INTERNATIONAL DESIGN CONFERENCE - DESIGN 2012
Dubrovnik - Croatia, May 21 - 24, 2012.

IDENTIFICATION AND SELECTION OF ECO-INNOVATIVE R&D PROJECTS IN COMPLEX SYSTEMS INDUSTRIES

F. Cluzel, B. Yannou, D. Millet and Y. Leroy

Keywords: eco-design, eco-innovation, complex industrials system, R&D project portfolio, creativity, eco-design strategy wheel

1. Introduction

Environmental concerns become more and more important as the awareness of human activities impact towards environment increases. It results for companies in a need to answer to new environmental requirements and regulations. In this perspective, eco-design permits to consider, manage and improve the environmental performance of products, processes and services.
However if this approach is now recognized and well deployed in competitive mass-consumer goods producers (B-to-C), the situation is not so advanced in B-to-B industries, in particular for complex industrial systems. They are characterized by a very long and uncertain life cycle, a high number of subsystems and components or strong interactions with their environment. The technological and regulatory constraints associated with these systems may slow down the ability to innovate, as reliable and long-term proven technologies are often favoured. Nevertheless the need for eco-innovation is clearly present, as these systems are often associated with strong environmental impacts.
However to eco-innovate on complex industrial systems is a hard task. R&D projects in complex systems industries are often driven by technological and not environmental considerations. These project need to be identified really early in the design process, with few information. On the other hand everybody agrees that environmental-oriented R&D projects are necessary, but the product complexity makes the initiation of an eco-innovation approach tricky. Furthermore only few R&D decision-makers are trained in eco-design or Life Cycle Assessment (LCA) and know how to manage eco-innovation. That is why a simple and effective eco-innovation method is necessary, with little necessary preliminary environmental knowledge and stimulating the collaboration.
Thus we propose in this paper such an intuitive eco-innovation process. It permits to identify at a strategic level and with limited time and resources eco-innovative R&D projects through a multidisciplinary working group. The eco-design strategy wheel [Brezet 1997] is used at the eco-ideation stage to comprehend the whole system and share environmental strategies with non-experts people. It is also used to assess the environmental performance of the projects in an original way. Other dimensions like feasibility and customers' value are also qualitatively considered to position the project and select a powerful eco-innovative portfolio with a multicriteria view. The competence levels of the working group members allow weighting their individual evaluations of each project to obtain reliable results. In this way the top management of the company is able to select a pertinent and well-balanced set of eco-innovative R&D projects that will be performed in the next months or years.
The whole eco-innovation process is deployed at Alstom Grid on complex electrical substations. It is further validated according to its ability to generate R&D ideas in terms of their quantity, quality, variety and novelty.
Section 2 presents a literature study about eco-innovation on the one hand and R&D projects

evaluation and selection for complex industrial systems on the other hand. It permits to introduce the adapted eco-ideation process in section 3. Section 4 deals with the application of this process at Alstom Grid. Finally, some concluding remarks and perspectives are presented in section 5.

2. How to eco-innovate in complex systems industries?

2.1 Complex industrial systems in eco-design

This paper focuses on complex industrial and technological systems whose specificities have not really been taken into account in eco-design and eco-innovation: these are industrial systems where complexity induces major issues in terms of modelling, prediction or configuration. Adding an environmental dimension to the classical definition of an engineered system, we define a complex industrial system in the sense of eco-design as:

- A large-scale system in terms of subsystems and components, mass and resource usage,
- A system whose life cycle is hardly predictable at the design level in the long-term, in particular its lifetime, upgrades, maintenance and end-of-life,
- A system whose subsystems may have different life cycles and different obsolescence times,
- A system in close interaction with its environment (super system, geographic site…),
- A system supervised by human decisions and management.

Concerning eco-innovation, the main problem of such systems is that the clients' specifications or the regulations and standards largely limit the ability to radically innovate, as only long-term proven technologies are used. Thus the challenge associated to an eco-innovation approach is whether to identify a set of reliable incremental eco-innovative projects, and/or to be able to make possible radical eco-innovations acceptable to the clients.

To deploy an adapted eco-innovation approach, a literature review is first performed on eco-innovation and R&D projects portfolio management. It permits to identify the limits associated to the current practices and to select the most efficient methods for complex industrial systems.

