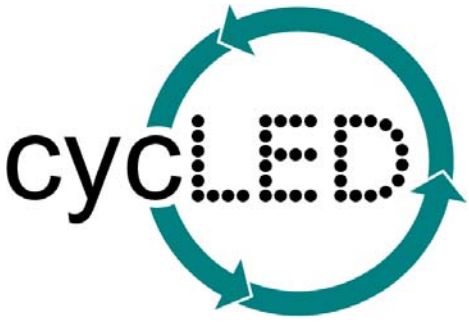

Grant Agreement number: 282793 (cycLED)

Project acronym: cycLED

Project title: Cycling resources embedded in systems containing Light Emitting Diodes

Deliverable 8.1.: Regulatory barriers to eco-innovation

Partner: IMT/TEM

Start date of project: 01.01.2012 Duration: 42 months

Main Author: Cédric Gossart (IMT/TEM)

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Project funded by the European Community under the 7th Framework Programme for Research and Technological Development.

Funding Scheme: Collaborative project

Call: FP7-ENV-2011-ECO-INNOVATION-TwoStage

Project website: http://www.cyc-LED.eu

Project number	282793 (cycLED)
Project title	Cycling resources embedded in systems containing Light Emitting Diodes

Deliverable title	Deliverable 8.1.: Regulatory barriers to ecoinnovation
Contractual date of delivery	30 March 2014
Actual date of delivery	22 April 2014
Deliverable file name	cycLED_D8.1_Regulatory barriers to eco-innovation
Nature of deliverable	R – Report
Number of pages	48
Work package	8
Partner responsible	IMT/TEM
Author(s)	Cédric Gossart, Altay Özaygen
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Abstract	This document presents the regulatory barriers to eco-innovation in the LED sector. These barriers have been collected through face-to-face interviews from the four cycLED partners in charge of developing a demonstrator (ONA, RIVA, BRAUN, ETAP), as well as through an online survey of European LED firms. This document also includes a study of patents as potential barriers to eco-innovation in the LED sector. It concludes by highlighting the benefits of its findings for actors involved in policy-making issues related to this sector.
Keywords	Barriers, regulation, eco-innovation, LED, SME, patent litigations.

Project funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	**x**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1. INTRODUCTION

This document is the Deliverable 8.1 of WP8. It summarises the results of our analysis of the regulatory barriers to eco-innovation collected from cycLED partners (Phase I) and from other LED firms (Phase II). On the basis of these findings, solutions will be formulated in D8.3 to help cycLED partners in charge of developing a demonstrator (ONA, RIVA, BRAUN, ETAP) as well as European LED firms to anticipate and overcome these barriers. Solutions for policy makers will also be suggested in D8.3. As argued in Cecere et al. (2014), an eco-innovation is an innovation that enables greater environmental performance compared to existing alternatives. Like innovation itself, it is not only technological but can also be organisational, behavioural, systemic, etc. Factors leading to increased firms' innovativeness originate both from within and outside the firm. Besides, a specificity of eco-innovations is that they are strongly shaped by regulatory measures. In order to ensure their success, it is therefore essential to identify potential regulatory obstacles to eco-innovation that could be overcome by developing and enforcing regulatory instruments. Indeed, not enforcing a regulation that could support eco-innovation can also be considered as a regulatory barrier that firms could suffer from.

Many studies have sought to analyse barriers to innovation. In their analysis of revealed versus deterring barriers, D'Este, Iammarino 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, conducted case studies, or focused on barriers to eco-innovation. Moreover, barriers faced by SMEs have seldom been analysed. In the context of the cycLED project (WP8), a qualitative analysis of eco-innovation barriers has been conducted by carrying out case studies with cycLED SME partners, covering both regulatory barriers as well as barriers to ecodesign (Phase I). In a second phase, the analysis of these two categories of barriers has been extended to other stakeholders beyond the cycLED project by means of an online survey (Phase II).

The methodologies and results of these two phases are presented below, with a focus on regulatory barriers, barriers to ecodesign being addressed in D8.2. Besides, an investigation of whether patents are barriers to LED eco-innovation is also presented in this document.

2. METHODOLOGIES

The activities of WP8 are divided into two phases. The first phase of WP8 aims to identify the barriers to eco-innovation faced by the four cycLED SMEs in charge of developing a demonstrator (ONA, RIVA, BRAUN, ETAP), and to suggest solutions for these four SMEs to overcome their own barriers. The second phase seeks to identify barriers to eco-innovation beyond the cycLED project, and has thus required extending the

identification of barriers and of their related solutions to other stakeholders involved in the European LED sector.

2.1. The methodology used in Phase I

In order to prepare the interview guideline that has helped us identify regulatory barriers to eco-innovation and barriers to ecodesign, a review of the literature has been prepared. A commonly used list of innovation barriers is also included in the Community Innovation Survey (CIS), which mentions three categories of barriers to innovation: Risk and finance, Knowledge-skill within enterprise, Knowledge-skill outside the enterprise, and Regulations (Mohnen and Röller (2005)). In their study of the potential and challenges of solid state lighting (SSL) in Europe, De Almeida, Santos et al. (2014) complemented the CIS barriers with the following barriers in the case 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 of information were used (see reference list in Appendix n°1), which has enabled us to prepare a more detailed list of barriers. The information collected on regulatory barriers to eco-innovation and on barriers to ecodesign contained a mixing of these two categories of barriers, but in our study we have separated these two categories.

Besides, in the context of the cycLED project, barriers to eco-innovation have been analysed in order to help cycLED demonstrators to overcome their barriers and to successfully eco-innovate, but also in order to support the development of a sustainable European lighting industry. By means of case studies, we have analysed barriers faced by cycLED SMEs and which originate both within their organisation and outside of their organisation.[1]

Case studies consisted in in-depth interviews carried out with the support of the abovementioned interview guideline reproduced in Appendix n°2, in which potential barriers were collected from the aforementioned literature review. The final guideline contained 144 barriers concerning regulatory barriers, as well as barriers to ecodesign.

Face-to-face interviews were conducted with the four SMEs of the project in charge of delivering demonstrators of ecodesigned LED products. For each of the 144 barriers, SMEs were asked to provide an evaluation about how important they were for their organisation by using four different levels:

- 2 (Major barrier to eco-innovation for my organisation).
- 1 (Relevant barrier to eco-innovation for my organisation)

[1] In the interview guideline included in Appendix n°2, we refer to barriers to ecodesign as “A. Barriers within your organisation”. As for regulatory barriers to eco-innovation, they are termed “B. Barriers outside your organisation”. As explained in the introduction of the interview guideline, this rephrasing has be adopted for pedagogical reasons in order to facilitate the interviews with firms, who had a clearer idea of what regulatory barriers and barriers to ecodesign were when using those terms.

- 0 (Irrelevant barrier to eco-innovation for my organisation)
- -1 (Not a barrier but rather a support to eco-innovation)

2.2. The methodology used in Phase II

After the qualitative analysis of barriers to eco-innovation within the cycLED project presented above, we have broadened the scope of our analysis of LED eco-innovation barriers by including other stakeholders. This has enabled us to examine the barriers faced by other stakeholders of the European LED sector, and to formulate specific policy recommendations to support the sustainability transition of the European lighting industry.

To do so, we have prepared an online questionnaire available in 6 languages.[2] As in any research project there were risks associated with this strategy, the main one being a low response rate from LED firms, despite the short duration required to fill in the questionnaire (15 minutes). In order to increase the number of responses to our email and telephone queries, we have also given the questionnaire during professional fairs where many firms are physically present. This strategy has enabled us to increase our response rate during the 2014 LED Forum in Paris. This positive strategy has been renewed during the 2015 Metropolitan solutions conference in Berlin, which hosted the Smart Lighting conference.

Our web-based survey has built on the Community Innovation Survey (CIS) to enable the assessment of barriers to eco-innovation in the European LED sector. The survey consists of a maximum number of 35 questions, because since some questions are conditional that number could be lower. It contained four sections:

1. Information about the firm (Name, address, capital structure, market, active in LED production or not);
2. Eco-innovation activities;
3. Barriers to eco-innovation (financial, knowledge, market, other factors hampering eco-innovation);
4. Other information about the firm (revenues, patents, patent licence).

To complete the qualitative analysis of Phase I, an online survey is conducted in order to obtain quantitative data during Phase II. Data obtained through surveys represent an important input to understand innovation activities. As it has been pointed out by Kemp and Pearson (2007), it is difficult for data obtained in surveys to be linked to different databases or other survey data. Kemp & Arundel (2009) argue that surveys should contain relevant questions to obtain data on determinants and control variables to measure eco-innovation, and they propose an optimal set of survey questions as given below.

[2] English, French, German, Italian, Spanish, and Turkish. See http://cycled-survey.eu/. These are the languages spoken in countries where we had contacts that could help us find interviewees.

Determinants (drivers and barriers) of eco-innovation:

- Inputs: financial and human resources, R&D expenditure supporting the technological capabilities of a firm;
- Environmental policy framework (e.g. regulatory stringency, different environmental policy instruments such as technology-based standards, emission taxes or liability for environmental damages);
- Existence of environmental management systems, practices and tools;
- Demand pull hypothesis: expected market demand, profit situation in the past;
- Appropriation problem: competition situation (e.g. number of competitors, concentration of the market), innovation cooperation;
- Influence of stakeholders and motivations for environmental innovation (e.g. public authorities, pressure groups such as industry or trade associations);
- Availability of risk capital;
- Availability of high-skilled labour force.

Control variables and impacts:

- Firm-level attributes (sector, size, stock market listing, employment, value of shipments);
- Commercial conditions (scope of the firms' markets, competition, sales, profitability);
- Environmental impacts of the facilities' products and production processes by different environmental fields (importance of each impact and change in impacts during the last three years).

As Kemp and Pearson (2007) point out, by adding questions related to eco-innovation to the Community Innovation Surveys, it is possible to gain a greater knowledge about eco-innovation activities in Europe. This is what we have done for the Phase II of WP8. We adapted the CIS survey with questions aiming to better understand eco-innovation activities in the European LED sector. Therefore, our survey integrates the propositions made by Kemp and Pearson (2007) as well as the suggestions made by Arundel (2005) regarding the formulation of questions (e.g. asking questions in a simple manner and if possible with binary answers, as argued in Kemp & Arundel (2009: 25): "In many cases, ordinal or nominal questions can provide higher quality results.").

Finally, we also used the control variables suggested by Kemp & Arundel (2009: 33-34):

> "the following types of control variables will need to be asked in the eco-innovation questionnaire:
>
> · Firm-level attributes (sector, employment, sales or other output measure).
>
> · Commercial conditions (scope of the firms' markets (where and what it sells), level of competition, and if possible, profitability)."

2.3. The methodology used to investigate patents as barriers to eco-innovation

During Phase I, a recurring barrier kept coming back in the interviews with cycLED SMEs and experts. It related with the potential role of patents as obstacles to LED eco-innovation. Patents are an instrument developed by governments to protect inventions and promote innovation. This explains why we have placed that investigation in this deliverable dealing with regulatory barriers. Indeed, if we were to find evidence that patents were indeed blocking LED eco-innovation, we could suggest changes in the regulations governing LED patenting in Europe. The results of our investigation are presented in Section 3.3 of this document.

