IS THIS SYSTEM ECO-INNOVATIVE? A CASE-BASED WORKSHOP

Vallet, Flore (1,2); Tyl, Benjamin (3); Pialot, Olivier (4); Millet, Dominique (5)
1: CentraleSupélec, Université Paris-Saclay, France; 2: IRT SystemX, Université Paris-Saclay, France; 3: APESA, France; 4: Seatech USTV, France; 5: LISMMA Seatech USTV, France

Abstract

Eco-innovation is a challenging topic for companies that are expected to promote the design of products and services for a sustainable society. Early phases of eco-innovation processes and more specifically eco-ideation (the generation phase of promising ideas) still needs efficient supportive methods. This paper empirically challenges a previous proposition of eight eco-ideation stimulation mechanisms (ESMs) thanks to a case-based activity. An explorative workshop on the examination of 16 supposed eco-innovative cases was conducted with four groups of 30 environmental experts. One objective of this workshop for participants was to define, individually and collectively, a way to label eco-innovation cases. This paper presents (1) the selection and characterization of top and flop cases in groups (2) an inductive characterization of eco-innovation regarding cases (3). This arises new perspectives for eco-innovation practice, for instance the consideration of systemic and mass effects.

Keywords: Innovation, Case study, Ecodesign, Sustainability, Small scale experiment

Contact:
Dr. Flore Vallet
IRT SystemX
Anthropolis Chair
France
flore.vallet@irt-systemx.fr

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 1: Resource-Sensitive Design | Design Research Applications and Case Studies, Vancouver, Canada, 21.-25.08.2017.

1 INTRODUCTION

Today, companies are faced up with harsh environmental and social issues. New issues, such as the resource efficiency, product lifespan, or fair trade are now more and more considered in design processes. Eco-innovation, i.e. the integration of environmental and social issues in innovation processes, is a possible answer to these issues. Therefore, a clear interest for eco-innovation has been noticed in institutions and academia in the past few years (Díaz-García et al. 2015, Hojnik and Ruzzier, 2015). Nevertheless, the concept remains ill-understood, limiting its dissemination in companies. As an example, a recent survey in a small panel of French companies underlined that eco-innovation is still ambiguous for industrial practitioners, and therefore they cannot identify examples of eco-innovative products (Cluzel et al., 2014).

The research work is part of a wider French research program (ALIENNOR), which should conduct to an open eco-innovation platform embedding: eco-ideation mechanisms, eco-evaluation tools, and a database of original eco-innovation cases (Tyl et al., 2016).

One of the goals of the ALIENNOR research project is to create a database of eco-innovations. For the selection of eco-innovation cases, the following procedure has been devised: 1) formulation of the eco-innovation issues of the case; 2) assessment by environmental experts of the production, the use (integrating at least one user) and the end of life; 3) decision phase. To this end, it is necessary to identify more actionable criteria than the dimensions of sustainable development to characterize what an eco-innovative system is.

In order to characterize cases for the eco-innovation database, this paper aims at investigating the criteria of eco-innovation thanks to the examination of cases. It starts with the introduction of eco-innovation theory, strategies and cases (section 2). In section 3, the qualitative explorative method of the eco-innovation workshop is presented. Results in section 4 deal with, on the one hand, individual and collective perception of cases provided to groups; salient dimensions of eco-innovation cases on the other hand. Lastly, eco-innovation challenges related to the exposed cases are highlighted in section 5.

2 ECO-INNOVATION FROM THEORY TO CASE STUDIES

2.1 Eco-innovation theory

Eco-innovation mostly concerns the integration of environmental criteria into the innovation process. Therefore, the outcomes are reduced environmental risks, less pollution, and fewer negative impacts of the utilization of resources when compared to the corresponding alternatives (Augusto de Jesus Pacheco et al., 2016). In (Vallet et al., 2016, Cluzel et al., 2016), an overview of the dimensions, scope and drivers associated with the eco-innovation concept is proposed.