2.2 Eco-innovation

2.2.1 Definition

Eco-innovation has been associated with numerous definitions during the last years. Carrillo-Hermosilla et al. lists for example 16 definitions [Carrillo-Hermosilla 2010]. Taking them into account, the authors propose their own: an eco-innovation is *"an innovation that improves environmental performance, in line with the idea that the reduction in environmental impacts (whether intentional or not) is the main distinguishing feature of eco-innovation"*. This includes in particular radical and incremental innovations. Considering the hierarchical nature of complex industrial systems, as well as the fact that radical changes are often hardly acceptable for clients in complex systems industries, we consider that the eco-innovation framework defined by Carrillo-Hermosilla et al. is well adapted to complex industrial systems.

An eco-innovation approach implies two major activities: the identification of eco-innovative ideas (or eco-ideation), and the evaluation and selection of the most promising ideas. These two fields are explored in the next paragraphs.

2.2.2 Eco-ideation

Bocken et al. shows that eco-ideation has not been widely explored and proposes to separately study ideation and eco-design [Bocken 2011]. However, different tools have been designed to support an eco-innovation process. The most known are explained with some details in the next paragraph.

Concerning the eco-ideation process in itself, experts groups are largely used through creativity sessions [Bocken 2011]. Researches performed in the last decade have identified some best practices to perform an effective creativity session in eco-innovation. Collado-Ruiz and Ostad-Ahmad-Ghorabi advise to diffuse only 'soft' environmental information to the group because 'hard' environmental information may restrict the creativity [Collado-Ruiz 2010]. Pujari shows that the multidisciplinarity

in the working group is an eco-innovation success factor [Pujari 2006].
Finally, eco-ideation processes in companies are often performed as classical creativity sessions supported by an eco-innovation tool. These tools are studied in the next paragraph.

2.2.3 Eco-innovation tools

Different eco-innovation tools are well known or regularly used in the literature. We distinguish in this paper two main types: simple tools allowing guiding the creativity process like the eco-design strategy wheel, and TRIZ-based tools that are more focused on the ideation process.
The eco-design strategy wheel (also known as the LiDS wheel) [Brezet 1997] is a very simple tool that proposes eco-design guidelines divided in 8 axes on a graphic wheel. 7 axes cover the whole life cycle of the product, whereas the last one aims at identifying new concepts. According to Tyl, its appropriation is really easy. It does not imply specific knowledge and the graphic representation is very clear. It is ideal for a multidisciplinary working group in a company. But as a simple tool, the eco-design strategy wheel may become simplistic, and the pre-defined guidelines hardly allow going further than product-level considerations [Tyl 2011].
Concerning TRIZ-based tools for eco-innovation, several examples exist in the literature, like EcoASIT proposed by Tyl [Tyl 2011]. TRIZ is known as a really effective ideation tool, but it is also perceived as a complex approach. Tyl also states that the initial TRIZ innovative principles do not really fit the eco-innovation principles and need to be reworked [Tyl 2011].
These tools are able to support an eco-ideation process. However they do not ensure an effective and multicriteria evaluation and selection step of the most promising ideas. The next section considers general methods in the field of R&D projects portfolio evaluation and selection.

2.3 Evaluation and selection of R&D projects

2.3.1 Overview of the methods

Once eco-innovation projects have been generated, it is then necessary to identify the best mix of R&D projects to perform. Actually the number of projects selected by a working group may be too high compared to the available resources in the company.
This issue deals with the field of R&D projects evaluation and selection and R&D portfolio management. Cooper et al. proposes a classification of the portfolio management techniques [Cooper 1999]: financial models, strategic approaches, scoring models and checklists, analytical hierarchy approaches, behavioural approaches and mapping approaches. Cooper et al. also states that mathematical models are not really deployed in companies, because they need a large amount of precise data and they are hard to manage. Another interesting point highlighted by Bitman and Sharif [Bitman 2008] is that the methods only based on financial aspects do not give the best results. The relevance of a hybrid approach is also emphasized by Cooper et al. [Cooper 1999].
Finally, Cooper et al. shows that a good method should allow to identify the right number of projects, to avoid gridlocks, to highlight high values projects, to ensure a balanced portfolio (for instance long term versus short term), and to be aligned with the company strategy [Cooper 1999].
Among all the methods, scoring models and mapping approaches are very popular, mainly because they are easy to use and give good performance results [Cooper 1999]. We focus in the two next sections on these models.