While much has been written about the extent to which patenting systems in general, or patent litigations in particular, deter firms from participating in the innovation process, discussions have usually focused on legal and institutional levels. In this section, we are interested in the technological dimension of litigations. In particular, we address the following question: do litigated patents differ in terms of their scientific and technological characteristics from other patents in the industry? This question is important in two related ways, from both a technology and policy perspective.

From a technological point of view, we draw upon theories of innovation to claim that in the evolution of technologies, certain inventions have a stronger potential to open up new paths for further inventions. These technologies are particularly important, because many subsequent inventions build upon them, thereby contributing to the process of variety generation, which further enhances innovation through recombination. Especially in periods of rapid technological change, where variety generation and participation by many firms is at its peak, **the extent to which patents subjected to litigation are technologically important is likely to enhance an atmosphere of innovation deterrence**, both in terms of innovation and of entry in the sector by young and creative firms.

This brings forth the second way in which this question is important. Recently, an important policy debate has emerged about the extent to which patent systems might deter innovation in certain technological areas. For example, as opposed to the case of technologies like pharmaceuticals or biotechnology where research and development costs are very high and must be covered before the patent expires, it is not the case in the software industry. Patenting in this industry has become a field of war as evident in the explosion of litigation cases, even for codes which are considered general knowledge. The LED sector might be facing a similar situation, which would inhibit eco-innovation in this sector. While many studies have been performed for well established technologies like the above, policy recommendations to support eco-innovation with the current IPR system are lacking for relatively new technologies such as LEDs. Despite a very rapid change in technologies and standardisation efforts made by large companies, we know little about the extent to which patenting systems in general, and threats of litigations in particular, deter some firms from innovating. By addressing the question of the extent to which litigation patents have the potential to deter innovation by smaller firms, we will be able to highlight the extent to which patent wars

in the LED sector are based predominantly on strategic, political, or technological bases. This distinction in turn is important for designing and implementing policies which will shape the evolution of LED technologies. Finally, since comparative lifecycle assessments of various lighting technologies suggest that all the environmental impacts of the future generations of LEDs will be much lower than the ones of older lighting technologies, we assume that forthcoming LED innovations will be eco-innovations, namely that for the same service, in this case providing a certain amount of lumens per watt, they will generate less ecological impacts throughout their lifecycle compared to existing alternatives.

The patent analyses presented in this section use solely patents classified under the International Patent Code (IPC) "H01L 33" (more precisely: H01L33/00 - 33/64). This is the main IPC class for LED technologies used in lighting. The choice of this IPC class has been validated by experts working in the cycLED project and data wise we have used PATSTAT EPO Worldwide Patent Statistical Database. Patents represent a wonderful archive of invention (Griliches, 1990; Jaffe and Trajtenberg, 2005). By using patent databases with some heuristics and algorithms, it is possible to trace past technological developments, and therefore which technological paths have stopped while others have continued become obsolete in the face of other technological choices (Hummon and Doreian, 1989; Bagatelj, 2003; Verspagen, 2007).

In the first phase of our patent analysis we provide an overview of technology and patenting activities in the LED sector in the EU and the USA. We then identify technological barriers that may have shaped past technological developments. For this purpose, we used patent citation networks and the SPNP algorithm described in Verspagen (2007). In the second phase of the patent analysis, in order to understand whether IPR are also a barrier for firms to innovate, we have used patent litigation data in US courts and patents filed in the US patent office (USPTO).

3. REGULATORY BARRIERS TO ECO-INNOVATION

3.1. Results from Phase I

cycLED SMEs have used four different levels to evaluate the 144 barriers included in the interview guideline:

- 2 (Major barrier to eco-innovation for my organisation).
- 1 (Relevant barrier to eco-innovation for my organisation)
- 0 (Irrelevant barrier to eco-innovation for my organisation)
- -1 (Not a barrier but rather a support to eco-innovation)

Answers have enabled us to prepare a list of the most important barriers to eco-innovation for each SME individually and for the four SMEs are a whole. The table included in Appendix n°3 shows how each barrier

has been evaluated, and groups them in terms of levels. For example, the first page of Appendix n°3 includes the 14 barriers that have been evaluated with a level 2 by at least one firm. These barriers are "major" barriers to eco-innovation according to cycLED SMEs. If one barrier has been evaluated with a level 2 by more than one firm, the last column adds these evaluations: but the table shows that only one of the 144 barriers has received a number of level 2 evaluations greater than one ("Lack of in-house sources of finance"). This is a first method to rank the barriers by order of importance for cycLED SMEs.

A second way to do so is to calculate a score estimating the importance of each barrier for cycLED SMEs, by multiplying for the positive levels the number of evaluations by their value. For example, if the four SMEs had deemed the barrier "Lack of in-house sources of finance" a major one, they would have given it a level 2 evaluation. Therefore, this barrier would have obtained a score of 8, the maximum score. But as the first page of Appendix n°3 shows, the maximum score obtained by a single barrier is 5. It concerns the regulatory barrier "Lack of certification mechanisms to check out the technical specifications of products put on the market", because it has received one level 2 evaluation by one SME and three level 1 evaluations by three SMEs. This barrier is therefore the most important barrier to eco-innovation for cycLED SMEs.

Looking at the score of other barriers we can see that seven barriers have obtained a score of 4, such as in the category 'Technology' the barrier "LED drivers are barriers to eco-innovation", or in the category 'Finance' the 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 other project partners, the four SMEs were asked to explain which barrier could be overcome internally, and where could they seek help to do so.

The next table offers an overview of the main barriers to eco-innovation that need to be given priority in order to support the development of ecodesigned LEDs. The first one has received a score of 5 and the remaining seven ones a score of 4. Five of these eight most important barriers to eco-innovation identified by cycLED SMEs are regulatory barriers.

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 and unfair competition from non-European firms
LED industry	Technology is not cost-effective enough
Global context/Macro-political	Critical materials are mainly exported by non-European countries
FINANCE	Lack of in-house sources of finance
FINANCE	The gross intrinsic value is too low
TECHNOLOGY	LED drivers are barriers to ecoinnovation

NB: Barriers in capital letters refer to BARRIERS TO ECODESIGN (they will be dealt with in D8.2), and others to regulatory barriers.

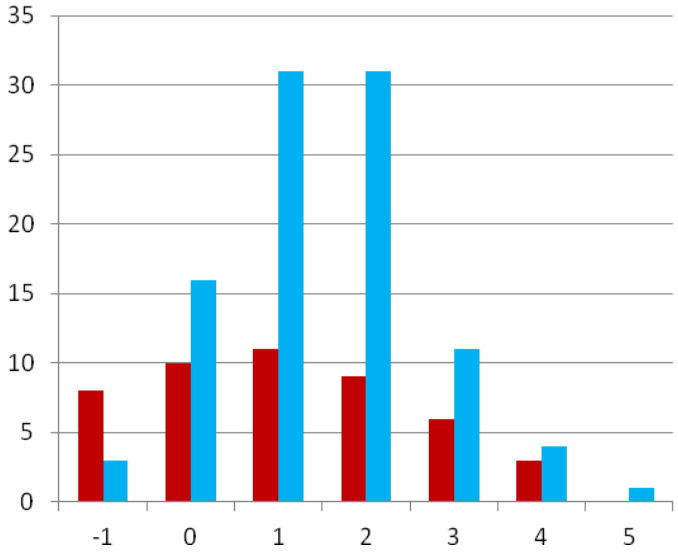
The following table shows that few barriers have obtained high scores, which suggests that the evaluations of cycLED SMEs were heterogeneous, i.e. that their obstacles to eco-innovation were quite different. It also shows that 42 regulatory barriers got a score of 2 or more, which represents 72% of the barriers having obtained such scores. This is partly due to the fact that the interview guideline contained more regulatory barriers (97) compared to barriers to ecodesign (47), namely 67% the 144 barriers evaluated in Phase I. This suggests that for cycLED SMEs, regulatory barriers seem to be more important than barriers to ecodesign.

Table 2. Distribution of barriers per type

Score of barriers	Regulatory barriers	Barriers to ecodesign	TOTAL NUMBER OF BARRIERS
5	1	0	1
4	4	3	7
3	11	6	17
2	31	9	40
1	31	11	42
0	16	10	26
-1	3	8	11
TOTAL	**97**	**47**	**144**

The following graphical representation of the above table shows a rather standard distribution of the barriers (blue bars represent regulatory barriers), since most of them are in the middle range, i.e. obtained a score of 2 or 3. But as explained above, there are more regulatory barriers evaluated with a higher level of importance than there are barriers to ecodesign.

Figure 1. Distribution of the scores of barriers (regulatory barriers in blue)

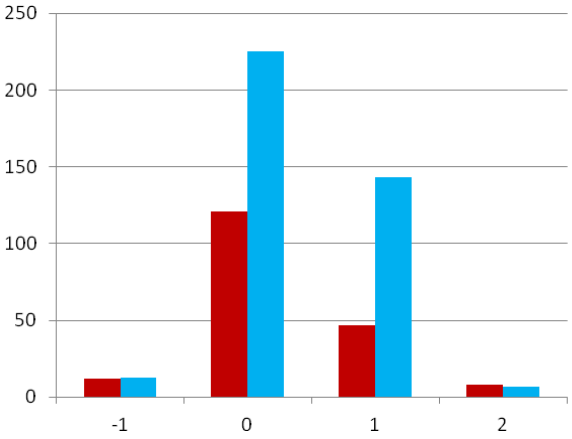


Each of the four SMEs has provided evaluations for each of the 144 barriers. Therefore, they have altogether completed 576 evaluations. The following table and graph show the distribution of these evaluations across each evaluation level (-1, 0, 1, 2).