Fussler and James defined eco-innovation as a new product, process or service, development (NPD) process that provides significant environmental performances (Fussler and James, 1996). Carrillo-Hermosilla et al. provided an inventory of 16 definitions related to eco-innovation and sustainable innovation (Carrillo-Hermosilla et al., 2010). These different definitions show divergent viewpoints about eco-innovation, such as the intensity (radical or incremental) or the intention of the eco-innovation. More recently, Vallet et al. (2016) underlined that the concept of eco-innovation has drifted from a product/service to a potentially more organizational focus; from a purely environmental to a mixed environmental, social and even institutional contribution.

Concerning the scope of eco-innovation, Rennings (2000) showed that it can be technological, organizational, social or institutional, and developed by a wide range of stakeholders, from companies to NGOs. More practically, Kemp (2010) specified various areas such as renewable energy technologies, pollution prevention systems, waste management equipment, eco-design products and the use of biological materials. OECD (2009) also analysed eco-innovation 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 viewpoint underlined a more holistic understanding of eco-innovation integrating an array of characteristics, ranging from modifications to innovation across products, processes, organizations and institutions.

2.2 Eco-innovation strategies

Recent works focus on eco-innovation at an organizational and business models level (Boons and Lüdeke Freund, 2013, Bocken et al., 2014, O'Hare et al., 2014). Sustainable business models (SBM) incorporate a triple bottom line approach, considering environmental, social and economic issues. Boons and Lüdeke-Freund (2013) raised the question of how business models can support eco-design and innovation, to allow easy adoption by users and in the same time eco-entrepreneurs to make business. The recent contribution of the UNEP guide emphasizes the importance of the business model issue associated with eco-innovation: "Eco - innovation is the development and application of a business model, shaped by a new business strategy that incorporates sustainability throughout all business operations based on life cycle thinking and in cooperation with partners across the value chain." (O'Hare et al., 2014). In a practical way, Bocken et al. (2014) unify bodies of knowledge into eight sustainable business model archetypes.

2.3 Eco-innovation cases

Starting from eco-innovative examples and "good practices" is relevant to better understand eco-innovation. Some academic works have already been proposed accordingly. Hellström (2007) analysed 105 concepts from an eco-innovation competition, according to the type of innovation and innovation mode (radical–incremental and component–architectural). Carrillo-Hermosilla et al. (2010) explored the diversity of eco-innovations according to several key dimensions (design, user, product service and governance) through the analysis a set of eco-innovative case studies processes. Finally, Bocken et al. (2014) used the same approach to characterize sustainable business models archetypes, identifying several good practices.

In a more institutional or industrial way, initiatives to coordinate eco-innovation projects have been developed. As an example, the Babele[1] platform hosts a wide stakeholder network (firms, NGOs, universities, experts, active citizens…) to develop sustainable projects. In line with this platform, UNEP wrote a publication on business cases for eco-innovation to illustrate the business benefits achieved by eight companies in developed and developing countries (UNEP, 2014).

As a conclusion, these various works and projects provide limited practical insights to better identify and characterize eco-innovation cases, and how it can be beneficial to better understand the eco-innovation concept, as well as to foster the development of eco-innovative projects. It seems difficult to conclude on a truly actionable definition to validate or invalidate a potentially eco-innovative case. Therefore, through a case study approach, the paper examines this issue, formulated as "How can a case-based approach reveal practical criteria of eco-innovation?"

3 RESEARCH METHOD

3.1 Overall method

This work complements the collection of experimental workshops carried out with the academic, industrial and institutional partners of the French EcoSD (EcoDesign of Sustainable Systems) network, cf. (Leroy et al., 2015) (Cluzel et al., 2014) (Vallet et al., 2013). The method is qualitative and explorative, in line with the small 'scale experiment' approach (Cash et al. 2011). This means that the empirical approach, being part of a design research, has to be rigorous, carefully tailored in order to build and test meaningful explanations (Cash, Stankovic and Storga, 2016).