2.3.2 Scoring models

The scoring models are simple, direct, effective and flexible [Bitman 2008]. They show a good ratio between rigor and time spent on the study. Projects are rated and scored according to several qualitative or quantitative indicators. The weighting of the criteria permits to customize the model for special needs [Cooper 1999].
One of the main forces of a scoring model is its ability to be easily implemented in companies. Actually, and contrarily to mathematical or financial models, the use of qualitative scales allows a large diffusion of the tools, for example through an Excel sheet or even a paper questionnaire.
However, the success of a scoring approach is clearly linked to the selection of sound variables and

indicators [Mikkola 2001]. References from the existing literature often propose some categories to consider. However environmental aspects are sometimes mentioned, but never analyzed in depth.

2.3.3 Mapping approaches

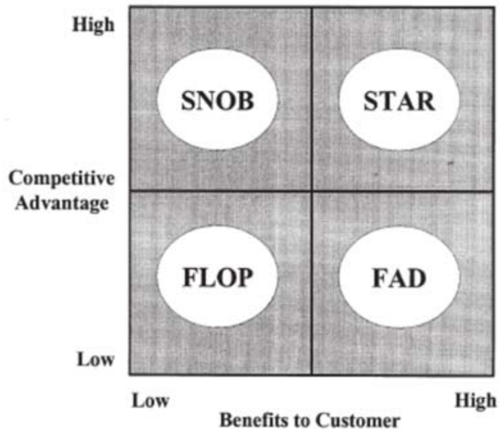

Figure 1. The R&D Project portfolio matrix [Mikkola 2001]

Historically the BCG (Boston Consulting Group) and the McKinsey matrices are the most familiar mapping approaches [Mikkola 2001]. Highlighting the particular needs for R&D projects selection, Mikkola introduces the R&D Project Portfolio Matrix [Mikkola 2001]. Two dimensions are considered: competitive advantage and benefits to client. The positioning of the candidate R&D projects (see Figure 1) permits to define four quadrants: FLOP projects are unlikely to generate positive returns and should be removed; SNOB projects often characterize first generation innovations; FAD projects often characterize imitation or mass production of existing products; Finally STAR projects characterize successful breakthrough innovations.

Mikkola clearly states that a balanced R&D project portfolio should include of course STARs, but also SNOBs and FADs, and in some cases FLOPs [Mikkola 2001].

Nevertheless if the two dimensions do not seem adapted to our needs, we notice that this representation type involving two (or more) dimensions may be powerful.

But as for scoring models, eco-innovation aspects, or more generally environmental concerns have not really been considered in the past. One single example is proposed by Millet et al. [Millet 2009]. Three dimensions are considered: technico-economic feasibility, functional attractiveness (clients' values), and environmental impacts through an Environmental Improvement Rate (EIR). The latter is represented thanks to bubbles whose size is proportional to the EIR value.

2.4 Requirements for an adapted eco-innovation process

Considering the constraints associated to complex industrial systems as well as the previous literature review, an adapted and effective eco-innovation process needs to:

- Consider the different system levels, as incremental innovations are easier at a component or subsystem level, and radical innovations easier at a system level;
- Be very simple, as multidisciplinary knowledge is mandatory to consider all the aspects of such a large scale system, i.e. the process mainly involves non-environmental experts;
- Be performed in a short time and with limited resources, to be easily accepted by the management and the involved experts,
- Be very efficient, to reach the best possible ratio between used resources and results;
- Build a strong basis for future eco-design works, to maximize the success rate of the identified R&D projects;
- Be multicriteria, by considering technical, financial and marketing aspects, to be accepted;
- Provide strong proofs in terms of feasibility and interest for the clients, to be successful on the markets.

Considering these requirements, it does not seem possible to give to a working group an in-depth training, whether it concerns eco-design or creativity tools. For this reason we do not consider TRIZ-based tools. The ideal tool to assist creativity should give predefined stimuli based on checklists or guidelines. That is why we consider and adopt the eco-design strategy wheel in the next section.
However this tool does not propose any post-processing filter treatment of the ideas, i.e. any process to follow up the group work to evaluate and select the most promising ideas. The R&D projects associated with complex industrial systems may be long-term studies. It is thus essential to ensure a multicriteria assessment of each project, even if it is mainly based on qualitative evaluations. A multidisciplinary group appears as the best solution to obtain a complete knowledge of the system.
Consequently we propose in the next section an adapted eco-innovation process for complex industrial system, based on a multidisciplinary working group, supported by the eco-design strategy wheel and using a hybrid scoring/mapping model for R&D projects evaluation and selection.