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

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

Figure 2. Distribution of SMEs' evaluations per level of barrier (regulatory barriers in blue)



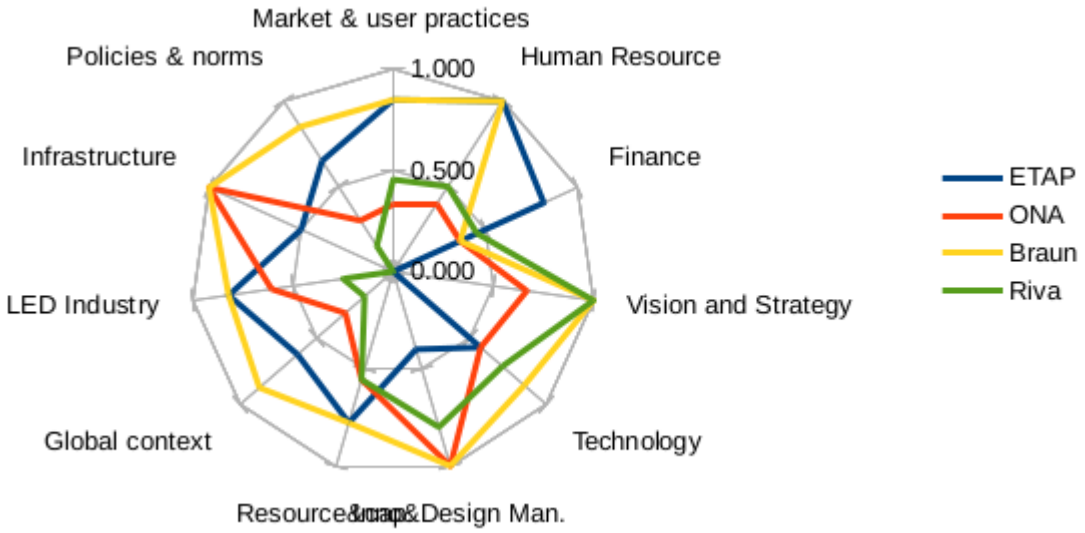
A first finding is that 60% of the evaluations correspond to barriers deemed by SMEs as "irrelevant" for their organisation (barrier level = 0). This can be explained by the fact that the range of barriers collected from the literature was much broader than the one covered by barriers to eco-innovation of SMEs in the LED sector. Among these barriers, 19 were deemed irrelevant by the four SMEs (**barrier level 0**). The following 11 regulatory barriers were deemed irrelevant by cycLED SMEs, suggesting that the following regulatory or contextual issues do not seem to be of any concern for LED SMEs:

- LED products are not modular enough
- Lack of professional associations supportive of ecoinnovation
- Too many competing consortia
- 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 new conferences where engineers and designers can meet and discuss
- Dominant design methods in the lighting industry are driven by built-in obsolescence
- Climate scepticism
- Currently, there is political instability that deters ecoinnovation

It is interesting to notice that three barriers were never deemed irrelevant by any of the four SMEs. One of them is the only barrier that obtained a score of five (regulatory barrier "Lack of certification mechanisms to check out the technical specifications of products put on the market"). The two others barriers never deemed irrelevant obtained a score of four and were also regulatory 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 reinforces the conclusion that regulatory barriers are an important source of eco-innovation blockage for LED SMEs.

But interesting results can be derived from the remaining 40% evaluations that got a positive or negative evaluation. Concerning negative evaluations (**evaluation level -1**), they mean that a firm could give a negative score to a barrier that from her point of view was actually not a barrier but rather an advantage. 23 barriers have received one evaluation of -1 (13 of which were regulatory barriers), and one regulatory barrier got two "-1" evaluations: "The size of your organisation is too small to ecoinnovate". This suggests that for cycLED SMEs being small is not perceived as a disadvantage to eco-innovate but rather as an advantage. The following figure shows that here again the responses of cycLED SMEs remain heterogeneous.

Figure 3. Irrelevant barriers to eco-innovation



Let us examine the barriers deemed relevant by cycLED SMEs (**evaluation level 1**). 75% of them were regulatory barriers, and cycLED SMEs had a different perception about the importance of these barriers, since only two regulatory barriers were deemed relevant by the 4 SMEs altogether:

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

Last but not least, 14 barriers were identified as major barriers by cycLED SMEs (**evaluation level 2**), but only one of them was mentioned as such by more than one SME (actually by only two SMEs): the barrier to ecodesign "Lack of in-house sources of finance", which will be discussed in D8.2. All the other barriers that received a level 2 evaluation concerned only one SME. The heterogeneity in the perception 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 in different countries or cities. This suggests that in order to better understand the barriers to eco-innovation in the LED sector, we should first analyse in detail the barriers identified by each SME (Phase I of WP8), and second expand our analysis beyond cycLED partners by studying barriers faced by other stakeholders (Phase II of WP8, whose results are presented in Section 3.2 of this document).

The following table presents the major barriers collected from cycLED SMEs. Barriers in capital letters refer to barriers to ecodesign (addressed in D8.2), and others to regulatory barriers. It shows that 8 of the 14 major barriers are regulatory barriers, which corroborates our finding that regulatory barriers seem to be major obstacles to eco-innovation for LED SMEs.

Table 4. Major barriers to eco-innovation according to cycLED SMEs (level 2)

Category	Barrier
LED industry	Increasing & unfair competition from non-European firms
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/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations
Markets & User practices/Technological niches	Lack of modularity between radical innovations
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
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
FINANCE	ECO-INNOVATION COSTS ARE TOO DIFFICULT TO CONTROL
HUMAN RESOURCES	LACK OF TECHNICAL PERSONNEL TO ECOINNOVATE
RESOURCES & CAPABILITIES	INFORMATION SYSTEMS ARE SOURCES OF RIGIDITY THAT DISCOURAGE ECOINNOVATION
TECHNOLOGY	LED DRIVERS ARE BARRIERS TO ECOINNOVATION

3.2. Results from Phase II

The survey questions dealing with barriers to eco-innovation were divided into four different groups: financial barriers, knowledge barriers, market barriers, and other barriers. Market and other barriers were taken as regulatory barriers and are thus dealt with in this deliverable. On the other hand, financial and knowledge barriers were taken as barriers to ecodesign and are thus dealt with in D8.2.

Barriers concerning the regulation of eco-innovation markets are presented in the following table. Our results suggest that the main one relates to the fact that **consumers lack knowledge about eco-innovative products** and services (black cell). It is also interesting to notice that 35% of the surveyed firms feel that incumbent firms prevent them from entering eco-innovative markets, and that consumers are not willing to spend money on eco-innovative LED products (grey cells). We will see in the next section that barriers to entry are placed by using aggressive intellectual property rights (IPR) management strategies.

Table 5. Market barriers to eco-innovate

	HIGH	MEDIUM	LOW	N/A	V	SUM
Consumers lack knowledge about eco-innovative products	41%	26%	24%	6%	3%	**100%**
Consumers not willing to spend on eco-innovations	24%	38%	21%	15%	2%	**100%**
Established firms prevent entering eco-innovation markets	21%	35%	24%	18%	2%	**100%**
Demand for eco-innovative goods or services is too uncertain	21%	32%	35%	9%	3%	**100%**
Unfair competition from non-European enterprises	18%	26%	35%	18%	3%	**100%**
Difficulty to find suppliers to develop eco-innovations	6%	26%	47%	18%	3%	**100%**

Finally, a last category of (mostly regulatory) barriers provides a result that should be of interest to the European Commission who financed the cycLED project, because the most important of the 16 miscellaneous barriers is that for 27% of the respondents there is a **lack of EU policies supporting eco-innovation** (black cell).

Table 6. Other factors to eco-innovate

	HIGH	MEDIUM	LOW	N/A	V	SUM
Lack of EU policies supporting eco-innovation	27%	35%	15%	21%	2%	**100%**
Lack of standardisation in your sector	18%	35%	35%	9%	3%	**100%**
Future standards in your sector are uncertain	18%	41%	26%	12%	3%	**100%**
Difficulty to adopt business models suitable to eco-innovations	18%	21%	32%	26%	3%	**100%**
High risk of legal conflicts on intellectual property rights	18%	29%	21%	18%	14%	**100%**
High risks associated with eco-innovations	12%	21%	47%	18%	2%	**100%**
Lack of cooperation between firms of your sector on eco-innovation	12%	35%	38%	12%	3%	**100%**
Difficulties to access EU instruments supporting eco-innovations	12%	47%	15%	24%	2%	**100%**
Eco-innovation is not a strategic priority for your enterprise	9%	18%	53%	18%	2%	**100%**
Firms using LEDs already eco-innovate	9%	27%	24%	38%	2%	**100%**
Low collection rates of e-waste take-back systems	9%	15%	27%	47%	2%	**100%**
LED drivers are obstacles to eco-innovation	6%	21%	47%	24%	2%	**100%**
High licensing costs of eco-innovations	3%	24%	38%	29%	6%	**100%**
Firms in your sector refuse to licence eco-innovations secret	3%	27%	32%	35%	3%	**100%**
Rigid information systems discourage eco-innovation	3%	15%	47%	32%	3%	**100%**
Used products becoming waste are not returned to their producers	3%	24%	24%	47%	2%	**100%**

Also, about half of surveyed firms felt that uncertain LED standards and difficulties to access EU eco-innovation instruments were important obstacles to eco-innovation (grey cells), as well as a lack of standardisation in the LED sector (41%). The next section turns to a specific potential barrier to eco-innovation in the European LED sector: patents as a means for incumbent firms to deter eco-innovation by new entrants.

3.3. Are patents obstacles to LED eco-innovation?

We have presented above a number of regulatory obstacles hindering LED eco-innovation. We will now examine the extent to which LED patenting strategies might as well block eco-innovation in the LED sector. To introduce the data set that we have used to investigate that question, the following table shows that the USPTO is the first patent office (PO) in terms of **LED-related granted patents**. The second one is the Japan Patent Office (JPO), whereas and the European Patent Office (EPO) is the sixth. Out of 50652 LED-related patents granted by the six main patent offices in the world, the USPTO receives 36% of them, the JPO 28%, and the EPO only 4%.

Table 7. Number of published and first granted H01L33 patents per patent office

USPTO	18.106
JPO	13.932
PO China	6.448
PO Korea	6.007
PO Taiwan	4.026
EPO	2.133

Regarding the number of LED-related **patents applications** per patent office, the following table shows that JPO receives more patent applications in H01L33 IPC classes than any other patent office in the world. Out of 125167 LED-related patent applications sent to the six main world patent offices, 40% have been received by the JPO, 22% by the USPTO, and only 6% by the EPO.

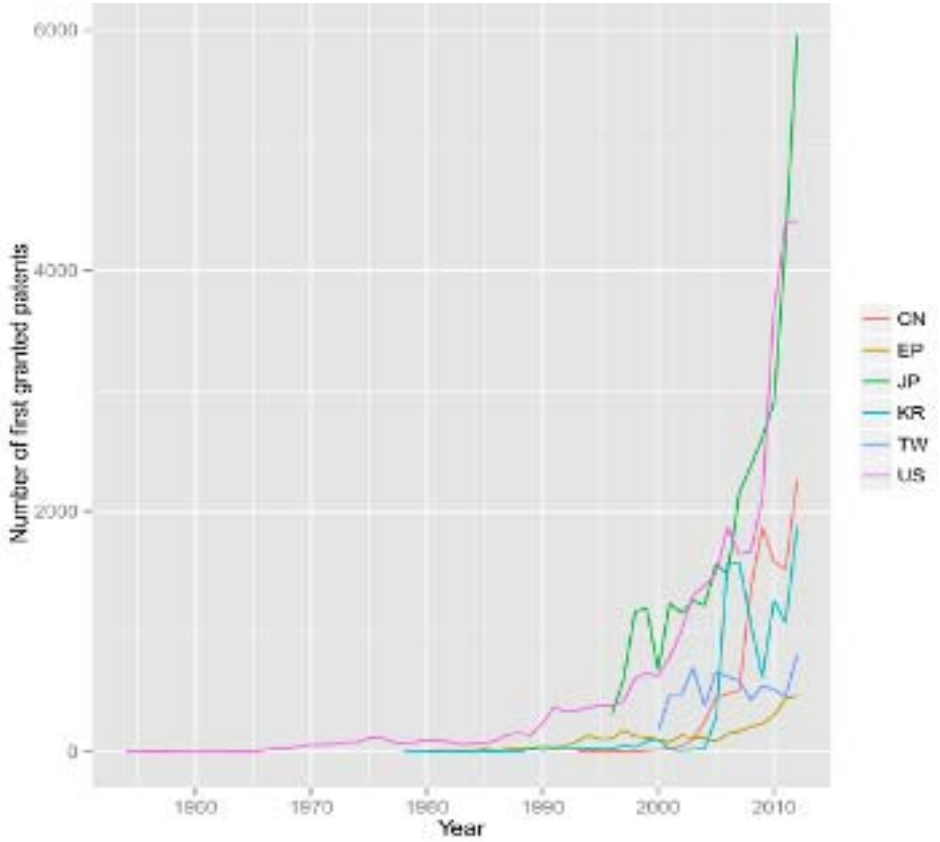
Table 8. Number of patent application in H01L33

Japan	49.931
United States	27.715
China	16.380
Korea	13.985
Taiwan	9.207
European Patent Office	7.949

Differences in national patent legislations can explain part of these differences, but the last two tables also suggest that Europe lags behind in terms of LED patenting. Since patents are an indicator of innovative activity in industrial sectors, it also suggests that the EU seems to be facing obstacles regarding LED-related innovations.

