

EUP PROJECT. DARK SKY ECO-LABELLING IN THE LIGHTING INDUSTRY

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Introduction

The study is a result of the EU directive for eco-design of Energy-using Products (EuP), Directive 2005/32/EC. The purpose is to fine-tune the environmental impact of these products during manufacture and lifetime. Not only energy is included, but also water use, production impact, ... The best solutions will be selected for the products by studies with co-operation of stakeholders from industry, environmental and consumer associations. It can also result in fine-tuning eco-labels for e.g. washing machines. The complete content of the directive can be downloaded from the following location: http://ec.europa.eu/enterprise/eco_design/directive_2005_32.pdf

The directive is explained at the following webpage: http://ec.europa.eu/enterprise/eco_design/index_en.htm

The studies for EuP reports has to be done with a defined frame work and analyzing methods. Also the EuP for light has to follow the here defined rules.

It is not necessary for reports to be written for all energy-using products, only for products meeting criteria such as important environmental impact, and volume of trade in the internal market and clear potential for improvement, for example where market forces fail to make progress in the absence of a legal requirement.

Also, for light, an EuP study was ordered by the European Commission. It was split into two lighting products: office lighting and street lighting. Other outdoor lighting products which are in a lot of cases a lot more energy-wasting then street lighting where not adopted in the scope of the study. In this way the study cannot give the complete picture linked to outdoor lighting and also cannot propose for all lighting problems the best available techniques.

It should be useful to provide also a study about other outdoor lighting systems. The reason that this is not adapted for the moment is because the European Commission has the opinion that this lighting is difficult to solve on a product level. Some products that are not good solutions for one application could be the best solution for another application. For that reason a report on product level for other outdoor lighting made, in the opinion of the EU, no sense. On the other



side, on the basis of studies in Flanders we learn that energy consumption of outdoor lighting other than street lighting is more than 40% of the total outdoor lighting energy consumption. Most of them with much more energy waste than street lighting. In the Netherlands 60% of light sent to the sky is the result of lighted greenhouses.

The scope of the project and definitions.

The EuP study deals with the environmental impact of the products during manufacturing and during life cycle. It involves all components of the lighting system i.e. the lamp, ballasts and luminaires.

The final version of the document for street lighting was published on 2 March 2007. The document for office lighting is expected in May 2007. The documents can be downloaded from the following site: <http://www.eup4light.net>

The product category for the street lighting report is defined as follows: *“fixed lighting installation intended to provide good visibility to users of outdoor public traffic areas during the hours of darkness to support traffic safety, traffic flow and public security”*

For these products are provided the following aspects in the study:

1. Product Definition;
2. Market and economic analysis;
3. Consumer Behavior & Local Infrastructure;
4. Technical Analysis Existing Products;
5. Definition of Base Case(s);
6. Technical Analysis of Best Available Technology (BAT) and BNAT;
7. Improvement Potential;
8. Scenario, Policy, Impact and Sensitivity Analyses.



This proceeding will discuss only light pollution related aspects of the report.

IDA Europe participated in the study as a stakeholder for the report about street lighting. All other stakeholders in the projects were related to the lighting industry. IDA was informed quite late on about the process of this study and so registered when a large part of the study was already finished. When reading the draft, light pollution was not much referenced, and most of the information about it was scientifically incorrect. IDA Europe tried to correct this information intensively.

Lighting systems for street lighting discussed in the report had to match with the performance requirements in existing European standard EN-13201-2. The lighting performances are specified for different road types on base of traffic speed and density. The road types are in general defined in EN-13201-1 which is not a standard to give the regions and countries more freedom in defining road categories. The road types in EN-13201-1 are very complex and with a large number of types. Simplified, the study this road types where reduced to 3 main road types as follows:

- Category F or “Fast Traffic”: fast motorized traffic use only, having only luminance requirements (cd/m^2). Also corresponding to classes ME1 to ME5 or MEW1 to MEW5 for new installations.
- Category M or “Mixed Traffic”: motorized traffic, slow moving vehicles, and pos-

sibly cyclists and pedestrians with only luminance requirements (cd/m²). Also corresponding to classes ME2 to ME5 or MEW2 to MEW5 for new installations.

