Analysing barriers to eco-innovation: The case of the LED sector

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Paper presented in the GCW conference, Turin, June 2014

Draft – Do not quote

Abstract

This paper investigates barriers to eco-innovation in the LED sector. It presents the results of the first phase of a project, in which these barriers are identified by conducting in-depth interviews with four SMEs that are in charge of developing ecodesigned LED products within the FP7 cycLED project. Following a review of the literature on barriers to (eco)innovation, a questionnaire has been prepared to guide the interviews. 144 external and internal barriers were identified, of which 14 were deemed "major barriers". Solutions to these barriers are discussed in the conclusion.

Keywords

Barriers to innovation, eco-innovation, LED, SME, lighting.

1. Introduction

Many studies have sought to analyse barriers to innovation. In their analysis of revealed versus deterring barriers, D'Este et al. (2012) underline that these studies have focused on financial variables and that many of them have used econometric analyses and CIS survey data. On the other hand, few studies have explored a broader range of barriers or conducted case studies. Moreover, barriers to eco-innovation and SMEs' barriers have seldom been analysed. This paper fills this gap by analysing the barriers to eco-innovation in the emerging LED sector. It present the results of the first phase of part of an on-going FP7 project called "cycLED", which was completed in February 2014.[1] The cycLED project aims at optimising the flows of resources over all life-cycle phases of Light Emitting Diodes (LED) products. The energy saving potential for LEDs is significant, and the strategic importance of the LED technology is reflected in current and upcoming market developments. However, LED-based product systems contain many resources like indium, gallium or rare earth metals. Some of these substances are classified as critical raw materials at EU level. Therefore, if the current expansion of LED technologies is most welcomed from an economic and energy point of view, it requires optimising resource flows and addressing key societal issues. To strengthen the emerging LED market in Europe, cycLED focuses on improvement of the material flows and policy measures to remove barriers for LED technology dissemination. Innovation is needed to achieve an efficient management of the different materials used in LED systems, so that the growth of the LED-related markets is decoupled from resource depletion.

[1] See WP8: Overcoming barriers to eco-innovation, see http://www.cyc-led.eu).

In order to analyse the barriers to eco-innovation in the LED sector, at first in-depth case studies were conducted with cycLED project SME partners. In a second phase, the analysis is extended to other stakeholders, including government and EU officials, in order for example to better explore regulatory barriers. Results from this research will be useful for policy-makers to design policies that can help SMEs overcome barriers to eco-innovation, and to strengthen eco-innovation in the LED sector, notably in Europe. It will also enable innovation scholars to better understand the dynamics of eco-innovation in an emerging field, which has the potential to support the sustainability transition of lighting and display technologies by switching to ecodesigned LEDs. This paper focuses on the first phase of this analysis, and consists in a presentation of the methodology used to identify the barriers, of the results (144 identified barriers), while solutions to the major barriers (14 of them) are discussed in conclusion.

2. Methodology

In order to prepare an interview guideline that would help firms identify their barriers to eco-innovation, a review of the literature was prepared. A commonly used list of barriers is the one of the Community Innovation Survey (CIS), which includes three categories of barriers: Risk and finance, Knowledge-skill within enterprise/outside enterprise, and Regulations (Mohnen and Röller (2005)). In their study of the potential and challenges of Solid State Lighting (SSL) in Europe, De Almeida et al. (2014) complement the CSI barriers and formulate the following barriers for the implementation of SSL: Cost, Payback time, Quality, Luminous efficacy, Lifetime, Educational barriers, Testing, Manufacturing, Lack/high cost of capital, Aversion to risk, Lack of time, Dramatic decline in the total number of lighting products.

In order to complement these lists, other sources were identified (see reference list in Appendix 1), which enabled us to draft a more detailed list of barriers that was circulated to all cycLED partners who could add new barriers. This list proposes a new categorisation of barriers to eco-innovation that is more helpful to find ways to overcome barriers to eco-innovation in the LED sector. In the context of the cycLED project, the barriers to eco-innovation are analysed in order to help our demonstrators overcome them and to successfully eco-innovate, but also in order to support the development of a sustainable European lighting industry. We will thus analyse the barriers that are faced by cycLED SMEs and that originate both within their organisation and outside their organisation.

Case studies consisted in interviews carried out with the support of an interview guideline (see Appendix 2), in which potential barriers were collected from the aforementioned literature review. The guideline contains 144 barriers organised in two groups: barriers within organisations (Vision and strategy, Finance, Human resources, ...); and barriers outside organisations (Policies and norms, Infrastructures, Values and beliefs, ...). Face-to-face interviews were conducted with high-level executives from the four SMEs of the project, which are in charge of delivering demonstrators of ecodesigned LEDs. For each barrier, SMEs were asked to estimate the importance of each barrier for their organisation: -1 (Not a barrier but rather a support to ecoinnovation); 0 (Irrelevant barrier to ecoinnovation for my organisation); 1 (Relevant barrier to ecoinnovation for my organisation); 2 (Major barrier to ecoinnovation for my organisation). After the interviews, a list of the most important barriers was compiled, for each SME and for the four of them altogehter. Summing up the scores obtained for each barrier, only one of them obtained a score of 5 (category 'Policies & norms': barrier 'Lack of certification mechanisms to check out the technical specifications of products put on the market'); and seven barriers obtained a score of 4 (e.g. category 'Technology': barrier 'LED drivers are

barriers to ecoinnovation'; or category 'Finance': barrier 'Lack of in-house sources of finance'). On the basis of the ranking of barriers obtained for each SME, all the barriers with a score of 1 and 2 were singled out, and discussed during an ad hoc workshop that took place during a consortium meeting of cycLED in November 2013. During this workshop, with the help of the other project partners, SMEs were asked to explain which barrier could be overcome internally, and where could they seek help to do so.