The following figure shows the annual change in the number of H01L33 patents published by the first six patent offices. It shows that after 2000, the US and Chinese PO are the two most active ones in terms of delivering LED related patents, which suggests a loss of LED innovation capacity in Japan.

Figure 4. Yearly published LED patents in the six leading patent offices in H01L33 IPC class (until the end of 2012)



The next table shows the first 20 firms in the number of granted patents in US. The first three firms are Japanese, followed by two Korean firms.

Table 9. Top 20 firms which have published patents in USPTO H01L33

TOSHIBA CORPORATION	577
SHARP CORPORATION	524
PANASONIC CORPORATION	482
LG INNOTEK COMPANY	481
SAMSUNG ELECTRONICS COMPANY	463
SONY CORPORATION	448
SEMICONDUCTOR ENERGY LABORATORY COMPANY	445
OSRAM OPTO SEMICONDUCTORS	375
TOYODA GOSEI COMPANY	367
CREE	347
NICHIA CORPORATION	329
ROHM COMPANY	272
SUMITOMO ELECTRIC INDUSTRIES	251
SAMSUNG ELECTRO-MECHANICS COMPANY	232
PHILIPS ELECTRONICS	221
SAMSUNG DISPLAY COMPANY	214
LG DISPLAY COMPANY	205
SHOWA DENKO	204
STANLEY ELECTRIC COMPANY	200
EPISTAR CORPORATION	174

NB: Firm names are aggregated according to the Eurocom-Eurostat-EPO PATSTAT person harmonized name.

The next table provides the same data with EPO-granted patents, and shows that the first firm is Philips followed by Osram, two European firms.

Table 10. Top 20 firms which have published patents in EPO H01L33

PHILIPS ELECTRONICS (and Lumileds)	200
OSRAM OPTO SEMICONDUCTORS	108
SHARP CORPORATION	65
PANASONIC CORPORATION	58
TOSHIBA CORPORATION	55
SUMITOMO ELECTRIC INDUSTRIES	54
CREE	53
AT&T	50
NICHIA CORPORATION	50
CANON	39
SONY CORPORATION	38
SIEMENS	36
TOYODA GOSEI COMPANY	34
LG INNOTEK COMPANY	33
NEC CORPORATION	32
FUJITSU	26
IBM	23
MITSUBISHI CHEMICALS CORPORATION	22
NATIONAL INSTITUTE FOR MATERIALS SCIENCE	20
SHIN ETSU HANDOTAI COMPANY	20
HITACHI	18

NB: Firm names are aggregated according to the Eurocom-Eurostat-EPO PATSTAT person harmonized name.

The next two tables show that Japanese firms have more patents in the US and in the EU compared to any other country, and that German companies rank third in the list of EPO granted patents (firms' nationality has been obtained by looking at the patent assignee's address given in patent documents).

Table 11. Top 10 countries based on the assignee address with the number of published H01L33 patents in USPTO

JP	7047
US	4300
KR	2367
TW	1717
DE	824
Unknown	471
NL	248
CN	221
FR	181
SG	156
GB	148
CA	70

Table 12. Top 12 countries based on the assignee address with the number of published patents in EPO H01L33

JP	871
US	471
DE	288
NL	153
FR	98
KR	95
GB	67
IT	26
SG	19
AT	17
TW	12
CN	12

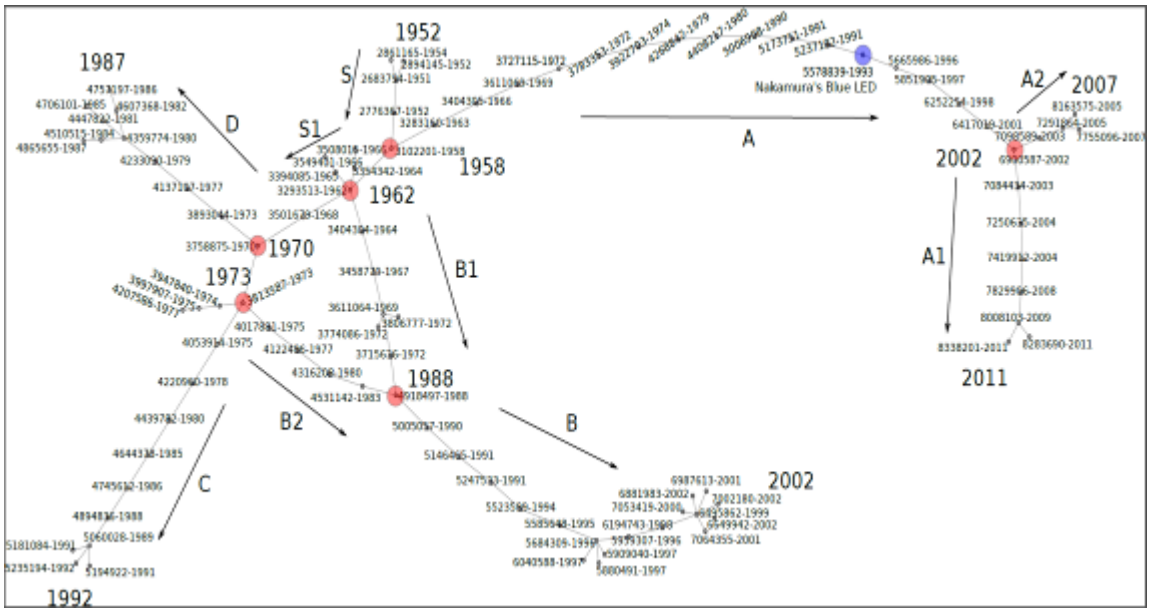
3.3.1. Technological development

Patent citation networks enable us to follow the development of a certain technological field in which patents have been granted. They allow us to trace different technological trajectories that a given technology has followed during its development (Verspagen, 2007). The next figure shows the

technological trajectories that LED technologies have followed since 1952. The main results of this analysis have been validated by experts from the cycLED team.

To obtain this figure, the SPNP algorithm has been used with an increment of 5 years starting from 1952. The A branch (1972-2002), which divides into two sub-branches (A1 and A2), represents the technological trajectory in which we find the most recently issued patents. This branch corresponds to patents used in technologies that dominate today's market, namely the ones that could manage to overcome barriers to innovation. Patents pertaining to other branches are related to technologies which have failed to persist and thus to overcome their barriers to innovation. We will examine to what extent these failures can be related to patenting strategies of incumbent firms.

Figure 5. Patent citation network of the LED lighting technology



The A branch (1972-2002) is related to gallium nitride (GaN) LEDs until 1997, which also comprise the famous blue LED patent filed by Nichia and the Nobel prize winner Nakamura. The last two patents of this branch, which have been filed in 1998 and 2001, are related to phosphor compositions used in LEDs. Then this main branch divides into two sub-branches. A1 relates to light extraction and light reflection and efficiency, and the last patent of this branch issued in 2011 to OLED fabrication (publication number = 8338201). A2 relates to the fabrication and growth of light emitting semi-conductor crystals.

The other branches diverging from branch A are branches B, C and D. The branch B and its sub-branches B1 and B2 are mainly related to SiC (silicon carbide) and the epitaxial growth of semiconductor material. The B branches starting in 1998 and continuing until 2002 account for various materials which are SiC, GaAl (gallium aluminium), GaN and Group III nitride-based semiconductors. The D branch (1970-1987) is related to the layering of substrate in wafer production. The C branch (1973-1992) is related to LEDs based on GaP (gallium phosphide) and GaAl.

In 2014, Shuji Nakamura won the Nobel Prize in physics for his research on blue LED. According to the *LEDs Magazine*, Nakamura's patent on blue LED is considered an important leap by introducing new techniques to obtain superior brightness for the commercialization of LEDs. However, the magazine also points out that even the brightest p-doped GaN-on-sapphire substrate cannot illuminate a living room on its own, and posits that advances in LED technologies mainly rely on system-wide synergies. Furthermore, the magazine questions the true impact of this patent, and argues that there are more important technological advances in LED optics for lighting. The magazine however asserts that the patents of Nakamura in the 1990s are disruptive.[3]

3.3.2. Product announcements and patent litigations

If patents are used to deter innovation in the LED sector, evidence of such strategies can be revealed by patent litigations, which could explain why some branches have stopped. In order to obtain data on patent litigations in the LED sector, in September 2013 the website of the *LEDs Magazine* (http://www.ledsmagazine.com) has been crawled in order to collect patent licensing and product announcements since 2002.

The next table gives the top 30 firms ranked in terms of product announcements. Their name is aggregated under firms' website. In this list, the first two firms are European (Philips and OSRAM). These firms have provided a larger number of product announcements compared to other firms.

[3] See http://ledsmagazine.com/features/10/5/2.