- Category S or “Slow Traffic”: mainly urban and pedestrian areas, with illuminance requirements only (lx). Corresponding to classes CE0 to CE5, S1 to S6 and ES, EV and A classes for new installations.

Analysing the existing situation

The report lists the current legislation on product-related aspects of street lighting systems. Most of them are technical specifications in European norms and directives. Initially there was mentioned no legislation in EU member states on products for street lighting, especially not related to light pollution. IDA Europe mentioned that, in several regions in Italy, legislation on light pollution exists and has very strict product-related design criteria. They are all based on the Lombardy law with have the following product-related key factors:

- Over 90° only 0cd/klm is allowed. So no upward light or only Full Cut-Off luminaires.
- The existing minimum luminance / illuminance norms as defined in other regulations (e.g. 13201-2) are at the same time also the maximum norms.
- All luminaires need to be equipped in such a way that they could be dimmed after midnight.
- Luminaires cannot sold before first being certified by a recognized lab and the results signed by the director of the lab, to check they match with the conditions required in this law.

The report contains a lot of data analysis about the current situation on the market and the situation in the past of luminaries, lamps and ballasts. Some of the numbers are interesting to have a picture of the lighting situation in Europe.

However, the numbers should be used with a lot of caution. The data was gathered from Europrom data; and inquiries. All data seems to be not complete or not inventorized in detail. Especially, data as the result of the inquiries seem to be incomplete data. In a lot of cases there was no response, data were not available or they were not offering it because they did not want rivals to know their market position. Some estimates were made for that reason on the basis of road length. For that reason the report expects that these data can be seriously underestimated. Only data from Belgium; Ireland, United Kingdom and Sweden.

From these data we learn that there is, in Europe, about 5318766 km of road. It is estimated that there are 58,904 million luminaires in use. That means that for each person there is 0.12 luminaires. On one km of road 11.075 are installed. This means that in an average of every 90 meters there is



one luminaire installed. In practice on illuminated roads luminaires are installed with an average distance of 30 meters. In that case about 1767120 km of road in Europe should be illuminated or 33.2% of European roads are illuminated. In 2005 the total energy use for street lighting in Europe was estimated at 35.058 GWh. The average burning hours per year are estimated at 4000 hours. On the basis of these estimates we can calculate that the average installed power per luminaire in Europe is about 149 Watt.

Consumer behavior and use phase

In the chapter about consumer behavior is also discussed the trend to install more public lighting to decrease crime and road safety. It is important that the study reports that lighting surely increases the feeling of security, but also that the absolute reduction of crime by public lighting is not proven, and controversial. This is because there are no large-scale studies. The report declares that it sounds logical that lighting alone cannot cure criminality; social control is also an important factor. Several studies show that lighting can displace criminality from more brightly lit places with social control to less brightly lit places. An opposite shift in criminality from poorly lit places to brightly-lit places without social control also seems to be possible. This is explained by the fact that light is simply helpful for the selection of the crime location and the execution of criminal activities. If no social control or surveillance is present, this lighting will only help criminals.

There are also some problems reported in energy savings on public lighting. Making energy saving products for street lighting commonly available will not result automatically in real energy savings on public lighting. Most of these problems are related to lack of interest by several partners.

First there is the lack of interest in energy savings by local authorities. This is the result of budget and planning of investments for new street lighting, payback period for new investments, risk for quality complaints for new technology, general resistance against changes, etc. On the other hand a new trend called 'city beautification' can be intended. The most important parameter here is an aesthetic one and might compromise eco-design of street-luminaires. In many cases design architects are dominating projects and it will be important that these people are aware of environmental impact (see also limitation in 3.3.4) and advantages of new eco-designed products. In some cases the energy reduction realized in street lighting can be used for spilling on monument lighting.