3. Results

Results from this research will be useful for policy-makers to design policies that can help SMEs overcome barriers to eco-innovation, and to strengthen eco-innovation in the European LED sector. It will also enable innovation scholars to better understand the dynamics of eco-innovation in an emerging field, which has the potential to support the sustainability transition of lighting and display technologies by switching to ecodesigned LEDs. The analysis of the identified barriers enables us to highlight the ones that must be addressed with top priority. Indeed, if 144 barriers were evaluated (hence a total of 576 evaluations for the four SMEs), not all of these evaluations will point our to barriers that need to be solved with top priority. To bring these major barriers to the fore, we can first use the level given to each barrier as a score (-1, 0, 1, or 2) and add up the scores given by the four SMEs to obtain a global score for each barrier. A second way to bring forward the most important barriers is to count how many times each barrier has been given a Level 2 and a Level 1. Both methods are used below to present an overview of all the identified barriers, and then to analyse relevant (Level 1) barriers and major (Level 2) barriers.

3.1. Overview of barriers to eco-innovation within cycLED

The table below shows the 8 barriers that are important for all cycLED SMEs, by taking the ones that received a score of 5 (only the first one written in bold font) and a global score of 4.

Table 1. Barriers to eco-innovation for European LED SMEs

CATEGORY OF BARRIER	BARRIERS
Policies & norms/Policy instruments	**Lack of certification mechanisms to check out the technical specifications of products put on the market**
Policies & norms/Policy objectives	National policies do not provide adequate support to ecoinnovation and/or emerging LED technologies
LED industry	Increasing & unfair competition from non-European firms
LED industry	Technology is not cost-effective enough
Global context/Macro-political	Critical materials like REEs are mainly exported by non-European countries
FINANCE	Lack of in-house sources of finance
FINANCE	The gross intrinsic value is too low, which discourages innovation in recycling technologies
TECHNOLOGY	LED drivers are barriers to ecoinnovation (too fragile e.g.)

NB: Barriers in capital font refer to internal barriers, others to external barriers. The barrier in bold font received a global score of 5.

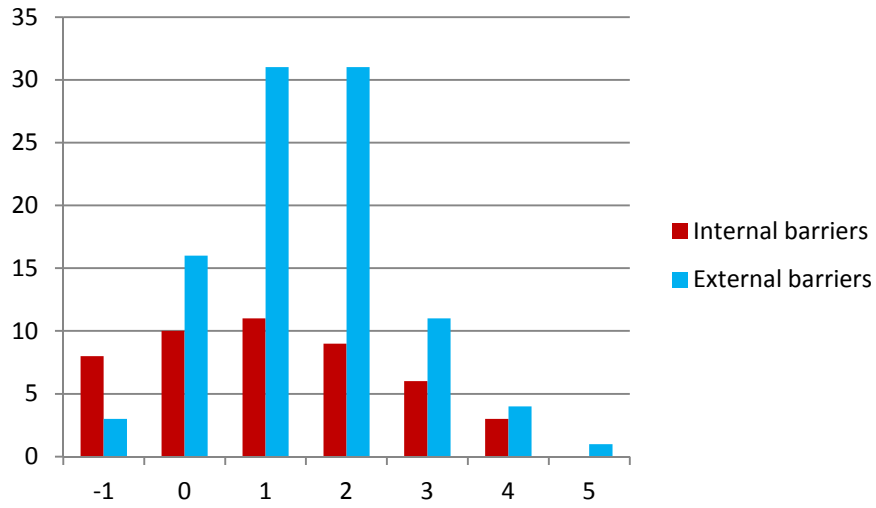
This table shows that five of the eight most important barriers are external ones. This emphasis given by cycLED SMEs on external barriers is partly due to the fact that following our literature review and consultation of cycLED partners, 67% of the barriers listed were external ones.

Table 2. External vs. internal barriers

Score of barriers	Internal barriers	External barriers	Total number of barriers
-1	8	3	11
0	10	16	26
1	11	31	42
2	9	31	40
3	6	11	17
4	3	4	7
5	0	1	1
TOTAL	**47**	**97**	**144**

The following graphical representation of the above table shows a rather standard distribution of the barriers, since most of them are in the middle range i.e. obtained a score of 2 or 3.

Figure 1. Distribution of the scores of barriers

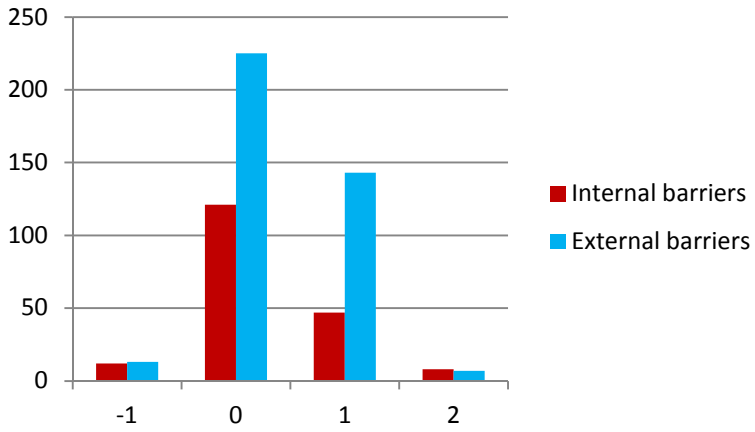


This aggregated analysis enables us to point out that external barriers are the main sources of blockage of eco-innovation for cycLED SMEs. The four SMEs have evaluated 144 barriers by giving them a level of -1, 0, 1, or 2, and thus altogether they have provided 576 evaluations. The following table and graph show the distribution of these evaluations across each level of barrier (-1, 0, 1, 2).