Table 13. Top 30 firms in terms of product announcements

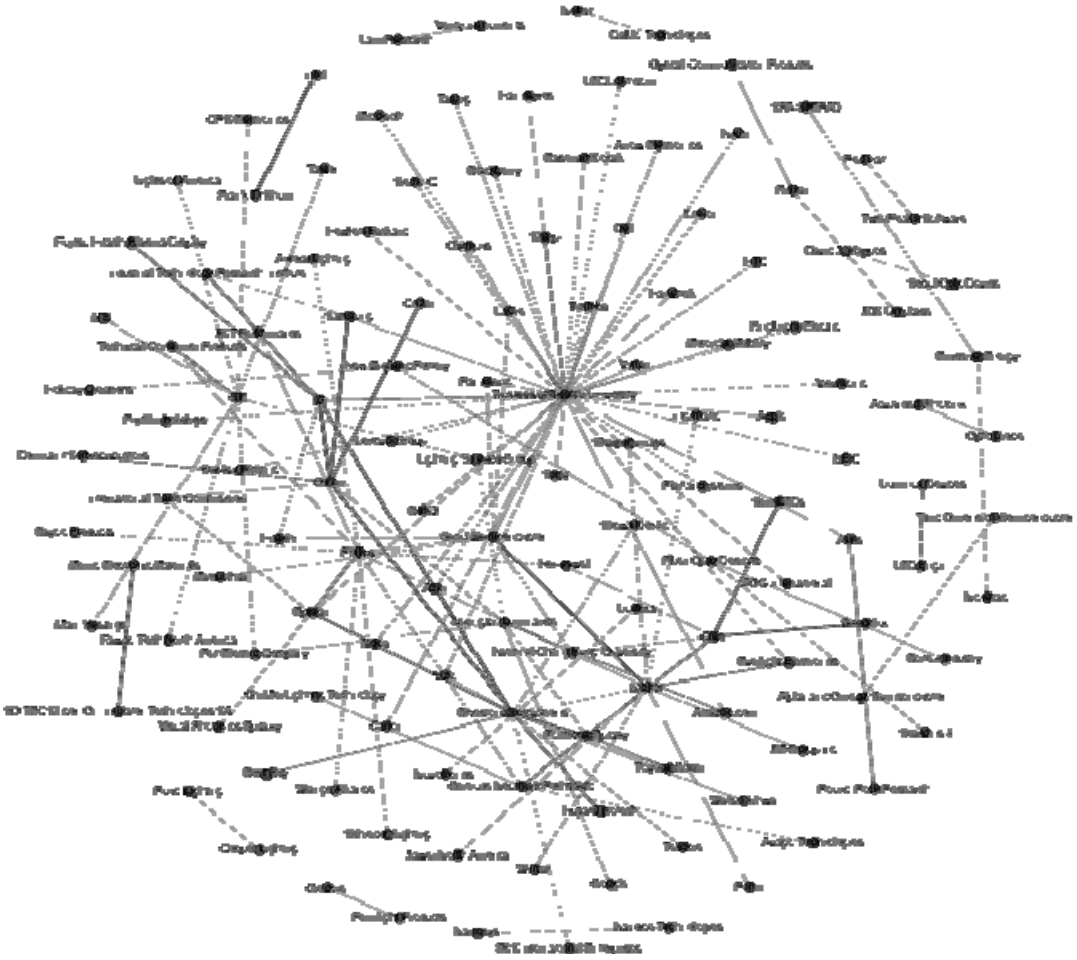
Firm website	Number of product announcements
http://www.osram.com	157
http://www.philips.com	101
http://www.cree.com	86
http://www.atgelectronics.com	84
http://www.linear.com	58
http://www.spark-oe.com	52
http://www.acuitybrands.com	47
http://www.ledtronics.com	46
http://www.lighthouse-tech.com	46
http://www.dialight.com	45
http://www.glaciallight.com	41
http://www.dominant-semi.com	40
http://www.edison-opto.com.tw	40
http://www.ambergreat.com	39
http://www.avagotech.com	35
http://www.aixtron.com	35
http://www.sharp.com	32
http://www.waclighting.com	29
http://www.ledialighting.com	29
http://www.elationlighting.com	29
http://www.khatod.com	29
http://www.masterbond.com	29
http://www.everlight.com	29
http://www.glacialtech.com	28
http://www.lumex.com	27
http://www.ti.com	26
http://www.futurelightingsolutions.com	25
http://www.ledengin.com	25
http://www.optekinc.com	24
http://www.daktronics.com	24
http://www.americanbrightled.com	24
http://www.mblock.com.tw	24
http://www.labsphere.com	23
http://www.luminus.com	23
http://www.magtechind.com	23
http://www.jkllamps.com	23
http://www.barco.com	23
http://www.supertex.com	23
http://www.meanwell.com	23
http://www.ledouxlite.com	22
http://www.gelighting.com	22

3.3.3. Alliances and litigation among firms active in LED industry

From the news section of the *LEDs Magazine*, we could obtain alliance and litigation data by using web scrapping techniques. In some cases, litigation or risk of litigation has been resolved by means of an alliance between the competing firms. The litigation issue is complex and shows various strategic decisions from involved firms. The literature on patent litigation is mainly focused on software industry (Bessen, 2009; Alison et al., 2009; Bessen et al., 2011), but it has been asserted that a tight IPR regime would increase the number of patent litigations (Dosi et al., 2006).

Data on litigation related to patent infringements are obtained from the *LEDs Magazine*. Infringements are related LED equipment and products, but not all infringements are related with patents bearing the H01L33 IPC code. The next figure shows patent litigation data for the H01L33 IPC code obtained through the Maxval-IP database.[4] The total number of patent litigations obtained by from Maxval-IP Litigation Databank is 171. Out of court settlements are not included in this analysis. This figure shows the importance of non-practicing entities (NPE) or patent trolls, which became important actors in intellectual property right issues, and which are using patents for profiteering and not to protect innovation; rather they deter it. Unfortunately, patent trolling also exists in the LED sector and is a barrier to innovation that needs to be addressed.

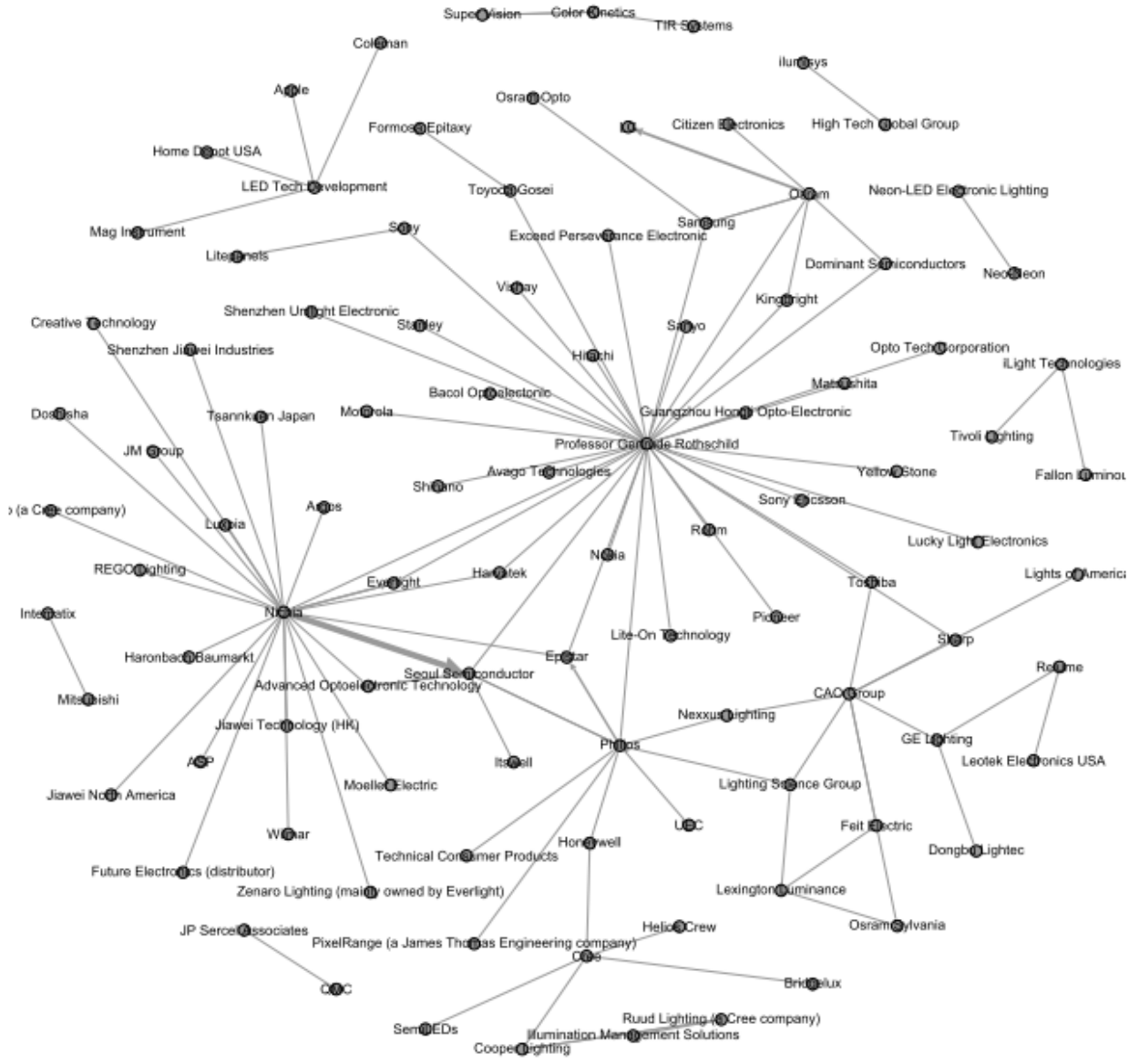
Figure 6. LED related patent litigation network of firms



The next figure is a directed graph of patent litigation cases based on inventors. The direction of the edge goes from the plaintiff to the defendant. As an independent researcher, Professor Gertrude Rothschild is as an important node in this figure. She made important contributions to the LED industry with her research and throughout her career was awarded a number of patents. Towards the end of life of her patents, she defended her patents with various litigation cases against different firms in US courts (Grimes, 2010).

[4] See http://litigation.maxval-ip.com.

Figure 7. LED related patent litigation network of inventors



Information obtained from the *LEDs Magazine* suggests that keeping litigations' resolutions secret is a common practice. The network of licences obtained from the *LEDs Magazine* suggests that Philips is not the most important licensor in the LED industry. However, Philips' LED licence program shows that it has signed more than 400 licence agreements. As the industry leader, Philips uses patents as an important revenue generation tool.

According to data obtained from Maxval-IP, the most valuable patent is US5686738, which is subjected to 43 patent litigation cases (see the list of plaintiffs below). This patent is owned by Boston University, which is also the plaintiff with the highest number of cases. The second plaintiff is Bluestone Innovation, with 24 litigation cases, followed by GE and Osram (8 cases). The second plaintiff, Bluestone Innovation is a non-practicing entity, which is why it is not found in the list of defendants. The list of firms facing legal proceedings starts with LG (12 cases), followed by Osram and Cree which are the most often sued firms

(see the list of defendants below). These litigation data show that Philips does not follow an aggressive patent litigation strategy. But in order to understand Philips' patenting strategy a more detailed analysis of its licensing program is needed.

Table 14. Top 10 plaintiff firms in H01L33-related patent litigation cases

Trustees of Boston University	43
Bluestone Innovations	24
Osram	8
GE	8
Nichia	7
Seoul Semiconductor	7
Philips	7
Lexington Luminance	6
Gertrude Neumark Rothschild	5
Frank T. Shum	4

Table 15. Top 10 defendant firms in H01L33-related patent litigation cases

LG	12
Osram	11
Cree	8
Nichia	7
Epistar	6
Formosa Epitaxy	6
Philips	5
Intel	4
Seoul Semiconductor	4
Samsung	4

3.3.4. Litigated patents and H01L33-related patents

In order to make profit out of patents without conducting innovation activities, some firms such as patent trolls issue low value patents and use them in litigation cases. Therefore, identifying these low value patents could help us identify actors deterring innovation by misusing the patent system.

To test whether litigated patents have a poor value, we compared the value of litigated patents with the one of non litigated patents. The value of a patent can be evaluated with indicators such as the number of claims, the number of citations in the scientific literature, and the number of citations by other patents. We can calculate the correlation between these explanatory variables and the value of a patent by calculating a logit regression on litigated patents (see table below). Results suggest that the number of claims, citation in

scientific literature, and number of citation is correlated with litigation risks. In order to increase the robustness of our analysis we have also computed a linear discriminant analysis which gave similar results.