A constant concern in the organization of the workshops is to (1) impulse a fruitful group dynamic by sharing and challenging relevant issues to the community; (2) pragmatically test research hypotheses regarding eco-innovation issues. As experienced previously, the choice made is to gain a dual insight thanks to individual as well as collective inputs of participants.

The overall method involved two stages:

- A pre-test (conducted in March 2016) taking the form of a so-called 'five-minute' workshop with 28 environmental experts, as detailed in 3.2;
- A two-hour workshop (conducted in October 2016) with 30 environmental experts, see 3.3.

1 https://babele.co/#!/projects, accessed 01/12/2016

3.2 Pre-test: five-minute workshop

In order to prepare the two-hour test, 28 environmental experts attending the quarterly EcoSD seminar were invited to give a fast written answer to two related questions: (1) Your Top 3 eco-innovations: give three propositions of an eco-innovation; (2) In front of various pre-defined eco-innovations strategies, give, whenever possible, one example of an eco-innovation.
Regarding the Top3 question, a total of 65 propositions were generated, identified as: global strategies to reduce environmental impacts or generate extra value (for instance remanufacturing, eco-technologies or frugal innovation); recurring examples (bicycle in multiple forms human-powered charger, modular electronic devices); single examples (biofuel from green algae, printer reducing paper consumption...).For the second question, a total of 66 propositions were generated.. Finally, a sample of nine most frequently cited propositions were extracted to feed the case-based workshop. The cases, selected depending on variety across sectors, are: community-supported agriculture, neighbour social network, Fairphone smartphone, fleet solution, bike sharing, Oslantis platform, Obiflam log, natural adhesive and cloud heating system.

3.3 Case-based workshop

The experimental approach was conducted in the same community, with 30 engineering designers experts in eco-design (automotive and sport industry, ICT, consulting …), and researchers in environmental analysis and eco-design. Half of the participants also took part to the pre-test. They were divided into four teams, expected to be homogeneous (regarding the balance of experience in eco-design, and the affiliations). Each team was facilitated by one researcher who managed the experiment progress. The experimental protocol was as follows in two steps.

- A presentation of the experiment as well as some feedbacks from the pre-test (15 min);
- Part 1: an overall analysis of 8 cases per team to obtain a common understanding and common criteria of eco-innovation (55 min)tackled in this paper;
- Part 2: a second in-depth examination of 8 cases, whose analysis is out of scope of this paper (50 min).

During Part 1, participants analysed the different cases and selected what they considered as the three 'best' or 'top', and three 'worst' or 'flop' eco-innovations. More precisely the cases that are ranked on 'top' passed the eco-innovation test, while the ones ranked as 'flops' failed the test.

From this analysis, they also had to formalize three criteria of eco-innovation (30 min). Then, a collective discussion was conducted in order to develop a common view of eco-innovation. After the test, a clustering of responses (which were reported by participants on pre-printed sheets) was operated by the authors though inductive classes of coding, followed by a qualitative analysis. Examples of codes are: EV for Environment; SO for Social, BU for Business, US for User etc.

As previously said, this experiment was built on 16 eco-innovative cases. The cases originated from the pre-test, as well as from the French database Efficycle[2] scanning online social and environmental oriented- projects (see Table 1). The rationale was to emphasize the inputs from the community of researchers, and also to broaden the scope of cases (across sectors notably) thanks to the database. The final selection was designed to mix well-known cases (for example the bicycle sharing system) and less known cases (for example the Nautilus water boiler or the community energy system).The cases were split in two series of eight cases (from A to H for groups 3 and 4; from 1 to 8 for groups 1 and 2). Each group analysed a single sample of eight cases.