3. Proposition of an adapted methodology for complex industrial systems

3.1 Prerequisites and general approach

The eco-innovation process for complex industrial systems presented is this paper is part of a larger methodology described in [Cluzel 2012]. It is built on the following hypothesis:

- The eco-innovation is deployed in a company providing complex industrial systems (as defined in section 2.1), but with no specific knowledge in eco-design/eco-innovation,
- The approach is supported by at least one eco-design expert leading the process,
- A primary environmental evaluation (Life Cycle Assessment or simplified LCA) of the considered complex technological system has permitted to identify the most impacting elements of the complete system life cycle,

Considering that the global vision of a complex industrial system is necessarily shared by several persons with different knowledge, the main departments of the company need to be represented.
The objective of the eco-innovation process is to identify a set of pertinent environmental improvement projects (incremental or radical eco-innovations) ready to be assessed by the decision-makers. Once the working group has been defined, the eco-innovation consists in two main steps: eco-ideation, and eco-innovation R&D projects evaluation and selection, detailed in the next sections.

3.2 Generation of eco-innovative projects

The eco-ideation phase is divided in three sessions, supported by the eco-design strategy wheel.
The first session is called *'introduction session'*. As the members of the working group are for most of them not familiar with environmental concerns and eco-design principles, it aims at introducing during a short meeting (1 to 2 hours) the main eco-design concepts, the previous environmental assessments as well as the eco-innovation approach. As stated in [Collado-Ruiz 2010], the diffusion of 'soft' environmental information is favoured.
The second session is called *'creativity session'* and may be performed as a half-day meeting. A short introduction is first necessary to remind the objectives and the scope of the study and to put the participants in good creativity conditions. Then a divergent creativity phase is launched. During this phase, only environmental considerations are taken into account (technical, economic or clients' aspects are voluntary omitted). Each of the 8 axes of the eco-design strategy wheel is separately considered during a short workshop (15 to 30 minutes) in a two-step approach:

- A brainwriting phase, where each participant individually generates a maximal number of ideas in accordance with the considered axis using Post-it® papers,
- Followed by a common brainstorming, where all ideas are read and grouped. The participants are encouraged to orally propose new ideas. All the ideas are stuck on pre-defined supports.

The divergent phase is followed by a convergent phase, where all ideas are discussed and sorted out. Technical, economic or clients' aspects are now considered. This phase aims at identifying a first set of promising ideas or ideas groups which are from now called eco-innovative projects.
These projects are synthesized in standardized sheets that include a description of the project, its

objectives, its potential environmental benefits, and its technical and economic feasibility. Of course this information is not well known at this step, so only qualitative or estimated data are available. The standardized sheets are then deepened during a few weeks by sharing them out between the working group members according to their own competencies.
The last session is called *'synthesis session'*. It consists in a discussion on each eco-innovative project in order to clarify the different design aspects and to ensure that a common vision emerges.
At that point, a first set of promising projects has been identified. But they are generally too numerous to be all considered as R&D projects. Thus the last step concerns the prioritization of the projects.

3.3 Prioritization of eco-innovative projects

The objective of this step is to evaluate and select a portfolio of eco-innovative R&D projects. It has been previously shown that scoring and mapping models are well adapted to our requirements. We propose in this paragraph an assessment grid based on five dimensions, assimilated to a simple scoring model without any prioritization of the projects. We consider that these five dimensions allow a good perception of the performance of an eco-innovative project inside and outside the company. Each dimension is measured by one or several indicators, as a two-level structure is preferable [Bitman 2008]:

- **Potential environmental benefits:** the environmental benefits of the project are compared to the environmental performance of the existing solution thanks to the eight axes of eco-design strategy wheel [Brezet 1997] on a six-level qualitative scale (0 to 5, see Table 1). A final score on 20 points is then calculated (average score on the eight axes).
- **Feasibility** explores both the technical and the economic feasibility thanks to 4 indicators resulting from an expert debate at Alstom Grid: ease of implementation (in terms of time and resources), financial return of investment, technical feasibility (in terms of knowledge), and internal level of control (is the company able to internally manage the entire project or not?). Each indicator is assessed thanks to a six-level qualitative scale (0 to 5) that permits to obtain a final feasibility on 20 points (sum of the four scores).
- **Clients' value:** this dimension assesses the benefits for the clients associated with each project. It uses 4 indicators proposed in [Kondoh 2006]: cost reduction, avoidance of risks, improvement of service quality, and improvement of image. As previously each indicator is assessed thanks to a six-level comparative and qualitative scale (0 to 5) that permits to obtain a final clients' value on 20 points (sum of the four scores).
- **Time horizon:** this fourth dimension gives information concerning the term of the studies associated to each project, which is often considered as important to get a balanced project portfolio [Cooper 1999]. It simply consists in a four-level textual indicator: short term, middle term, long term, prospective (i.e. at a very long term and with high uncertainties).
- **Project perimeter:** this last dimension concerns the system level considered in each project. It also consists in a four-level textual indicator inspired by Carrillo-Hermosilla's typology [Carrillo-Hermosilla 2010]: component, subsystem, system, super system.

Moreover for each project we have added an expertise indicator that expresses the self-assessment of a user expertise on each project, with four possible levels (from non-expert to expert).
The four first dimensions are formalized in an evaluation sheet, and each member of the working group evaluates each eco-innovative project. By weighting each evaluation with the member's level of expertise, we give more value to the assessments performed by an expert rather than by a non-expert. Finally an average score is obtained on the five dimensions and for each project.
The last dimension (project perimeter) is not assessed as we assume that each project is clearly linked to one level without ambiguity. This information is simply given to the decision-makers.
We then use a mapping model to draw an overview of the performance of the eco-innovative projects. The most powerful graph involves potential environmental benefits, feasibility and clients' value on a 'bubble diagram', but other graphs are possible to consider the five dimensions. By defining different quadrants inspired by [Mikkola 2001], we give to the decision-makers the ability to identify a powerful and pertinent set of eco-innovative projects according to their available resources.

Table 1. Qualitative scale used to measure potential environmental benefits on each eco-design strategy wheel axis. The scales used for the other dimensions are based on the same principle

Score	Description
0	The project highly deteriorates the environmental performance of the current solution.
1	The project significantly deteriorates the environmental performance of the current solution.
2	The project does not bring any benefit or damage compared to the current solution.
3	The benefits brought by the considered project are weak.
4	The benefits brought by the considered project are significant.
5	The benefits brought by the considered project are very important.

3.4 Validation criteria

The validation of such a process is not easy, because it involves subjective and qualitative elements. We consider in this paper the four criteria proposed by Shah et al. [Shah 2003], who combines *variety* and *novelty* with *quantity* and *quality*. We associate the following indicators with those criteria:

- ***Novelty:*** two questions are added in the assessment grid: 1) Do you think that this project already exist before the eco-innovation approach in the mind of one or several persons in the company, in a subliminal way? 2) Do you think that this project would have emerged, been formalized and seriously considered by the decision-makers without this process?
- ***Variety*** considers the balance between short/middle/long term and prospective projects, the balance between component/subsystem/system/super system related projects, and the balance of the nature of the projects (technological, organisational or methodological projects).
- ***Quantity*** is assessed by the total number of ideas generated during the divergent creativity phase and the total number of eco-innovative projects proposed after the convergent phase. The time spent on the different phases of the eco-innovation process is also considered.
- ***Quality*** is assessed thanks to the three dimensions: potential environmental benefits, feasibility and clients' value.

These four criteria permit to assess the global performance of the eco-innovation process proposed in this paper. In the next section, we propose a case study performed at Alstom Grid.

4. Case study: Application at Alstom Grid

4.1 AC/DC conversion substations for the aluminium industry

Alstom Grid PEM (Power Electronics Massy) designs, assembles and sells substations for the electrolysis of aluminium worldwide. These are large electrical stations designed to convert energy from the high voltage network to energy usable for aluminium electrolysis, which is a particularly environmentally impacting and energy-consuming activity. A substation represents thousands of tons of power electronics components and transformers, costing tens of millions of Euros.

These substations are considered to be complex industrial systems because the number of subsystems and components is considerable, and the lifetime of a substation is really long, up to 35 or 40 years with high uncertainties. Furthermore the substation is only a part of the aluminium plant. Their processes are closely connected. Finally no standard design exists: the substation is tailor-made for each client, even though the general design is often the same.