Table 3. Distribution of SMEs' evaluations per level of barrier

Levels		Internal barriers	External barriers	Total number of evaluations	Total number of evaluations (%)
-1	Not a barrier	12	13	25	4%
0	Irrelevant	121	225	346	60%
1	Relevant	47	143	190	33%
2	Major barrier	8	7	15	3%
Total		**188**	**388**	**576**	**100%**

Figure 2. Distribution of SMEs' evaluations per level of barrier



The first important finding here is that 60% of the evaluations corresponded to barriers deemed by SMEs as irrelevant for their organisation (barrier level = 0). This could be explained by the fact that the range of barriers collected from the literature was too broad for studying the barriers to eco-innovation of SMEs in the LED sector. Among these barriers, 19 of them were deemed irrelevant by the four SMEs altogether, a homogeneity of evaluation that we will not find in the cases of relevant and major barriers.

11 irrelevant barriers were external barriers:

- Too many heterogeneous LED market niches, which tends to slow down technological accumulation
- The claim for environmental-friendliness of LEDs is not yet trusted by industrial consumers
- The claim for the energy saving potential of LEDs is not yet trusted by industrial consumers
- Insurance rules are obstacles to ecoinnovation
- Lack of professional associations supportive of ecoinnovation
- Lack of new conferences where engineers and designers can meet and discuss
- LED products are not modular enough
- Dominant design methods in the lighting industry are driven by built-in obsolescence
- Too many competing consortia (can reduce opportunities)
- Climate scepticism
- Currently, there is political instability that deters ecoinnovation

8 irrelevant barriers were internal barriers:

- Cognitive routines and shared beliefs of designers are not geared towards ecoinnovation
- Blue light hazard is an obstacle to ecoinnovation
- Employees' resistance to implementing ecoinnovation
- LEDs perceived as ecoinnovations per se, and thus no further effort seems to be required to reduce its ecological impacts
- Human resource management is not supportive of ecoinnovation
- High sunk investments (switch to new technologies once investments are written off)
- Information sharing between marketing and R&D departments is weak
- The location of your organisation is detrimental to ecoinnovation

It is interesting to notice that three barriers were never deemed irrelevant by any of the four SMEs; one of them being the most significant barrier (score = 5). One of them is the only barrier that obtained a score of five (external barrier "Lack of certification mechanisms to check out the technical specifications of products put on the market", category "Policies & norms/Policy instruments"). The two others obtained a score of four and were also external barriers: "Technology is not cost-effective enough" (category "LED industry"); "Critical materials like REEs are mainly exported by non-European countries" (category "Global context/Macro-political"). This suggests that the framework is coherent and that it does enable us to capture the main barriers perceived by cycLED SMEs.

Other interesting results can be derived from the remaining 40% evaluations that got a positive or negative score. Concerning the negative scores, a firm was able to give a score of -1 to a barrier that from her point of view was actually not a barrier but an advantage for her. 23 barriers received one evaluation with a Level -1 (13 of which were external barriers), and one (external) barrier got two negative evaluations (Level -1): "The size of your organisation is too small to ecoinnovate". This case means that for two SMEs, being small was not perceived as a disadvantage to eco-innovate.

3.1. Relevant barriers to eco-innovation (level 1)

Of the 576 evaluations 190 corresponded to a Level 1 and concerned 113 different barriers. This means that several times more that one SME gave a Level 1 to the same barrier. The distribution of these Level 1 evaluations is presented in the table below.

Table 4. Number of Level 1 barriers per frequency of occurrence

Number of SMEs that used the Level 1 to evaluate a given barrier	1	2	3	4	Total number of barriers that were deemed relevant (Level 1)
Number of barriers deemed relevant by 1, 2, 3, or 4 SMEs	52	47	12	2	**113**

This table underlines a heterogeneity in the identification of barriers among cycLED SMEs. Indeed, only 2 barriers were deemed relevant by the 4 SMEs altogether, 12 by 3 SMEs, 47 by two SMEs, and the highest number of Level 1 barriers (52) were deemed relevant by only one SME. 75% of the barriers that were deemed relevant by cycLED SMEs were external barriers, but only two of them were deemed relevant by the four SMEs altogether:

- Technology is not cost-effective enough
- Critical materials like REEs are mainly exported by non-European countries

Of the 12 barriers deemed relevant by at least three of the four cycLED SMEs, there are 2 internal barriers that both belong to the category "FINANCE", which stresses the importance of financial issues for cycLED SMEs to eco-innovate:

- The pay-off period of ecoinnovation is too long
- Economies of scope are too small to reduce costs

Of the 12 barriers deemed relevant by at least three of the four cycLED SMEs, 10 are external barriers:

- Lack of certification mechanisms to check out the technical specifications of products put on the market
- Financial institutions are not sensitive enough to ecoinnovation
- Reluctance of skilled personnel to work for SMEs
- LED technological niches are not protective enough for radical ecoinnovations to emerge
- European policies do not provide adequate support to ecoinnovation and/or emerging LED technologies
- Ecoinnovation policies are not SME-friendly
- There are legally binding contracts for the provision of electricity and/or lighting that discourage ecoinnovation
- Highly competitive environment (prevents the of trust between organizations)
- The current macroeconomic context is not favourable to ecoinnovation
- Current macroeconomic policies are not supportive of ecoinnovation

3.2. Major barriers to eco-innovation (Level 2)

Last but not least, 14 barriers were identified as major barriers by SMEs (Level 2), but only one of them was mentioned as such by more than one SME (but by only two of them): the internal barrier "Lack of in-house sources of finance". The table below confirms the heterogeneity in the identification of barriers among cycLED SMEs found for Level 1 barriers. Indeed, not a single barrier was deemed major by the four SMEs altogether, and not even one was deemed major by three SMEs altogether.

Table 5. Number of Level 2 barriers (major barriers) per frequency of occurrence

Number of SMEs that used the Level 2 to evaluate a given barrier	1	2	3	4	Total number of barriers that were given Level 2
Number of barriers deemed relevant by 1, 2, 3, or 4 SMEs	13	1	0	0	14

If we look at the Level 2 barriers that were common to cycLED SMEs, only one was common to just two SMEs (the aforementioned internal barrier "Lack of in-house sources of finance"). The 13 remaining major barriers that received one Level 2 evaluation were deemed major by only one SME (solutions to these 14 major barriers are discussed in the conclusion of this paper). This heterogeneity of the perceptions of barriers by cycLED SMEs can be explained by the fact that they operate in different contexts such as different segments of the LED market and sometimes in different countries. This suggests that in order to better understand the barriers to eco-innovation in the LED sector, we should at first analyse in detail the barriers identified by each SME (this will be done in the individual reports sent to each firm). Second we must expand our analysis beyond cycLED by investigating other firms operating in different contexts, as well as other stakeholders such as multinationals or government officials (this will be done in a second phase).

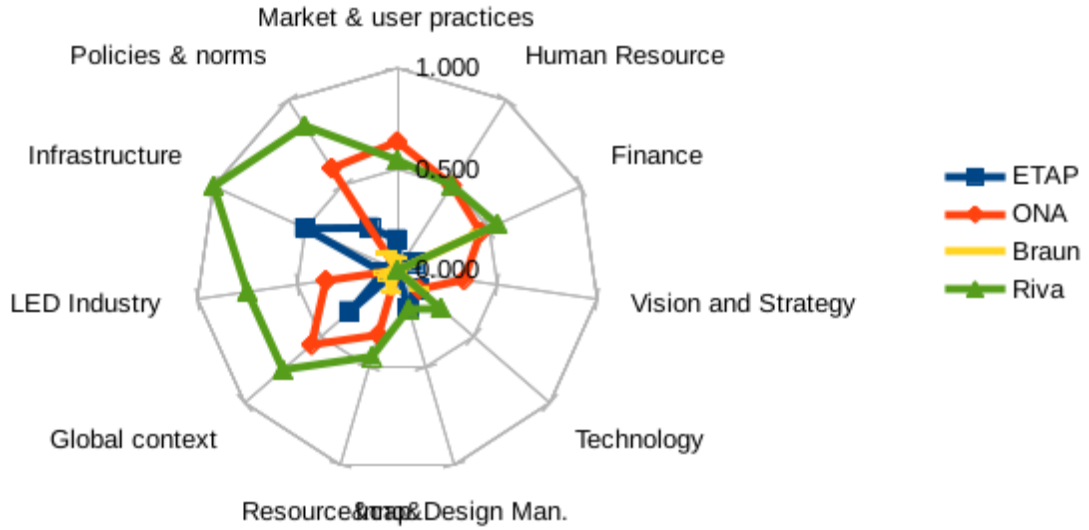
Table 6. Major barriers to eco-innovation according to cycLED SMEs

Category	Barrier
Policies & norms/Policy instruments	**Lack of certification mechanisms to check out the technical specifications of products put on the market**
FINANCE	***LACK OF IN-HOUSE SOURCES OF FINANCE***
FINANCE	**THE GROSS INTRINSIC VALUE OF THE LED PRODUCT IS TOO LOW, WHICH DISCOURAGES INNOVATION IN RECYCLING TECHNOLOGIES**
TECHNOLOGY	**LED DRIVERS ARE BARRIERS TO ECOINNOVATION**
LED industry	**Increasing & unfair competition from non-European firms**
Policies & norms/Policy objectives	**National policies do not provide adequate support to ecoinnovation and/or emerging LED technologies**
FINANCE	*ECO-INNOVATION COSTS ARE TOO DIFFICULT TO CONTROL*
RESOURCES & CAPABILITIES	*INFORMATION SYSTEMS ARE SOURCES OF RIGIDITY THAT DISCOURAGE ECOINNOVATION*
LED industry	*Existence of litigations between firms*
Markets & User practices/Financial markets	*Lack of funding to support SMEs' ecoinnovation*
Markets & User practices/Labour market	*Lack of skilled people to repair used LED products*
Markets & User practices/Technological niches	*Lack of modularity between radical innovations*
HUMAN RESOURCES	LACK OF TECHNICAL PERSONNEL TO ECOINNOVATE
Markets & User practices/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations

NB: Capital letters = INTERNAL BARRIERS. Bold font underlined: **score of 5**. Bold font italics: ***score of 4 with two level 2***. Bold font: **score of 4**. Italics: *score of 3*. Normal font: score of 2.