2 http://www.efficycle.fr/

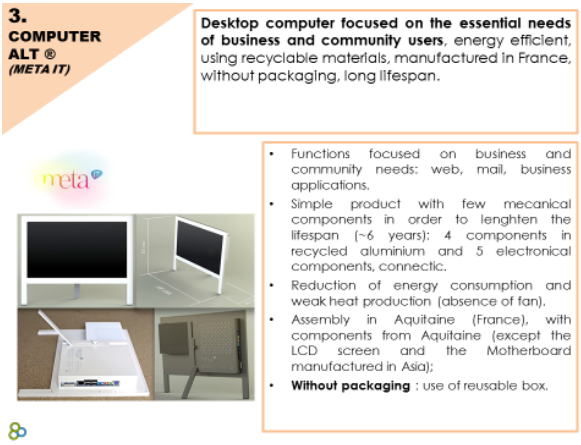

Figure 1. Example of worksheet of an eco-innovation case

Table 1. Brief description of cases

Case study	Short description
Glowee Lighting	Biolighting living system without electricity consumption, thanks to natural properties of bioluminescent cells.
Neighbour social network	Social network to share product and services between inhabitants from the same city or district
Fairphone	Smartphone integrating ethical, social and environmental criteria (no conflict minerals, fair supply chain, modular and reparable)
Bike sharing	Large-scale public bicycle sharing system in Paris
Eco-cup	Sharing system of reusable and customizable cups for festivals and associative, cultural or sportive events
Community energy	Citizen society developing renewable energy projects in the bask territory thanks to citizen funding
Cloud heating system	Water heating system thanks to the energy released by computer and processors systems
Lignine adhesive	Natural adhesive as a substitute of some components of the main adhesive used in the manufacture of wood panels.
Wood community-supported agriculture	Network of consumers and forest actors to provide wood (for consumers) and in the same time to guarantee (from forest actors) a sustainable forest management.
Water boiler Nautilus	Bio-inspired water boiler designed to reduce the water and energy consumption.
BtoB computer Alt®	Desktop computer focused on the essential needs of business and community users, energy efficient, using recyclable materials, manufactured in France, without packaging, and with a long lifespan.
Fleet solution	Deployment of services around the tire, for professional fleets (heavy trucks, light commercial vehicles, light trucks and civil engines).
Oslantis platform	Crowdfunding platform to solve community problems in an open source way, used to promote projects with a sustainable dimension
Obiflam log	Heat logs used in all wood stoves on the market, manufactured from co-products, sawdust (80%) and coffee grounds (20%).
Furniture	Urban micro-plant inspired from the Fablab concept, bringing more than 500 m2 of digital production lines, a collaborative workspace to share knowledge, and a point of sale for objects and services
Uber green service	Mobile application for linking users who submit a trip request, to drivers with electric or hybrid vehicles

4 RESULTS FROM THE WORKSHOP

4.1 Group selection of top and flop eco-innovation cases

This section sheds light on how participants judged the proposed cases as tops or flops in each group. Table 2 includes the absolute number of votes for the 16 different cases. For instance, in Group 1, wood community-supported agriculture was selected by three people as very relevant, whereas four people judged it not relevant.

It was unfortunately not possible to implement a non-parametric test on paired observations to state whether the two groups (for each set of cases) identify an identical sample of top and flop cases. This is due to the limited number of pairs (i.e. eight) which should theoretically be over ten to apply the test. Consequently, a qualitative analysis is provided to give a trend in tops and flops. Our objective is to state if there is an intra-group agreement on cases 1 to 8 (respectively A to H), and if the trends in tops and flops are shared between Group 1 and 2 (respectively 3 and 4). Four categories of trends are highlighted.

- Most eco-innovative cases for the pairs of groups appear to be: BtoB computer Alt®, Fairphone and Glowee biolighting system.
- Least eco-innovative cases for the pairs of groups are: OSlantis platform, Uber green service, community energy.
- Cases causing intra-group balance: Wood Community-Supported Agriculture (Group 1); Obiflam log and furniture (Group 2), bike sharing and eco-cup (Group 4), cloud heating system and lignin adhesive (Group 3).
- One case causing inter-group disagreement between Group 1 (flop) and Group 2 (top): the Nautilus water boiler.

