundaries between eco-design and eco-innovation from an academic or normative point of view. And the industrial survey related in this paper shows that this ambiguity is more than ever valid inside the interviewed companies, which all have a strong experience of eco-design. At first sight one could presume that these companies should have a clearer positioning than companies not involved in such environmental or sustainable design approaches. But the survey shows that their understanding of eco-innovation is varied and sometimes confused according to the different opinions expressed in the interviews. This may be highly related to the limited sample size and the lack of organizations' maturity concerning eco-design practices. Consequently the authors highlight the absence of standardized eco-innovation process in these companies. These two statements finally show that no particular reflections have been conducted by companies concerning eco-innovation, although eco-design is (more or less) already well integrated in the design processes. If eco-design is at the same time a large research field and a common industrial approach, eco-innovation process and strategy are not a so mature subject and mainly concern the research side. However the authors do not consider that it is due to a lack of interest from industry, but as an emerging approach, eco-innovation still needs to be precisely defined. In comparison with the classical innovation process the scope of the initial brief should be deliberately opened to new functionalities like social impacts of the future product. Such an objective implies a holistic approach of the customers' needs and consequently stronger companies sustainable positioning that in eco-design projects. In parallel innovation management is always a difficult and risked exercise for the companies and fortunately sometimes a very benefic approach for them. Need to identify these new benefits and create solutions that satisfy both the technical, economic, environmental, and social objectives are therefore a challenge for companies with a higher level of risk. As processes in large

companies are generally difficult to modify, one remaining question is how to successfully and durably implement eco-innovation on the basis of existing design and innovation processes.
By analyzing in detail the perception of eco-design versus eco-innovation, the latter is seen as the answer to a specific issue containing more or less environmental dimension, as substance or material substitution due to new regulation for example. Moreover, the "eco" dimension in "eco-innovation" essentially relates to the activation of an eco-design process. Indeed, the most often cited tools used for eco-innovation refer to the eco-design area and more specifically to Life Cycle Assessment and environmental accounting tools. On the other hand, few innovation tools were cited. All of them are creativity-centered and not perceived as being able to cover specifically the environmental dimension. So, none of the eco-innovation tools such as the Eco-design strategy wheel" [Brezet and Van Hemel 1997], "EcoASIT" [Tyl 2011], "Information/Inspiration" [Lofthouse 2001] or "the Eco-functional matrix" [Lagerstedt 2003] for example, appeared in the survey. This point is also stated by Bocken et al. [2014], who analyzed eco-innovation in several Dutch SMEs. This statement raises some questions about eco-innovation tools dissemination, the panel's maturity level concerning eco-innovation issue or the applicability of such tools in large companies with well-defined processes. Existing eco-innovation tools do not seem to be the best entry point to implement eco-innovation.
This observation may also be explained through the manner to handle the environmental issue. Indeed, as mentioned in [Deutz 2013], the environmental aspects are settled as design criteria in the eco-design process. In an eco-innovative project they must be recognized as a functional requirement taken into account at the beginning of the ideation step. This condition is essential to define a design space of eco innovative solutions. If environment is not just a design criteria but a functional requirement in eco-innovation, a crucial point rarely treated by existing tools and methods is the evaluation of this environmental potential upstream from the design process, i.e. in the ideation step. Answering this issue could be a good entry point towards a better integration of eco-innovation processes in companies.
Even so, several studies have shown the importance to consider the environment as an initial brief [Deutz 2013], or at least to include the environment as soon as possible in the innovation process [Sherwin and Bhamra 2001], in order to build consciously high performance eco-innovation product or services. That is why eco-ideation tools also seem essential but they probably need to be rethought or improved to obtain a better alignment with preexisting industrial processes and practices.
It is interesting to draw a parallel between our study and the survey of [Santoloria et al. 2011], as they intend to *"verify the perception of innovation driven companies about sustainability and eco-design"*. We identify the legislative adjustment as one of the powerful driver to eco-innovation for interviewed large companies just as in [Santoloria et al. 2011]. But our survey also pinpoints two additional drivers, namely CSR and health of consumers. Moreover, comparing to [Santoloria et al. 2011] which define eco-innovation as a hybridization of innovation and eco-design where the technology plays an important role, we observe trends much more balanced between technological and services eco-innovation where services are based on existing technologies.
However two sources of limitation to the survey have to be reported.

- What is the influence of the sample choice and size on results?

The reduced sample of companies and their profile (i.e. their experience in eco-design) do not allow drawing any general conclusions on the perception and implementation of eco-innovation in industry, but indicate some valuable tendencies. Despite this drawback, this means of investigation (i.e. in-depth interviews) remains appropriate to obtain detailed responses to 'How' and 'Why' questions, as opposed to extensive methods through mailed questionnaires for instance. This sample should be extended in future work. A stronger alignment of the responses than the one obtained could therefore be expected. Our assumption is that the absence of a normative common ground in eco-innovation favors a broad and diverse understanding of the subject. Moreover, eco-innovation strategies may vary depending on the type of company, should it be mainly process, product or service-focused [Santoloria et al. 2011].

- Was the construct of the survey questions efficient to investigate the difference of perception between eco-design and eco-innovation?

It is assumed that the term "eco-innovation" might have encountered a limited understanding by the subjects as it is a new concept. Therefore it could have been approached using a general definition at

the start, or alternative descriptions. Consequently, a larger questionnaire, built on terms that characterize but do not explicitly use the definition "eco-innovation" could be future approach, hence more suitable to the topic.
It is also assumed that the technical background of respondents potentially influences the content of the responses. Due to their position in the company, interviewees do not necessarily have a broad view on the eco-design process and more especially on the elaboration of the design briefs. A more focused and interesting question would therefore be: *"Does your company introduce sustainable issues in design briefs?"*

6. Conclusion and future work

This paper aimed at defining the features and goals of eco-innovative projects compared to eco-design projects in industry. The literature review revealed that both academic and normative approaches have difficulties establishing sharp boundaries between eco-design and eco-innovation. In order to gain understanding on industrial viewpoint about eco-innovation practice, a survey with 12 French industrial organizations with an acknowledged expertise in eco-design was conducted. Results of the survey confirm the ambiguity perceived by industrial practitioners between the two approaches. The difficulty for industrials to identify an example of an eco-innovative product is an evidence of it. As eco-innovation still is an emerging topic, it does not seem to be supported by any structured process. Nevertheless, products or eco-innovative systems are sometimes created but this eco-innovation seems to be most often the result of taking into account economic and environmental constraints. Although numerous methods and tools are developed in academic work, a crucial question that appears is the transfer of this academic research in design to industrial practices.
Currently, the following perspectives for future work are envisaged:

- Extension of the questionnaire to a larger sample of industrial respondents through an improved questioning script.
- Development of requirements for eco-innovation tools, since the existing tools are not proved to be suitable for industrial practitioners. More precisely instead of developing eco-innovation or eco-ideation tools, this survey raised the question to develop appropriate stimulation mechanisms to be integrated into the eco-design process.
- Development and test of an efficient method to evaluate the environmental potential of an eco-innovation outcome from the ideation step. This is assumed to foster the implementation of eco-innovation processes in industry.

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