Our analysis enables us to examine how each category of barrier is perceived by SMEs, and to represent it graphically (see following figure, normalized with respect to the number of questions asked for a specific category).

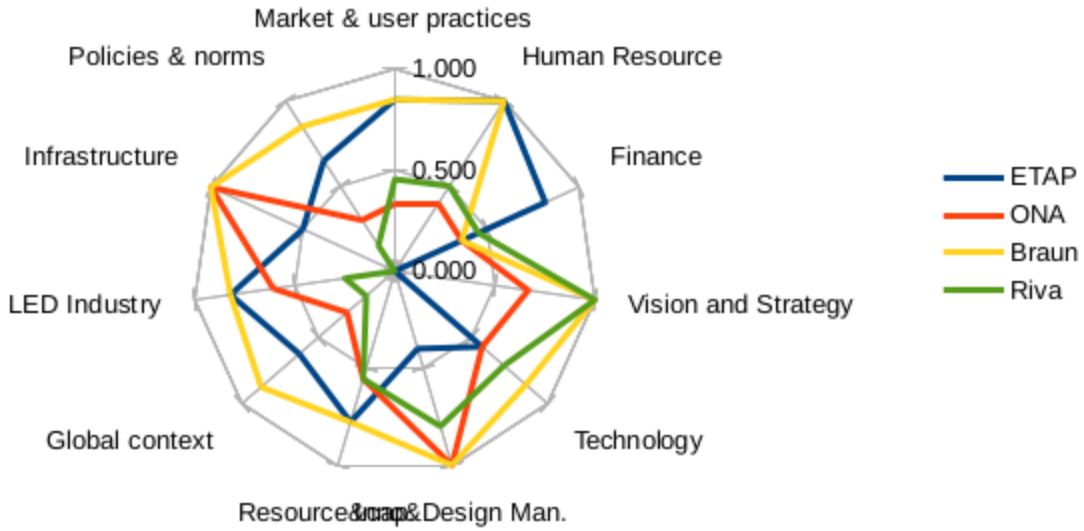
Figure 3. Categories of external barriers perceived by cycLED SMEs



We can see that no category of barrier clearly stands out for the four SMEs except for the global context, which can be explained by the fact that the economic crisis affects most businesses. On the contrary, some categories such as “Technology”, “Design management” or even “Vision and strategy”

are not perceived as barriers to eco-innovation. This suggests that despite their size, cycLED SMEs feel that they have a good vision and strategy to achieve eco-innovation, and have a good command of the technological and design drivers to do so. This corroborates the findings of Saunila and Ukko (2014) according to which firm's size does not seem to affect SMEs' innovation capability. The following figure shows the categories or barriers that are deemed irrelevant by cycLED SMEs, which corroborates the latter comment.

Figure 4. Irrelevant barriers to eco-innovation



4. Conclusion

The case studies conducted within the cycLED projects have enabled us to identify 14 major barriers to eco-innovation (Level 2). However, only one of these major barriers was mentioned as such by more than one SME (but by only two of them): the internal barrier "Lack of in-house sources of finance". Financial resources are an important ingredient for innovations in general and eco-innovations in particular. For example, they are a prerequisite for R&D investments which according to Klewitz and Hansen (2014) are one of the four main critical success factors for environmentally sustainable product innovation (with market, law and regulation knowledge; interfunctional collaboration; and innovation-oriented learning). The importance of in-house sources of finance for SMEs' eco-innovation is corroborated by other studies on SMEs, such as the one carried out by Madrid-Guijarro et al. (2009) on the barriers to innovation among Spanish manufacturing SMEs, who underlines that "challenges associated with human resources and weakening of financial position act as obstacles to innovation". On the other hand, other authors like Alessandrini et al. (2010) suggest that financial barriers depend on SMEs' location, since "SMEs located in provinces where the local banking system is functionally distant are less inclined to introduce process and product innovations". Financial constraints are also important barriers to innovation for low-tech SMEs, and hence Cuerva et al. (2014) suggest to "to reduce the financial constraints for SMEs in order to incentivize eco-innovation".

The 13 other barriers identified by at least one cycLED SME to be a major barrier to their eco-innovation are presented in the table below (7 external, 8 internal).

Table 7. Major barriers according to cycLED SMEs

Global Score	Category	Barrier
5	Policies & norms/Policy instruments	Lack of certification mechanisms to check out the technical specifications of products
4	Policies & norms/Policy objectives	National policies do not provide adequate support to ecoinnovation and/or emerging LED technologies
4	LED industry	Increasing & unfair competition from non-European firms
4	TECHNOLOGY	LED DRIVERS ARE BARRIERS TO ECOINNOVATION
4	FINANCE	THE GROSS INTRINSIC VALUE IS TOO LOW
3	Markets & User practices/Financial markets	Lack of funding to support SMEs' ecoinnovation
3	Markets & User practices/Labour market	Lack of skilled people to repair used LED products, which is a disincentive to undertake DfR projects
3	Markets & User practices/Technological niches	Lack of modularity between radical innovations
2	Markets & User practices/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations
3	FINANCE	ECO-INNOVATION COSTS ARE TOO DIFFICULT TO CONTROL
3	RESOURCES & CAPABILITIES	INFORMATION SYSTEMS ARE SOURCES OF RIGIDITY THAT DISCOURAGE ECOINNOVATION
3	LED industry	Existence of litigations between firms
2	HUMAN RESOURCES	LACK OF TECHNICAL PERSONNEL TO ECOINNOVATE

NB: Capital letters = INTERNAL BARRIERS.