In this context, Alstom Grid PEM wishes to minimise the environmental impacts of its products. A first global Life Cycle Assessment has been performed on an entire substation [Cluzel 2012]. This LCA is the basis for the eco-innovation process described in the next parts.

4.2 Eco-innovation process deployment

A working group was built with complementary knowledge of a substation, including two persons from the R&D department, one from the Engineering department, one from the Commercial department, two from the R&D department of another Alstom Grid unit providing the transformers, and one academic eco-design expert. The animation was managed by one junior eco-design expert assisted by one eco-design trainee, who were not proposing ideas during the creativity session. So the eco-innovation process involved 9 persons. The whole process lasted about 10 weeks (see Figure 2).

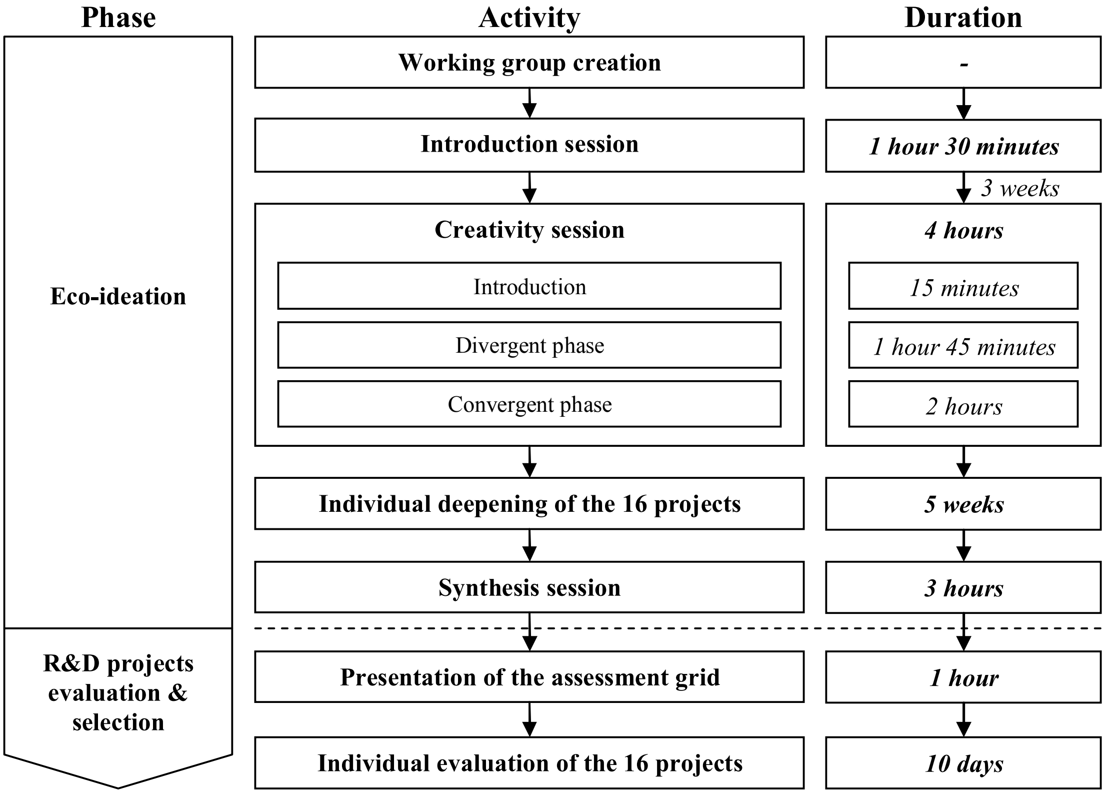

Figure 2. Time line of the eco-innovation process at Alstom Grid PEM

After the creativity session, 16 eco-innovative projects were selected and assessed by the working group thanks to the assessment grid presented in section 3.3.
The next part presents the results obtained according to the four validation criteria.

4.3 Results and discussion

4.3.1 Quantity

109 ideas were generated during the creativity sessions. Each axis of the eco-design strategy wheel provided between 10 and 23% of theses ideas. Each active member of the working group proposed between 8 and 35 ideas. Relatively to the time spent in the divergent session (1 hour and 45 minutes), it is really satisfactory. After the convergent session, 16 eco-innovative projects were identified.