Table 16. Regression analysis of patent litigation in H01L33 IPC code

Logit results

	Dependent variable		
	LITIGATION		
	(1980-2010)	(1990-2000)	(2000-2010)
CLAIMS	0.012**	-0.010	0.018***
	(0.006)	(0.015)	(0.006)
SCI_CIT	0.021***	0.035***	0.019***
	(0.004)	(0.011)	(0.005)
IPC	0.032*	0.027	0.018
	(0.018)	(0.034)	(0.027)
FWD_CIT	0.031***	0.048***	0.015***
	(0.011)	(0.013)	(0.006)
Constant	-5.707***	-5.087***	-5.832***
	(0.187)	(0.372)	(0.247)
Observations	13,770	2,387	0,982
Log Likelihood	-543.529	-141.797	-341.803
Akaike Inf. Crit.	1,097.057	293.594	693.606

Note: *p<0.1; **p<0.05; ***p<0.01

These results suggest that litigated patents have a higher quality, and are thus not similar to the poor value ones used for example by patent trolls in the software industry. Therefore, we conclude that the patent litigation process in the LED sector is not similar to the one of the software industry. Actors active in LED patenting do not seem to be using patents for profiteering, thereby offsetting resources away from innovation activities and deterring them.

The patent analysis showed that there are technological barriers but also opportunities which have to be investigated with actors of the LED industry for their future technology and innovation strategies. The patent citation network showed that the main technological trajectory is related to GaN LEDs. However, other technologies have ceased to be developed according to the patent analysis. These technologies are interpreted as technological barriers but it they also represent some technological opportunities.

The patent ligation analysis showed that firms which are in legal battle in US are in general incumbent firms, but there are also a few non-practicing entities. However, this analysis cannot show us the legal hurdles that SMEs are facing. SMEs are in general threatened with law suits in order to sign patent licence

agreements which are difficult to identify because they are secret.[5] We have also made a comparison of litigated patents with those which are not and we have found that litigated patents can be described as good patents. Indeed, litigated patents contain more citations to scientific work and more claims. Moreover, these litigated patents have received also more citations compared to other patents bearing the IPC code H01L33.

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5. APPENDICES

5.1. Appendix n°1: References on barriers to innovation used in the literature review

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5.2. Appendix n°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					
	…					

5.3. Appendix n°3: Results of the Phase I evaluations of eco-innovation barriers per level

Score	Type of barrier		Category of barrier	Title of barrier	576
	Internal	External			Number of level 2 evaluations
Score 4	2		FINANCE	Lack of in-house sources of finance	2
Score 5		1	Policies & norms/Policy instruments	Lack of certification mechanisms to check out the technical specifications of products put on the	1
Score 4	1		TECHNOLOGY	LED drivers are barriers to ecoinnovation (too fragile e.g.)	1
Score 4	1		FINANCE	The gross intrinsic value is too low, which discourages innovation in recycling technologies	1
Score 4		1	Policies & norms/Policy objectives	National policies do not provide adequate support to ecoinnovation and/or emerging LED techno	1
Score 4		1	LED industry	Increasing & unfair competition from non-European firms	1
Score 3	1		FINANCE	Eco-innovation costs are too difficult to control	1
Score 3	1		RESOURCES & CAPABILITIES	Information systems are sources of rigidity that discourage ecoinnovation	1
Score 3		1	Markets & User practices/Financial market	Lack of funding to support SMEs' ecoinnovation	1
Score 3		1	Markets & User practices/Labour market	Lack of skilled people to repair used LED products, which is a disincentive to undertake DfR proje	1
Score 3		1	Markets & User practices/Technological nic	Lack of modularity between radical innovations	1
Score 3		1	LED industry	Existence of litigations between firms	1
Score 2	1		HUMAN RESOURCES	Lack of technical personnel to ecoinnovate	1
Score 2		1	Markets & User practices/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations	1
	7	8			15

NB: as explained earlier in the methodology of Phase I, “external” barriers refer to regulatory ones, and “internal” barriers to barriers to ecodesign.

	Type of barrier		Category of barrier	Title of barrier	
	Internal	External			Number of level 1 evaluations
Score 4		4	LED industry	Technology is not cost-effective enough	4
Score 4		4	Global context/Macro-political	Critical materials like REEs are mainly exported by non-european countries	4
Score 5		3	Policies & norms/Policy instruments	Lack of certification mechanisms to check out the technical specifications of products put on the	3
Score 3	3		FINANCE	The pay-off period of ecoinnovation is too long	3
Score 3	3		FINANCE	Economies of scope are too small to reduce costs (hence a difficulty to apply innovations to diffe	3
Score 3		3	Markets & User practices/Financial market	Financial institutions are not sensitive enough to ecoinnovation	3
Score 3		3	Markets & User practices/Labour market	Reluctance of skilled personnel to work for SMEs	3
Score 3		3	Markets & User practices/Technological ni	LED technological niches are not protective enough for radical ecoinnovations to emerge	3
Score 3		3	Policies & norms/Policy objectives	European policies do not provide adequate support to ecoinnovation and/or emerging LED techr	3
Score 3		3	Policies & norms/Policy instruments	Ecoinnovation policies are not SME-friendly	3
Score 3		3	Policies & norms/Policy instruments	There are legally binding contracts for the provision of electricity and/or lighting that discourage	3
Score 3		3	LED industry	Highly competitive environment (prevents the of trust between organizations)	3
Score 3		3	Global context/Macro-economic	The current macroeconomic context is not favourable to ecoinnovation	3
Score 3		3	Global context/Macro-economic	Current macroeconomic policies are not supportive of ecoinnovation	3
Score 4	2		TECHNOLOGY	LED drivers are barriers to ecoinnovation (too fragile e.g.)	2
Score 4	2		FINANCE	The gross intrinsic value is too low, which discourages innovation in recycling technologies	2
Score 4		2	Policies & norms/Policy objectives	National policies do not provide adequate support to ecoinnovation and/or emerging LED techn	2
Score 4		2	LED industry	Increasing & unfair competition from non-European firms	2
Score 2	2		HUMAN RESOURCES	Staff lacks information on technologies & markets	2
Score 2	2		HUMAN RESOURCES	Lack of access to the knowledge of other firms through strategic alliances	2
Score 2	2		HUMAN RESOURCES	Difficulties in allocating staff to new ecoinnovation missions due to on-going projects	2
Score 2	2		HUMAN RESOURCES	Lack of skilled sales personnel in ecoinnovation	2
Score 2	2		FINANCE	Difficulty to calculate future benefits	2
Score 2	2		FINANCE	High cost of ecoinnovation development (capital, software, maintenance ...)	2
Score 2	2		RESOURCES & CAPABILITIES	Marketing and sales channels have not been developed yet	2
Score 2	2		RESOURCES & CAPABILITIES	Lack of ecodesign tools	2
Score 2		2	Markets & User practices/Markets for raw	Key resources are mostly available from monopolistic markets	2
Score 2		2	Markets & User practices/Financial market	Lack of funding for ecoinnovation	2
Score 2		2	Markets & User practices/Financial market	Inadequate instruments of credit to support ecoinnovation	2
Score 2		2	Markets & User practices/Financial market	Tax regimes not supportive of ecoinnovation (R&D tax credit, ...)	2
Score 2		2	Markets & User practices/User practices &	Insufficient demand for greener products	2
Score 2		2	Markets & User practices/User practices &	Users lack information on LED markets & technologies	2
Score 2		2	Markets & User practices/User practices &	Little recycling of used lighting equipment => lack incentive for DfR since too little collection	2
Score 2		2	Markets & User practices/Technological ni	The allocation of LED technological niches among organisations is biased towards large organisat	2
Score 2		2	Policies & norms/Policy objectives	National policies do not support enough SMEs	2
Score 2		2	Policies & norms/Policy objectives	European policies do not support enough SMEs	2

Score 2		2	Policies & norms/Policy instruments	Innovation policies are not enough supporting ecoinnovation	2
Score 2		2	Policies & norms/Policy instruments	Ecoinnovation policies are not consistent enough (e.g. hard to anticipate, lack consultation with i	2
Score 2		2	Policies & norms/IPR regime	Some firms are keeping their technologies secret or refuse to licence them (hold-up problem)	2
Score 2		2	Policies & norms/IPR regime	In the LED sector, secrecy is more valuable than patents (thus knowledge leakage is minimised)	2
Score 2		2	Policies & norms/End-of-life policies	Lack of support for DfR	2
Score 2		2	Policies & norms/End-of-life policies	E-waste regulations are not supporting ecoinnovation, notably DfR	2
Score 2		2	Policies & norms/End-of-life policies	The European patchwork of e-waste policy implementaion is detrimental to ecoinnovation	2
Score 2		2	Infrastructures	Current electrical / lighting infrastructure deters ecoinnovation (problems of compatibility, comp	2
Score 2		2	LED industry	Product take-back systems are not efficient enough to ensure high collection rates (thus DfR disc	2
Score 2		2	LED industry	Lack of specialised press and/or general media support on LEDs	2
Score 2		2	LED industry	Weak linkages between small & large firms	2
Score 2		2	LED industry	Lack of collaboration among LED firms to share knowledge	2
Score 2		2	LED industry	Lack of skilled suppliers	2
Score 2		2	Global context/Values, beliefs, ideologies,	Belief that saving resources is not a very important thing to do	2
Score 2		2	Markets & User practices/Markets for raw	Perceived economic risk influences negatively innovation in LEDs	2
Score 2		2	Global context/Macro-economic	WTO free trade rules have a negative impact on ecoinnovations	2
Score 2		2	Global context/Macro-economic	Market logics are driven by short term concerns	2
Score 2		2	Global context/Macro-political	Lack of European vision & ambition on ecoinnovation	2
Score 2		2	Global context/Macro-political	Member states not supportive of EU ecoinnovation plans	2
Score 2		2	Global context/Ecological constraints	REE not critical enough	2
Score 1	2		FINANCE	Excessive perceived risk of ecoinnovation investments	2
Score 1		2	Markets & User practices/Technological ni	Lack of trust among the core actors of LED technological niches	2
Score 1		2	LED industry	Technological selection mechanisms in the LED market are not favourable to ecoinnovation	2
Score 1		2	LED industry	Lack of trust, collective norms, networks and shared expectations and beliefs	2
Score 1		2	Global context/Ecological constraints	Energy sources not scarce enough	2
Score 3	1		FINANCE	Eco-innovation costs are too difficult to control	1
Score 3	1		RESOURCES & CAPABILITIES	Information systems are sources of rigidity that discourage ecoinnovation	1
Score 3		1	Markets & User practices/Financial market	Lack of funding to support SMEs' ecoinnovation	1
Score 3		1	Markets & User practices/Labour market	Lack of skilled people to repair used LED products, which is a disincentive to undertake DfR proje	1
Score 3		1	Markets & User practices/Technological ni	Lack of modularity between radical innovations	1
Score 3		1	LED industry	Existence of litigations between firms	1
Score 2		1	Markets & User practices/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations	1
Score 1	1		INNOVATION & DESIGN MANAGEMENT	Too much uncertainty in the timing of innovation	1
Score 1	1		INNOVATION & DESIGN MANAGEMENT	Sticky Knowledge: some people are reluctant to share their knowledge, recipients cannot proces	1
Score 1	1		TECHNOLOGY	LED products are not recyclable enough	1
Score 1	1		TECHNOLOGY	The hazardousness of LEDs is an obstacle to ecoinnovation	1
Score 1	1		HUMAN RESOURCES	Lack of access to information about the needs of different markets	1
Score 1	1		HUMAN RESOURCES	Lack of training for ecoinnovation	1
Score 1	1		FINANCE	Lack of networks to access external financial resources	1