In 2006, an IEA report lamented the lack of adherence to guidelines promoting efficient lighting (IEA (2006:482). Our study suggests that it is still the case in Europe. Indeed, the only barrier that obtained a score of 5 is an external one related to the policy context ("Lack of certification mechanisms to check out the technical specifications of products put on the market"): it was ranked with a level 2 by one SME (ETAP) and with a level 1 by the remaining 3 SMEs, hence a global score of 5 (this barrier was mentioned by a cycLED member during one of the consortium meeting during which WP8 issues were being discussed). This is therefore a key issue to be addressed for eco-innovative LEDs to emerge in Europe. In the US, the US DoE "LED Lighting Facts" programme aims "to assure decision makers that the performance of solid-state lighting (SSL) products is represented accurately as products reach the market" (http://www.lightingfacts.com/About). A similar programme could be launched at European level. This barrier has thus been given a key priority and support from the professional association Lighting Europe has been sought to overcome it.

Another major external barrier that got a global score of 4 (it was given a Level 2 by 2 SMEs) relates to policy issues: "National policies do not provide adequate support to ecoinnovation and/or emerging LED technologies". This barrier will be voiced to national policy makers, who could for example introduce a financial support scheme for consumers that adopt ecodesigned LEDs. In California, according to The Climate Group (2012) an "Efficiency and Conservation Block Grant Program" (EECBG) granted USD 37.3 million to 40 small cities and counties to develop LED street and parking area retrofit projects. The last major external barrier that got a score of 4 concerns "Increasing & unfair competition from non-European firms", which during the interviews clearly concerned Asian firms, especially Chinese ones. The creation of strong certification mechanisms could reduce this unfair

competition, and possibly be used to strengthen the standards of LEDs that are put on the EU market, for example by only authorising the ones that achieve a certain level of environmental performance.

The last four major external barriers obtained a global score of 3, and they all belong to the category "Markets & User practices". One of them concerns financial market and the lack of specific sources of finance to support eco-innovation by SMEs. Another one focuses on the labour market and suggests that there is a "Lack of skilled people to repair used LED products, which is a disincentive to undertake DfR projects". This is a barrier to be solved by a multiplicity of actors in charge of training such as governments (they can ask engineering schools to train students on DfR), universities (they can develop DfR courses), or companies (they can request that their technicians be trained on DfR). The lighting sector could give a specific contribution here by organising an industry-wide training programme to level up the skills of people working in the sector. Such a progress would contribute to a virtuous circle by encouraging companies to manufacture repairable and more easily recyclable LED products. A third barrier points out the "Lack of modularity between radical innovations", a problem which is partly addressed by the Zhaga consortium.[2]

Finally, the last major external barrier got a global score of 2 and also concerns the labour market: "Educational institutions do not provide enough people well trained to develop ecoinnovations". It is line with the aforementioned comments on the need to scale up educational and training curricula on eco-innovation related issues. It also suggests that cycLED SMEs find it important to collaborate with stakeholders in charge of education and training, which could be seen as a favourable sign for the success of the project. Indeed, in their study of the drivers of different types of eco-innovation in European SMEs, Triguero et al. (2013) found that "those entrepreneurs who give importance to collaboration with research institutes, agencies and universities, and to the increase of market demand for green products are more active in all types of eco-innovations." However, if this issue is to be taken up by policy makers, it should not do it separately from other forms of eco-innovation policy supports. As Hansen et al. (2002) suggested, to support eco-innovation in SMEs "policy to support SME's adoption of environmental innovations has to take an integrated form, i.e. addressing and developing competence, networks and strategic orientation of SMEs simultaneously whilst remaining systemic and context sensitive."

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6. Appendices

Appendix 1. References on barriers to innovation used in the literature review

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Appendix 2. Interview guidelines prepared on the basis of the literature review

cycLED project - WP8 - Analysing the barriers to eco-innovation in the LED sector - Phase I: The perspective of cycLED members

The objective of the first phase of WP8 is to collect the barriers to **ecoinnovation** (**EI**) that your organisation is facing at present or has faced in the past*.

To do so, I will conduct face-to-face interviews in order to identify with your collaboration the barriers to ecoinnovation of your organisation. To facilitate this process of identifying the barriers to ecoinnovation in the LED sector, I will use the below list of barriers that I have collected from the research literature.

I have used two simple levels of barriers: those originating from within your organisation (A), and those originating from outside (B). The barriers are organised in different categories. I will use the transistions approach introduced in Leuven later on when analysing of the interviews.

During the interview, I will ask you 3 things:

1) to evaluate how important is the barrier for your organisation [-1: Not a barrier but on the contrary a support to ecoinnovation; 0: Barrier irrelevant for my organisation, 1: Barrier relevant for my organisation],

2) at the end of the interview, to suggest solutions to lift that obstacle for your organisation (for the major barriers only).

* EI is defined as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollu- tion and other negative impacts of resources use (including energy use) compared to relevant alternatives"
Source: Kemp, R. (2010). Eco-innovation: Definition, Measurement and Open Research Issues. Economia Politica 0(3): 397-420.