Table 2. Number of votes for most and least relevant cases for cases 1 to 8 and A to H

Name	Case index	Group 1 (N=7)		Group 2 (N=8)		Name	Case index	Group 3 (N=8)		Group 4 (N=7)	
		Top	Flop	Top	Flop			Top	Flop	Top	Flop
Wood community-supported agriculture	1	3	4	5	2	Glowee Lighting	A	6	2	6	2
Nautilus Water boiler	2	1	6	6	0	Neighbour social network	B	6	1	4	2
Computer Alt®	3	6	1	5	1	Fairphone	C	5	2	5	2
Fleet solution	4	4	1	4	2	Bike sharing	D	2	4	3	4
Oslantis platform	5	1	4	1	4	Eco-cup	E	2	6	3	2
Obiflam log	6	1	3	3	3	Community energy	F	1	4	1	4
Furniture	7	5	2	4	4	Cloud heating system	G	4	4	1	5
Uber green service	8	1	5	2	6	Lignin adhesive	H	3	3	0	4

To complement the global perception of cases, it is relevant to capture the rationale, and sometimes the controversy, of the expressed judgments. Illustrations of 'pro' and 'against' arguments are given for six cases, considered as representative of the categories presented above (see Table 3).

- Among the most relevant cases for the two groups, can be found the Fairphone, and the Glowee biolighting system.
- Uber Green service is categorized in the questionable cases for the two groups, notably for its social impact on employment conditions.
- The bike sharing system and lignin adhesive caused an intra-group balance.

- The Nautilus bio-inspired water-boiler was typically controversial (top for Group 2 and flop for Group 1). A question of one participant in Group 1 about the "biomimicry washing" of the water-boiler can explain this contradiction.

Table 3. Excerpt of detailed perception of cases by participants

Case	Quoted in pre-test Yes/No	'Pro 'arguments The case is inspiring because…	'Against' arguments The case is questionable because…
Faiphone	Yes	The value chain has been reconsidered. Consumers are invited be responsible through upgradability options.	Affordability can be an issue.
Glowee Lighting	No	A very high potential of reduction of electric energy and matter consumption for lighting in cities.	Non-commercialized: is it effective? What system does it replace? What is the lighting power?
Uber Green	No	An incentive for masses to leave the use of personal vehicles.	Employment conditions of drivers.
Lignin adhesive	Yes	A high potential of replacement of chemical adhesives at a large scale.	Chemistry expertise is needed: risk of slowing down the production process?
Bike sharing	Yes	A 10-year old concept, but still very relevant. Should be expanded.	A weak point in the business model, bound to an advertising company.
Water boiler	No	A very high potential of reduction of electric energy consumption.	Bio-inspiration seems only cosmetic.

4.2 Individual and collective characterization of eco-innovation

This section first presents a qualitative synthesis of the various individual inputs in the four groups.

As expected, the need to reduce the environmental impacts or induce an environmental gain across life cycle was emphasized by most participants. Eco-innovation is expected to reduce raw material and energy consumption (n=2). Moreover, the combination of environmental, economic and social expectations in eco-innovations was claimed by 6 people. In line with this, People-Profit-Planet expectations were also mentioned.
Business - Eco-innovation is associated with a new plausible business model (n=1); an economic viability (n=2); a commercial success (n=1).
Technology - Eco-innovation is innovative compared to a like-for-like technology (n=1); is based on a technology new to the company or application domain (n=1).
Users - Eco-innovative approach always takes desires and needs of people into account (n=2). In one case, long-lasting needs were cited. Eco-innovation should be accepted (n=1), create added value to the customer (n=2). It is meant to foster a change in behaviour and a sustainable consumption (n=1). A close link between producer and consumer is expected in eco-innovation (n=1). Eco-innovation is supposed to make individuals independent (i.e. able to satisfy their own needs) (n=1).
Mass - Four participants suggested that eco-innovation should be relevant to as many people as possible.
Disruption It was also recorded that eco-innovation should result in a radical change of life (n=1); be disruptive in the business model (n=2), technology (n=2), organization (n=1) or user-experience provided (n=1).
Locality - Production and distribution of eco-innovative solutions should be local (n=2); eco-innovation promotes a 'just necessary' solution for local actors (n=1).
The second step consisted in a group characterization, each group being prompted to collectively emphasize three to five main features of eco-innovation cases (Table 4). The effective or intended reduction of impacts, whether environmental, economic or social is a commonality across the four groups. The satisfaction or modification of the user experience and usages is also a recurring idea. The third important statement deals with the notion of scalability and wide acceptation of eco-innovative solutions by citizens.
Unlike other groups, Group 1 supported that a successful eco-innovation should, in addition, avoid some 'anti-criteria', i.e. it should not promote any false claims (known as 'greenwashing'), or infer any