Score 1	1		FINANCE	High cost of knowledge acquisition	1
Score 1	1		RESOURCES & CAPABILITIES	Difficulties in training skilled people on ecoinnovation	1
Score 1	1		RESOURCES & CAPABILITIES	Lack of access to the technical knowledge of research labs and universities through alliances	1
Score 1		1	Markets & User practices/Markets for raw	Decreasing scarcity & hence decreasing prices of raw materials	1
Score 1		1	Markets & User practices/Markets for raw	Lack of traceability of raw materials	1
Score 1		1	Markets & User practices/Financial market	Slowness in the setting of financing	1
Score 1		1	Markets & User practices/Financial market	Upfront costs to set up an LED system as too high (e.g. the initial costs associated with the LED p	1
Score 1		1	Markets & User practices/Labour market	Lack of external technical services that are key to the development of ecodesigned LEDs	1
Score 1		1	Markets & User practices/User practices &	Lack of consumer awareness & concern regarding ecological issues in general and energy saving	1
Score 1		1	Markets & User practices/User practices &	There are too many lighting products on the market for consumers to identify LEDs as a potentia	1
Score 1		1	Markets & User practices/User practices &	Consumers perceive LEDs as a risky and/or fragile technology	1
Score 1		1	Markets & User practices/User practices &	Setting up an LED system is too complex (e.g. need to change whole lighting system while produ	1
Score 1		1	Markets & User practices/Technological ni	Mismatch between LED technological niches and its broader context (markets, policies, ...)	1
Score 1		1	Markets & User practices/Technological ni	LED technological niches have a low potential for acting as technological add-ons (deters hybridi	1
Score 1		1	Markets & User practices/	The claim for environmental-friendliness of LEDs is not yet trusted by household consumers	1
Score 1		1	Policies & norms/Policy instruments	Commercial law is not favourable to ecoinnovation	1
Score 1		1	Policies & norms/Policy instruments	There is a lack of enforcement of the policies that could support ecoinnovation in the LED sector	1
Score 1		1	Infrastructures	Material environments (urban structures, electricity networks, infrastructures, ...) are obstacles t	1
Score 1		1	LED industry	Lack of appropriate luminaires suitable for LEDs	1
Score 1		1	LED industry	Obsolescence by design is a strong driver of competition in the lighting and/or LED sector	1
Score 1		1	LED industry	Formation of firm cliques (groups), which prevent other firms to enter the clique	1
Score 1		1	LED industry	Lack of opportunities to cooperate with other firms and technological institutions	1
Score 1		1	LED industry	There are weak linkages between universities and industry	1
Score 1		1	LED industry	A dominant design has emerged & reduces design variety that could foster ecoinnovation	1
Score 1		1	LED industry	Consortia membership is expensive	1
Score 1		1	LED industry	Strong lobbying power of consortia that can impose their standards to the whole industry	1
Score 1		1	LED industry	Lobbying through industry consortia, can prevent the diffusion of ecoinnovations made by small	1
Score 1		1	Global context/Values, beliefs, ideologies,	Belief that natural resources are meant to be exploited by human beings until they are exhauste	1
Score 1		1	Global context/Macro-political	High labour costs deter ecoinnovation	1
Score 1		1	Global context/Macro-political	Dominant political coalitions are not effectively supporting ecoinnovation	1
Score 0	1		VISION & STRATEGY	Environmental commitments are not realised	1
Score 0	1		TECHNOLOGY	LED glare is an obstacle to ecoinnovation	1
Score 0		1	Markets & User practices/Technological ni	Lack of knowledge exchange among the actors of LED technological niches	1
Score 0		1	Policies & norms/Policy instruments	Governmental subsidies are discouraging ecoinnovation by LED firms	1
Score 0		1	Policies & norms/IPR regime	Standard setting in the LED sector is made at the expense of SMEs' ecoinnovation, e.g. Zhaga	1
Score 0		1	LED industry	Industry consortia generate obstacles to ecoinnovation for SMEs	1
Score 0		1	LED industry	Lack of 'coopetition' between actors (e.g. collaboration among competitors prior to production)	1
Score -1	1		RESOURCES & CAPABILITIES	The size of your organisation is too small to ecoinnovate	1
	43	**147**			**190**

	Type of barrier		Category of barrier	Title of barrier	
	Internal	External			Number of level 0 evaluations
Score 0	4		INNOVATION & DESIGN MANAGEMENT	Cognitive routines and shared beliefs of designers are not geared towards ecoinnovation	4
Score 0	4		TECHNOLOGY	Blue light hazard is an obstacle to ecoinnovation	4
Score 0	4		HUMAN RESOURCES	Employees' resistance to implementing ecoinnovation	4
Score 0	4		HUMAN RESOURCES	LEDs perceived as ecoinnovations per se, and thus no further effort seems to be required to redu	4
Score 0	4		HUMAN RESOURCES	Human resource management is not supportive of ecoinnovation	4
Score 0	4		FINANCE	High sunk investments (switch to new technologies once investments are written off)	4
Score 0	4		RESOURCES & CAPABILITIES	Information sharing between marketing and R&D departments is weak	4
Score 0	4		RESOURCES & CAPABILITIES	The location of your organisation is detrimental to ecoinnovation	4
Score 0		4	Markets & User practices/Technological ni	Too many heterogeneous LED market niches, which tends to slow down technological accumulat	4
Score 0		4	Markets & User practices/	The claim for environmental-friendliness of LEDs is not yet trusted by industrial consumers	4
Score 0		4	Markets & User practices/	The claim for the energy saving potential of LEDs is not yet trusted by industrial consumers	4
Score 0		4	Policies & norms/Policy instruments	Insurance rules are obstacles to ecoinnovation	4
Score 0		4	LED industry	Lack of professional associations supportive of ecoinnovation	4
Score 0		4	LED industry	Lack of new conferences where engineers and designers can meet and discuss	4
Score 0		4	LED industry	LED products are not modular enough	4
Score 0		4	LED industry	Dominant design methods in the lighting industry are driven by built-in obsolescence	4
Score 0		4	LED industry	Too many competing consortia (can reduce opportunities)	4
Score 0		4	Global context/Values, beliefs, ideologies,	Climate scepticism	4
Score 0		4	Global context/Macro-political	Currently, there is political instability that deters ecoinnovation	4
Score 1	3		INNOVATION & DESIGN MANAGEMENT	Too much uncertainty in the timing of innovation	3
Score 1	3		INNOVATION & DESIGN MANAGEMENT	Sticky Knowledge: some people are reluctant to share their knowledge, recipients cannot proces	3
Score 1	3		TECHNOLOGY	LED products are not recyclable enough	3
Score 1	3		TECHNOLOGY	The hazardousness of LEDs is an obstacle to ecoinnovation	3
Score 1	3		HUMAN RESOURCES	Lack of access to information about the needs of different markets	3
Score 1	3		HUMAN RESOURCES	Lack of training for ecoinnovation	3
Score 1	3		FINANCE	Lack of networks to access external financial resources	3
Score 1	3		FINANCE	High cost of knowledge acquisition	3
Score 1	3		RESOURCES & CAPABILITIES	Difficulties in training skilled people on ecoinnovation	3
Score 1	3		RESOURCES & CAPABILITIES	Lack of access to the technical knowledge of research labs and universities through alliances	3
Score 1		3	Markets & User practices/Markets for raw	Decreasing scarcity & hence decreasing prices of raw materials	3
Score 1		3	Markets & User practices/Markets for raw	Lack of traceability of raw materials	3
Score 1		3	Markets & User practices/Financial market	Slowness in the setting of financing	3
Score 1		3	Markets & User practices/Financial market	Upfront costs to set up an LED system as too high (e.g. the initial costs associated with the LED p	3
Score 1		3	Markets & User practices/Labour market	Lack of external technical services that are key to the development of ecodesigned LEDs	3
Score 1		3	Markets & User practices/User practices &	Lack of consumer awareness & concern regarding ecological issues in general and energy saving	3

Score 1		3	Markets & User practices/User practices &	There are too many lighting products on the market for consumers to identify LEDs as a potentia	3
Score 1		3	Markets & User practices/User practices &	Consumers perceive LEDs as a risky and/or fragile technology	3
Score 1		3	Markets & User practices/User practices &	Setting up an LED system is too complex (e.g. need to change whole lighting system while produc	3
Score 1		3	Markets & User practices/Technological ni	Mismatch between LED technological niches and its broader context (markets, policies, ...)	3
Score 1		3	Markets & User practices/Technological ni	LED technological niches have a low potential for acting as technological add-ons (deters hybridiz	3
Score 1		3	Markets & User practices/	The claim for environmental-friendliness of LEDs is not yet trusted by household consumers	3
Score 1		3	Policies & norms/Policy instruments	Commercial law is not favourable to ecoinnovation	3
Score 1		3	Policies & norms/Policy instruments	There is a lack of enforcement of the policies that could support ecoinnovation in the LED sector	3
Score 1		3	Infrastructures	Material environments (urban structures, electricity networks, infrastructures, ...) are obstacles t	3
Score 1		3	LED industry	Lack of appropriate luminaires suitable for LEDs	3
Score 1		3	LED industry	Obsolescence by design is a strong driver of competition in the lighting and/or LED sector	3
Score 1		3	LED industry	Formation of firm cliques (groups), which prevent other firms to enter the clique	3
Score 1		3	LED industry	Lack of opportunities to cooperate with other firms and technological institutions	3
Score 1		3	LED industry	There are weak linkages between universities and industry	3
Score 1		3	LED industry	A dominant design has emerged & reduces design variety that could foster ecoinnovation	3
Score 1		3	LED industry	Consortia membership is expensive	3
Score 1		3	LED industry	Strong lobbying power of consortia that can impose their standards to the whole industry	3
Score 1		3	LED industry	Lobbying through industry consortia, can prevent the diffusion of ecoinnovations made by small	3
Score 1		3	Global context/Values, beliefs, ideologies,	Belief that natural resources are meant to be exploited by human beings until they are exhauste	3
Score 1		3	Global context/Macro-political	High labour costs deter ecoinnovation	3
Score 1		3	Global context/Macro-political	Dominant political coalitions are not effectively supporting ecoinnovation	3
Score 2	3		HUMAN RESOURCES	Lack of technical personnel to ecoinnovate	3
Score -1	3		VISION & STRATEGY	Lack of clear definition of ecoinnovation	3
Score -1	3		VISION & STRATEGY	Weak environmental commitments	3
Score -1	3		INNOVATION & DESIGN MANAGEMENT	Lack of consistent R&D strategy	3
Score -1	3		INNOVATION & DESIGN MANAGEMENT	Lack of integration of ecological objectives in the design phase	3
Score -1	3		TECHNOLOGY	All weather usage design is an obstacle to ecoinnovation	3
Score -1	3		TECHNOLOGY	The light spectrum demanded by consumers contradicts with an ecoinnovation approach	3
Score -1	3		RESOURCES & CAPABILITIES	Disadvantageous position in the product chain	3
Score -1		3	Markets & User practices/Labour market	The domestic labour market is too heavily regulated	3
Score -1		3	Policies & norms/Policy instruments	Environmental policies are not innovation-friendly (e.g. ETAP, RoHS, WEEE, EuP, IPP, ...)	3
Score -1		3	LED industry	Lack of hypes and bandwagon effects around LEDs (they tend to push firms to innovate)	3
Score 2	2		HUMAN RESOURCES	Staff lacks information on technologies & markets	2
Score 2	2		HUMAN RESOURCES	Lack of access to the knowledge of other firms through strategic alliances	2
Score 2	2		HUMAN RESOURCES	Difficulties in allocating staff to new ecoinnovation missions due to on-going projects	2
Score 2	2		HUMAN RESOURCES	Lack of skilled sales personnel in ecoinnovation	2
Score 2	2		FINANCE	Difficulty to calculate future benefits	2
Score 2	2		FINANCE	High cost of ecoinnovation development (capital, software, maintenance ...)	2
Score 2	2		RESOURCES & CAPABILITIES	Marketing and sales channels have not been developed yet	2