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A - BARRIERS WITHIN YOUR ORGANISATION (1/3)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
VISION & STRATEGY	Lack of clear definition of ecoinnovation					
	Weak environmental commitments					
	Environmental commitments are not realised					
	...					
INNOVATION & DESIGN MANAGEMENT	Lack of consistent R&D strategy					
	Lack of integration of ecological objectives in the design phase					
	Too much uncertainty in the timing of innovation					
	Cognitive routines and shared beliefs of designers are not geared towards ecoinnovation					
	Sticky Knowledge: some people are reluctant to share their knowledge, recipients cannot process the information, ...					
	...					

A - BARRIERS WITHIN YOUR ORGANISATION (2/3)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
TECHNOLOGY	LED products are not recyclable enough					
	LED glare is an obstacle to ecoinnovation					
	Blue light hazard is an obstacle to ecoinnovation					
	The hazardousness of LEDs is an obstacle to ecoinnovation					
	All weather usage design is an obstacle to ecoinnovation					
	The light spectrum demanded by consumers contradicts with an ecoinnovation approach					
	LED drivers are barriers to ecoinnovation (too fragile e.g.)					
	...					
HUMAN RESOURCES	Staff lacks information on technologies & markets					
	Employees' resistance to implementing ecoinnovation					
	Lack of access to the knowledge of other firms through strategic alliances					
	Lack of access to information about the needs of different markets					
	Human resource management is not supportive of ecoinnovation					
	Lack of technical personnel to ecoinnovate					
	Difficulties in allocating staff to new ecoinnovation missions due to on-going projects					
	LEDs perceived as ecoinnovations per se, and thus no further effort seems to be required to reduce its ecological impacts					
	Lack of training for ecoinnovation					
	Lack of skilled sales personnel in ecoinnovation					
	...					

A - BARRIERS WITHIN YOUR ORGANISATION (3/3)

Categories	Barriers	How problematic is that barrier to ecoinnovation for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
FINANCE	Lack of networks to access external financial resources					
	Lack of in-house sources of finance					
	Excessive perceived risk of ecoinnovation investments					
	The pay-off period of ecoinnovation is too long					
	Difficulty to calculate future benefits					
	The gross intrinsic value is too low, which discourages innovation in recycling technologies					
	High cost of ecoinnovation development (capital, software, maintenance ...)					
	High cost of knowledge acquisition					
	Eco-innovation costs are too difficult to control					
	Economies of scope are too small to reduce costs (hence a difficulty to apply innovations to different contexts)					
	High sunk investments (switch to new technologies once investments are written off)					
	...					
RESOURCES & CAPABILITIES	Marketing and sales channels have not been developed yet					
	Information sharing between marketing and R&D departments is weak					
	Disadvantageous position in the product chain					
	Difficulties in training skilled people on ecoinnovation					
	The location of your organisation is detrimental to ecoinnovation					
	Information systems are sources of rigidity that discourage ecoinnovation					
	Lack of ecodesign tools					
	The size of your organisation is too small to ecoinnovate					
	Lack of access to the technical knowledge of research labs and universities through alliances					
	...					

B - BARRIERS OUTSIDE YOUR ORGANISATION (1/6)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
Markets & User practices						
Markets for raw materials	Decreasing scarcity & hence decreasing prices of raw materials					
	Key resources are mostly available from monopolistic markets					
	Lack of traceability of raw materials					
	...					
Financial markets	Financial institutions are not sensitive enough to ecoinnovation					
	Lack of funding for ecoinnovation					
	Lack of funding to support SMEs' ecoinnovation					
	Inadequate instruments of credit to support ecoinnovation					
	Tax regimes not supportive of ecoinnovation (R&D tax credit, ...)					
	Slowness in the setting of financing					
	Upfront costs to set up an LED system as too high (e.g. the initial costs associated with the LED panel)					
	...					
Labour market	The domestic labour market is too heavily regulated					
	Educational institutions do not provide enough people well trained to develop ecoinnovations					
	Reluctance of skilled personnel to work for SMEs					
	Lack of skilled people to repair used LED products, which is a disincentive to undertake DfR projects					
	Lack of external technical services that are key to the development of ecodesigned LEDs					
	...					

B - BARRIERS OUTSIDE YOUR ORGANISATION (2/6)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
User practices & lifestyles	Insufficient demand for greener products					
	Users lack information on LED markets & technologies					
	Lack of consumer awareness & concern regarding ecological issues in general and energy saving in particular					
	There are too many lighting products on the market for consumers to identify LEDs as a potential choice					
	Consumers perceive LEDs as a risky and/or fragile technology					
	Little recycling of used lighting equipment => lack incentive for DfR since too little collection					
	Setting up an LED system is too complex (e.g. need to change whole lighting system while production is running)					
	...					
Markets & User practices (suite)						
Technological niches (radical innovations: e.g. the demonstrators of the cycLED project)	LED technological niches are not protective enough for radical ecoinnovations to emerge					
	The allocation of LED technological niches among organisations is biased towards large organisations					
	Lack of modularity between radical innovations					
	Lack of knowledge exchange among the actors of LED technological niches					
	Lack of trust among the core actors of LED technological niches					
	Too many heterogeneous LED market niches, which tends to slow down technological accumulation					
	Mismatch between LED technological niches and its broader context (markets, policies, ...)					
	LED technological niches have a low potential for acting as technological add-ons (deters hybridization & diffusion)					