'boho a priori'. In the anti-criteria category, it was also mentioned solutions causing rebound effects, for instance a reduction of the unit consumption leading to a global increase of volume. Two practical recommendations were expressed in Group 1 as follows.

- Proposition of a bonus in the form of an 'eco-innovation methodological label'. The aim is to acknowledge that a certified process considering the different dimensions of eco-innovation was conducted.
- Proposition of a second bonus to guarantee sustainable change of behaviours at a large scale. This is to avoid solutions that may not be long lasting.

Table 4. Group characterization of eco-innovation

Group	Criteria expressed by the group
Group 1	Identification and proof of newness Environmental and commercial success Avoidance of the 'anti-criteria'
Group 2	Systemic vision Modification of the user experience and usages Reduction of environmental and social impact
Group 3	Contribution to the value chain Transferability to other usage situations Potential of impact reduction: (environmental, economic and social) Scalability of products/systems Temporality of market launch In harmony with users' needs and usages
Group 4	Reduction of environmental and social impact at a large scale Reinforcement of the value added to client and functional performance Disruptive character (environmental, technological, organizational, business model…) Wide acceptation by people

5 CONCLUSION AND PERSPECTIVES

As eco-innovation remains an ill-defined concept, the development and description of best eco-innovative cases is an opportunity to foster the development of eco-innovation in companies. Examination of eco-innovative cases can be seen as an opportunity to define a common language into the design team in companies, but also to stimulate the generation of innovative ideas. The related research question is "How can a case-based approach reveal practical criteria of eco-innovation?"
This paper focuses on a practical case-based approach to eco-innovation. We have thus selected 16 cases to be analysed by four teams in order to extract eco-innovation criteria. The results give some new insights to the eco-innovation domain.
Eco-innovation cases appear to be interesting intermediary objects to favour a common understanding of eco-innovation challenges. Linked to the research question, two types of meaningful actions were achieved in groups: (1) extract commonalities from best eco-innovation cases; (2) induce 'anti-criteria' which should be avoided through the criticism of worst cases.
As expected, the experimental workshop highlights that an eco-innovation mainly contributes to a reduction of environmental impacts. The shift from a pure environmental point of view to a triple bottom line approach, also considering economic and social criteria was confirmed. But cases were also considered as eco-innovative when they drastically impacted the user experience. The disruptive aspect of eco-innovation compared to a reference system lastly emerged. To the question "Is this system eco-innovative?", our contribution is hence that a system may be judged eco-innovative, but only with regard to a sectorial reference.

A less expected finding concerns the significance of scalability - or mass effect - in eco-innovation. Participants consider as a relevant the dissemination of the eco-innovation to a wide range of citizens, in order to reach critical mass and have a significant environmental impact reduction. Even if this is in line with recent works on systemic approach of sustainable design -see for example Gaziulusoy and Brezet (2015) - future works should better integrate the 'mass effect' in the eco-innovation process.