Score 2	2		RESOURCES & CAPABILITIES	Lack of ecodesign tools	2
Score 2		2	Markets & User practices/Markets for raw	Key resources are mostly available from monopolistic markets	2
Score 2		2	Markets & User practices/Financial market	Lack of funding for ecoinnovation	2
Score 2		2	Markets & User practices/Financial market	Inadequate instruments of credit to support ecoinnovation	2
Score 2		2	Markets & User practices/Financial market	Tax regimes not supportive of ecoinnovation (R&D tax credit, ...)	2
Score 2		2	Markets & User practices/User practices &	Insufficient demand for greener products	2
Score 2		2	Markets & User practices/User practices &	Users lack information on LED markets & technologies	2
Score 2		2	Markets & User practices/User practices &	Little recycling of used lighting equipment => lack incentive for DfR since too little collection	2
Score 2		2	Markets & User practices/Technological ni	The allocation of LED technological niches among organisations is biased towards large organisat	2
Score 2		2	Policies & norms/Policy objectives	National policies do not support enough SMEs	2
Score 2		2	Policies & norms/Policy objectives	European policies do not support enough SMEs	2
Score 2		2	Policies & norms/Policy instruments	Innovation policies are not enough supporting ecoinnovation	2
Score 2		2	Policies & norms/Policy instruments	Ecoinnovation policies are not consistent enough (e.g. hard to anticipate, lack consultation with i	2
Score 2		2	Policies & norms/IPR regime	Some firms are keeping their technologies secret or refuse to licence them (hold-up problem)	2
Score 2		2	Policies & norms/IPR regime	In the LED sector, secrecy is more valuable than patents (thus knowledge leakage is minimised)	2
Score 2		2	Policies & norms/End-of-life policies	Lack of support for DfR	2
Score 2		2	Policies & norms/End-of-life policies	E-waste regulations are not supporting ecoinnovation, notably DfR	2
Score 2		2	Policies & norms/End-of-life policies	The European patchwork of e-waste policy implementaion is detrimental to ecoinnovation	2
Score 2		2	Infrastructures	Current electrical / lighting infrastructure deters ecoinnovation (problems of compatibility, comp	2
Score 2		2	LED industry	Product take-back systems are not efficient enough to ensure high collection rates (thus DfR disc	2
Score 2		2	LED industry	Lack of specialised press and/or general media support on LEDs	2
Score 2		2	LED industry	Weak linkages between small & large firms	2
Score 2		2	LED industry	Lack of collaboration among LED firms to share knowledge	2
Score 2		2	LED industry	Lack of skilled suppliers	2
Score 2		2	Global context/Values, beliefs, ideologies,	Belief that saving resources is not a very important thing to do	2
Score 2		2	Markets & User practices/Markets for raw	Perceived economic risk influences negatively innovation in LEDs	2
Score 2		2	Global context/Macro-economic	WTO free trade rules have a negative impact on ecoinnovations	2
Score 2		2	Global context/Macro-economic	Market logics are driven by short term concerns	2
Score 2		2	Global context/Macro-political	Lack of European vision & ambition on ecoinnovation	2
Score 2		2	Global context/Macro-political	Member states not supportive of EU ecoinnovation plans	2
Score 2		2	Global context/Ecological constraints	REE not critical enough	2
Score 3	2		FINANCE	Eco-innovation costs are too difficult to control	2
Score 3	2		RESOURCES & CAPABILITIES	Information systems are sources of rigidity that discourage ecoinnovation	2
Score 3		2	Markets & User practices/Financial market	Lack of funding to support SMEs' ecoinnovation	2
Score 3		2	Markets & User practices/Labour market	Lack of skilled people to repair used LED products, which is a disincentive to undertake DfR proje	2
Score 3		2	Markets & User practices/Technological ni	Lack of modularity between radical innovations	2
Score 3	2		LED industry	Existence of litigations between firms	2
Score 0	2		VISION & STRATEGY	Environmental commitments are not realised	2
Score 0	2		TECHNOLOGY	LED glare is an obstacle to ecoinnovation	2

Score 0		2	Markets & User practices/Technological ni	Lack of knowledge exchange among the actors of LED technological niches	2
Score 0		2	Policies & norms/Policy instruments	Governmental subsidies are discouraging ecoinnovation by LED firms	2
Score 0		2	Policies & norms/IPR regime	Standard setting in the LED sector is made at the expense of SMEs' ecoinnovation, e.g. Zhaga	2
Score 0		2	LED industry	Industry consortia generate obstacles to ecoinnovation for SMEs	2
Score 0		2	LED industry	Lack of 'coopetition' between actors (e.g. collaboration among competitors prior to production)	2
Score 4	2		FINANCE	Lack of in-house sources of finance	2
Score 3	1		FINANCE	The pay-off period of ecoinnovation is too long	1
Score 3	1		FINANCE	Economies of scope are too small to reduce costs (hence a difficulty to apply innovations to diffe	1
Score 3		1	Markets & User practices/Financial market	Financial institutions are not sensitive enough to ecoinnovation	1
Score 3		1	Markets & User practices/Labour market	Reluctance of skilled personnel to work for SMEs	1
Score 3		1	Markets & User practices/Technological ni	LED technological niches are not protective enough for radical ecoinnovations to emerge	1
Score 3		1	Policies & norms/Policy objectives	European policies do not provide adequate support to ecoinnovation and/or emerging LED techr	1
Score 3		1	Policies & norms/Policy instruments	Ecoinnovation policies are not SME-friendly	1
Score 3		1	Policies & norms/Policy instruments	There are legally binding contracts for the provision of electricity and/or lighting that discourage	1
Score 3	1		LED industry	Highly competitive environment (prevents the of trust between organizations)	1
Score 3		1	Global context/Macro-economic	The current macroeconomic context is not favourable to ecoinnovation	1
Score 3		1	Global context/Macro-economic	Current macroeconomic policies are not supportive of ecoinnovation	1
Score 4	1		TECHNOLOGY	LED drivers are barriers to ecoinnovation (too fragile e.g.)	1
Score 4	1		FINANCE	The gross intrinsic value is too low, which discourages innovation in recycling technologies	1
Score 4		1	Policies & norms/Policy objectives	National policies do not provide adequate support to ecoinnovation and/or emerging LED techn	1
Score 4		1	LED industry	Increasing & unfair competition from non-European firms	1
Score 1	1		FINANCE	Excessive perceived risk of ecoinnovation investments	1
Score 1		1	Markets & User practices/Technological ni	Lack of trust among the core actors of LED technological niches	1
Score 1		1	LED industry	Technological selection mechanisms in the LED market are not favourable to ecoinnovation	1
Score 1		1	LED industry	Lack of trust, collective norms, networks and shared expectations and beliefs	1
Score 1		1	Global context/Ecological constraints	Energy sources not scarce enough	1
Score 2		1	Markets & User practices/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations	1
Score -1	1		RESOURCES & CAPABILITIES	The size of your organisation is too small to ecoinnovate	1
Score 4		0	LED industry	Technology is not cost-effective enough	0
Score 4		0	Global context/Macro-political	Critical materials like REEs are mainly exported by non-european countries	0
Score 5		0	Policies & norms/Policy instruments	Lack of certification mechanisms to check out the technical specifications of products put on the	0
	121	**225**			**346**

Type of barrier		Category of barrier	Title of barrier	
Internal	External			Number of level -1 evaluations
2		RESOURCES & CAPABILITIES	The size of your organisation is too small to ecoinnovate	2
1		VISION & STRATEGY	Lack of clear definition of ecoinnovation	1
1		VISION & STRATEGY	Weak environmental commitments	1
1		INNOVATION & DESIGN MANAGEMENT	Lack of consistent R&D strategy	1
1		INNOVATION & DESIGN MANAGEMENT	Lack of integration of ecological objectives in the design phase	1
1		TECHNOLOGY	All weather usage design is an obstacle to ecoinnovation	1
1		TECHNOLOGY	The light spectrum demanded by consumers contradicts with an ecoinnovation approach	1
1		RESOURCES & CAPABILITIES	Disadvantageous position in the product chain	1
	1	Markets & User practices/Labour market	The domestic labour market is too heavily regulated	1
	1	Policies & norms/Policy instruments	Environmental policies are not innovation-friendly (e.g. ETAP, RoHS, WEEE, EuP, IPP, ...)	1
	1	LED industry	Lack of hypes and bandwagon effects around LEDs (they tend to push firms to innovate)	1
1		VISION & STRATEGY	Environmental commitments are not realised	1
1		TECHNOLOGY	LED glare is an obstacle to ecoinnovation	1
	1	Markets & User practices/Technological ni	Lack of knowledge exchange among the actors of LED technological niches	1
	1	Policies & norms/Policy instruments	Governmental subsidies are discouraging ecoinnovation by LED firms	1
	1	Policies & norms/IPR regime	Standard setting in the LED sector is made at the expense of SMEs' ecoinnovation, e.g. Zhaga	1
	1	LED industry	Industry consortia generate obstacles to ecoinnovation for SMEs	1
	1	LED industry	Lack of 'coopetition' between actors (e.g. collaboration among competitors prior to production)	1
1		FINANCE	Excessive perceived risk of ecoinnovation investments	1
	1	Markets & User practices/Technological ni	Lack of trust among the core actors of LED technological niches	1
	1	LED industry	Technological selection mechanisms in the LED market are not favourable to ecoinnovation	1
	1	LED industry	Lack of trust, collective norms, networks and shared expectations and beliefs	1
	1	Global context/Ecological constraints	Energy sources not scarce enough	1
	1	Markets & User practices/Labour market	Educational institutions do not provide enough people well trained to develop ecoinnovations	1
12	13			25