B - BARRIERS OUTSIDE YOUR ORGANISATION (3/6)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
Markets & User practices (suite)	The claim for environmental-friendliness of LEDs is not yet trusted by household consumers					
	The claim for environmental-friendliness of LEDs is not yet trusted by industrial consumers					
	The claim for the energy saving potential of LEDs is not yet trusted by industrial consumers					
	...					
Policies & norms						
Policy objectives	National policies do not provide adequate support to ecoinnovation and/or emerging LED technologies					
	European policies do not provide adequate support to ecoinnovation and/or emerging LED technologies					
	National policies do not support enough SMEs					
	European policies do not support enough SMEs					
	...					
Policy instruments	Environmental policies are not innovation-friendly (e.g. ETAP, RoHS, WEEE, EuP, IPP, ...)					
	Innovation policies are not enough supporting ecoinnovation					
	Ecoinnovation policies are not consistent enough (e.g. hard to anticipate, lack consultation with industry, ...)					
	Ecoinnovation policies are not SME-friendly					
	Commercial law is not favourable to ecoinnovation					
	Insurance rules are obstacles to ecoinnovation					
	Governmental subsidies are discouraging ecoinnovation by LED firms					
	There are legally binding contracts for the provision of electricity and/or lighting that discourage ecoinnovation					
	Lack of certification mechanisms to check out the technical specifications of products put on the market					
	There is a lack of enforcement of the policies that could support ecoinnovation in the LED sector					
	...					

B - BARRIERS OUTSIDE YOUR ORGANISATION (4/6)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
Policies & norms						
IPR regime	Some firms are keeping their technologies secret or refuse to licence them (hold-up problem)					
	In the LED sector, secrecy is more valuable than patents (thus knowledge leakage is minimised)					
	Standard setting in the LED sector is made at the expense of SMEs' ecoinnovation, e.g. Zhaga					
	...					
End-of-life policies	Lack of support for DfR					
	E-waste regulations are not supporting ecoinnovation, notably DfR					
	The European patchwork of e-waste policy implementaion is detrimental to ecoinnovation					
	...					
Infrastructures	Material environments (urban structures, electricity networks, infrastructures, ...) are obstacles to EIs					
	Current electrical / lighting infrastructure deters ecoinnovation (problems of compatibility, competencies...)					
	...					
LED industry	Product take-back systems are not efficient enough to ensure high collection rates (thus DfR discouraged)					
	Lack of professional associations supportive of ecoinnovation					
	Industry consortia generate obstacles to ecoinnovation for SMEs					
	Lack of specialised press and/or general media support on LEDs					
	Lack of 'coopetition' between actors (e.g. collaboration among competitors prior to production)					
	Lack of appropriate luminaires suitable for LEDs					
	Obsolescence by design is a strong driver of competition in the lighting and/or LED sector					

B - BARRIERS OUTSIDE YOUR ORGANISATION (5/6)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
LED industry	Technological selection mechanisms in the LED market are not favourable to ecoinnovation					
	Increasing & unfair competition from non-European firms					
	Lack of hypes and bandwagon effects around LEDs (they tend to push firms to innovate)					
	Lack of new conferences where engineers and designers can meet and discuss					
	Weak linkages between small & large firms					
	Lack of trust, collective norms, networks and shared expectations and beliefs					
	Existence of litigations between firms					
	Formation of firm cliques (groups), which prevent other firms to enter the clique					
	Highly competitive environment (prevents the of trust between organizations)					
	Lack of opportunities to cooperate with other firms and technological institutions					
	Lack of collaboration among LED firms to share knowledge					
	There are weak linkages between universities and industry					
	Lack of skilled suppliers					
	Technology is not cost-effective enough					
	LED products are not modular enough					
	A dominant design has emerged & reduces design variety that could foster ecoinnovation					
	Dominant design methods in the lighting industry are driven by built-in obsolescence					
	Consortia membership is expensive					
	Strong lobbying power of consortia that can impose their standards to the whole industry					
	Too many competing consortia (can reduce opportunities)					
	Lobbying through industry consortia, can prevent the diffusion of ecoinnovations made by small firms					
	...					

B - BARRIERS OUTSIDE YOUR ORGANISATION (6/6)

Categories	Barriers	How problematic is that barrier to EI for your organisation?				Suggest solutions to overcome this barrier
		-1	0	1	2	
		Not a barrier: a support to ecoinnovation	Irrelevant for my organisation	Relevant barrier for my organisation	Major barrier for my organisation	
Global context						
Values, beliefs, ideologies, …	Belief that saving resources is not a very important thing to do					
	Belief that natural resources are meant to be exploited by human beings until they are exhausted					
	Climate scepticism					
	…					
Macro-economic	The current macroeconomic context is not favourable to ecoinnovation					
	Current macroeconomic policies are not supportive of ecoinnovation					
	Perceived economic risk influences negatively innovation in LEDs					
	WTO free trade rules have a negative impact on ecoinnovations					
	Market logics are driven by short term concerns					
	…					
Macro-political	High labour costs deter ecoinnovation					
	Currently, there is political instability that deters ecoinnovation					
	Lack of European vision & ambition on ecoinnovation					
	Member states not supportive of EU ecoinnovation plans					
	Dominant political coalitions are not effectively supporting ecoinnovation					
	Critical materials like REEs are mainly exported by non-european countries					
	…					
Ecological constraints	Energy sources not scarce enough					
	REE not critical enough					
	…					