The experiment also shows that an organizational business model approach generally seems to be under-evaluated. Participants indicated that organizational cases are difficult to understand, underlining the difficulties to formalize, communicate and set the debate on such cases (for instance the energy cooperative case). Therefore, future work will need to analyse the appropriate format to report an eco-innovation case (to make it understandable, usable, prone to evaluation), and until which point the presentation is biased by the information. Indeed one limit is that arguments and quotations (best or worst cases) may depend on the details given to the groups. One way to mitigate this effect would be to fill in compulsory fields for every case on the basis of our findings (add an argument about mass diffusion for instance).
This paper draws a set of new perspectives. First, one proposal is to analyse the sensitivity to the participants' expertise and background on the perception of cases. The difference of perception, most notably between academic researchers and industrials, is worth investigating in further work. Online tests with a larger sample of raters (for instance from other eco-design communities) could be conducted at a statistically relevant level, which is another current limit of the approach. Moreover specific sectorial cases (in energy, or funding) can be difficult to handle by participants, and therefore not be considered as relevant eco-innovative cases. Future focus groups will be organized by industrial sector (energy, mobility, etc.) to give robustness to a database of eco-innovative cases.
Secondly, the criteria formulated by the participants should be formatted in order to be used by the researchers during the selection process of eco-innovations cases. Two types of cases can then be distinguished: 1) validated cases of eco-innovations, tested by facts and implemented, and 2) inspiring cases of eco-innovations, at the stage of an advanced idea, of a financing project, hence having a strong power of inspiration because they are disruptive on one or several aspects.

Finally, this workshop was performed in the framework of the ALIENNOR project (Tyl et al., 2016). One result of the project is to support the eco-ideation stage (i.e. the generation of eco-innovative ideas) thanks to a set of heuristics, called Eco-ideation Stimulation Mechanisms (ESMs).
Two main results were obtained in a first stage (Tyl et al. 2016): (1) the development of a set of mechanisms to explore the dimensions of eco-innovation; (2) a transformation process of ideas, core part of the mechanisms. In particular, a toolbox of eight mechanisms was proposed: (1) Innovate through value creation considering all stakeholders, (2) Innovate through biomimicry, (3) Innovate through end-user and sustainable uses; (4) Innovate through services and functional economy; (5) Innovate through new funding outlines; (6) Innovate through closed loop and short loop thinking; (7) Innovate through new material and processes; (8) Innovate through impact transfer and rebound effect management.

Some authors tested the effect of visual stimuli to inspire design teams (Goldschmidt and Smolkov, 2006). Therefore, a last perspective will be to exploit the second part of the workshop. This is aimed at characterizing the most inspiring cases thanks to ESMs, as a complementary approach, to support eco-ideation stages.

REFERENCES

Bocken, N., Short, S., Rana, P., Evans, S. (2014), "A literature and practice review to develop Sustainable Business Model Archetypes", *Journal of Cleaner Production*, Vol.65, pp. 42–56.

Boons, F., Lüdeke-Freund, F. (2013), "Business models for sustainable innovation: state-of-the-art and steps towards a research agenda", *Journal of Cleaner Production*, 45, pp. 9–19.

Carrillo-Hermosilla J., del Rio P., Könnöla T. (2010), "Diversity of eco-innovations: Reflections from selected case-studies". *Journal of. Cleaner Production*, 18 (10-11), pp. 1073-1083.

Cash P., Stanković P., Štorga M (2016), Exp*erimental Design Research: Approaches, Perspectives*, Applications. Springer, 2016. ISBN 3319337815, 9783319337814.

Cash, P., Elias, E., Dekoninck, E. A. and Culley, S., 2012. "Methodological insights from a rigorous small scale design experiment". *Design Studies*, 33 (2), pp. 208-235.

Cluzel, F., Tyl, B., Vallet, F. (coord.) (2016), T*he challenges of eco-innovation – From eco-ideation toward sustainable business models. EcoSD Annual Workshop 2015*. Presses des Mines, ISBN : 978-2-35671-401-5, Paris.