4.3.2 Variety

Considering the 16 eco-innovative projects, 2 of them were judged to deal with short-term studies (less than 6 months), 9 with middle-term studies (6 months to 2 years), 3 with long-term studies (more than 2 years). For two projects no consensus was found (in particular one was judged between long-term and prospective, i.e. more than 5 years with high uncertainties).
Concerning the project perimeter, one project concerns a component, whereas 5 projects deals with the subsystem level. 9 projects involve the whole system, and only one the super system.
Finally, concerning project nature, 8 projects concern methodological aspects, 12 projects include technological considerations, and 2 projects organisational aspects (a hybrid nature is possible).
These results are considered as really satisfactory, as the portfolio including the 16 projects is well balanced on the three criteria. All categories are represented. A consensus is almost always found for the ‘time horizon’ criteria, which was the only one evaluated by the working group.

4.3.3 Novelty

5 projects were judged by the majority of the working as being already present in the mind of one or several persons in the company (but not formalized), whereas one project was judged as not being present. It was not possible to find a consensus for the 10 other projects.

But even if some project ideas were already present in some people's mind, only one project was considered as possibly formalized without the eco-innovation process. Moreover the working group estimated that 10 out of the 16 projects would not have emerged without the eco-innovation process.

These results clearly show that a lot of eco-innovative ideas may be present in the company employees' mind but would never emerge without the proposed method. It also shows that new ideas could appear thanks to this method, and that it is a good way to stimulate designer's creativity.

4.3.4 Quality

The quality of the process is assessed thanks to the designer's evaluation of the 16 projects according to three criteria (environmental benefits, feasibility, client's value).

The results for the environmental benefits shows that the average score is 10.8 (out of 20), but with a low standard deviation (0.98). It means that the 16 projects propose environmental improvements on some axes of the eco-design strategy wheel, but no generalized environmental improvements. This clearly characterises incremental eco-innovations. But it also shows that the environmental qualitative scales are not sensitive enough to assess in a good way the differences between the projects.

For the feasibility criteria, the average score is 12.2 and the standard deviation is clearly higher (2.70). The projects are well ranged on the scale (from 4.5 to 15.2) showing that the proposed qualitative indicators are sufficient to distinguish the projects.

Finally, the results for the client's value criterion show that the average score reaches 10.9 with a standard deviation at 1.34. As for environmental benefits, it is hard to distinguish the 16 projects. But if we consider that only incremental eco-innovations have been identified, it could be explained by the fact that the projects would only bring little benefits for the client's value.

5. Concluding remarks

Starting from the statement that eco-innovation methods are not adapted to complex industrial and technological systems, we have proposed an adapted eco-innovation process. This process includes two main stages:

- An eco-ideation phase involving a multidisciplinary working group and a creativity session in order to identify powerful eco-innovative projects involving the complete life cycle of the system and its subsystems,
- A multicriteria assessment phase performed by the working group, considering environmental, but also technical and economic feasibility, client's value, project perimeter and time horizon. This original assessment stage ensures the selection of an optimized eco-innovative R&D projects portfolio.

This process has been applied at Alstom Grid on large electrical substations. The results are very satisfactory as we have shown that this method permits to obtain a high number of ideas with limited time and resources. From these ideas a balanced eco-innovative R&D projects portfolio is identified, mainly composed of ideas that would not have emerged without the method, but also of some new ideas. The assessment grid seems satisfactory for the feasibility and client aspects. However the sensitivity of the environmental indicators does not seem sufficient to assess the projects, as the constraints associated with complex industrial systems favour incremental eco-innovations.

That is why further works need to be performed to assess the potential environmental benefits associated to the projects, in order to give to the decision-makers powerful information through the proposed mapping approach. Two perspectives will be considered. The first one consists in performing a new assessment of the environmental performance of each project with eco-design experts. This process would permit to refine environmental evaluations and to study if the low variability between the projects is due to the participation of non-expert people or is inherent in these projects. The second perspective concerns the development of a more sophisticated model based on

LCA to quantitatively assess at an early stage the environmental performance of the R&D projects.

Acknowledgement

We gratefully thank Joël Devautour and François Puchar from Alstom Grid for their full support, as well as Frankie Rico Sanz and all the working group members for their contribution.

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François Cluzel
PhD student
Ecole Centrale Paris, Laboratoire Genie Industriel
Grande Voie des Vignes, 92290 Chatenay-Malabry, France
Telphone: +33 1 41 13 11 39
Telefax: +33 1 41 13 12 72
Email: francois.cluzel@ecp.fr