Cluzel F., Vallet F., Tyl B., Bertoluci G., Leroy Y. (2014), *Eco-design vs eco-innovation: an industrial survey, International design conference – Design 2014*. Dubrovnik, Croatia

de Jesus Pacheco, D. A., Carla, S., Jung, C. F., Ribeiro, J. L. D., Navas, H. V. G., & Cruz-Machado, V. A. (2016), "Eco-innovation determinants in manufacturing SMEs: Systematic review and research directions". *Journal of Cleaner Production* 142(4), pp. 2277-2287.

Díaz-García, C., González-Moreno, Á.,Sáez-Martínez, F. J. (2015), "Eco-innovation: insights from a literature review". *Innovation, Organization and management* 17(1), pp. 6-23.

Fussler C. And James P. (1996), "Driving Eco Innovation-A breakthrough discipline for innovation and sustainability". *Pitman Publishing, Pearson Professional Ltd*.

Gaziulusoy, A. I., and Brezet, H. (2015), Desi"gn for system innovations and transitions: a conceptual framework integrating insights from sustainablity science and theories of system innovations and transitions". *Journal of Cleaner Production*, 108, pp. 558-568.

Hellström, T. (2013), "Dimensions of environmentally sustainable innovation: the structure of eco-innovation concepts". *Sustainable Development 2013*, 15(3), pp. 148-159.

Hojnik, J., Ruzzier, M. (2016), "What drives eco-innovation? A review of an emerging literature". *Environmental Innovation and Societal Transitions* 19, pp. 31-41.

Kemp, R. (2010), "Eco-Innovation: definition, measurement and open research issues". *Economia politica*, 27(3), pp. 397-420.

Leroy, Y., Tyl, B., Vallet, F., Cluzel, F. (2015), "Environmental evaluation of ideas in early phases: a challenging issue for design teams". In *The 20th International Conference on Engineering Design (ICED 15)*, Vol. 1, pp. 117-126.

OECD, (2009),. *Sustainable Manufacturing and Eco-innovation: Framework, Practices and Measurement. Synthesis Report Paris: OECD*. Available in: http:// www.oecd.org/dataoecd/15/58/43423689.pdf.

O'Hare, J.A., McAloone, T.C., Pigosso, D.C.A., Howard, T.J. (2014), *Eco-Innovation Manual – Tools instruction*, United Nations Environment Programme / DTU.

Rennings, K., 2000. "Redefining innovation-eco-innovation research and the contribution from ecological economics". *Ecol. Econ*. 32 (2), pp. 319-332.

Tyl, B., Vallet, F., Pialot, O., Millet, D., Le Duigou, J., Graves, G. (2016), T"he ESM approach: 8 mechanisms to efficiently support eco-ideation". In: P*roceedings of International Design Conference – Design 2016. Presented at the International Design Conference – Design 2016*, Dubrovnik, Croatia.

UNEP (2014), *The Business case for Eco-innovation*. Available at (http://www.unep.org/) (Accessed 15/10/16),

Vallet F., Tyl B., Millet D., Eynard B. (2013), "A method to select best nuggets from eco-innovation sessions. In Green Design", *Materials and Manufacturing Processes*, H. Bartolo et al. (Eds), pp 647-654. CRC Press/Balkema, Leiden Netherlands.

Vallet, F., Tyl, B., Cluzel, F., Leroy, Y. (2016), "Research directions in eco-innovation: a French perspective", *International Journal on Interactive Design and Manufacturing* (IJIDeM) 10(3), pp. 309-318.

ACKNOWLEDGMENTS

The authors express their gratitude to the participants to the EcoSD seminars involved in the reported tests. They wish to thank the French National Research Agency (ANR) for the funding of the ALIENNOR project (reference: ANR-15-CE10-0001), as well as the Region Nouvelle Aquitaine. This research work has been carried out in the framework of the Technological Research Institute SystemX, and therefore granted with public funds within the scope of the French Program "Investissements d'Avenir".