There is also a lack of a skilled work force. The proliferation of more advanced lighting energy saving techniques can require additional skills that people responsible for design and installation might be lacking. Especially lighting energy saving techniques where complex telemanagement technologies are used. Optical systems that require fine-tuning related to the real surroundings. When urban architects are more involved in street lighting they need technical lighting designer skills.

Light pollution.

In the report, light pollution is split into two types of light pollution. Astronomical light pollution that obscures the view of the night sky, and ecological light pollution that alters natural light regimes in terrestrial and aquatic ecosystems.

Astronomical light pollution is related to skyglow. Researchers were originally claiming that this was mostly caused by FCO fixtures because they reflect more light directly to the sky. The way they describe the process of sky glow was completely incorrect and also influenced some descriptions of how skyglow has to be reduced. In the final report they recognize that sky glow is mostly caused by light going into the sky at an angle of 0 to 10 degrees. This lighting will be more diverted in the sky and causing sky glow at a larger distance. That is a clear result of the research of Cinzano et al. (2000a).

On the ecological consequences, the report declares that there are not already clear proofs that light pollution has mitigating effects. Also effects on health will be not clearly proven. This is in contradiction with the book 'Ecological consequences of artificial lighting'. The report recognizes that there are indications that possible consequences exist. But as long they are not proven; the report will not encourage actions to reduce light pollution in the eco-design of the products. IDA Europe cannot agree with this point of view. When there are strong indications it is better to prevent the problems increasing until such time as there is proof in one or the other direction.

The report also defines problems in the way that energy saving products are used. The report indicates that even the most efficient luminaires can lead to a waste of light when they are not properly used, due to a wrong tilt angle orientation or optics of the luminaire, therefore proper lighting design and installation are of equal importance to obtain energy efficient street lighting. The report indicates that installation instructions need to accompany the luminaire. IDA Europe notes that in most cases, such instructions are undelivered to the installation teams. In practice the installers still install the lighting products the wrong way. This is because they do not understand the instructions and plans, or because it is difficult for the people in the field to draw attention to these instructions. A better solution would be that installers are obliged to be well educated in correctly installing lighting.

BAT and BNAT

In the chapter on Best Available Techniques, there are not many solutions presented that will result in better lighting. Only three aspects are a little related to light pollution. The most important is improving the luminaire maintenance factor (LMF). For this they want to increase the degree of ingress protection degree. They propose for that reason an IP 66 for the optical component. This optical compartment has so to be protected against

dust and damp, and so guaranteed after repetitive opening of the luminaire for lamp or control gear replacement, and is designed to withstand the high temperature variations that can occur.

The second method for increasing the LMF is the use of self-cleaning glass. This glass is treated with a coating that reduces the build-up of external dirt. UV rays activate the self-cleaning coating to break down and disintegrate dirt. The surface of the glass is hydrophilic which means that the rain spreads over the glass, instead of forming drops, and washes away the residue.

This can be positive for light pollution when properly used. At installation the light level is installed higher than needed because of the reduction of the performance of the luminaire over time. This still matches the lighting norms with the lower optical performance. If this could improve this performance for a longer time, over-lighting is no longer necessary, resulting in less reflection to the sky.

The other aspect is increasing the Utilisation factor by limiting the Upward Light Output Ratio (ULOR) and increasing the Downward Light Output Ratio (DLOR). Light sent to the sky will be limited in this way and should result in less light pollution.

The report does not specifically choose Full Cut-off luminaires or luminaires with $0\text{cd}/\text{klm}$ over 90 degrees. In the eyes of the researchers this results in less performance and higher energy consumption. They define that in most cases the Space/Height Ratio (SHR) for FCOs is 1:4. So the distance between light poles can be 4 times the height of the light pole. That is less than for luminaires with curved glasses. They mostly have a SHR of 1:5. This results in more light poles and so in more energy consuming lamps. That has to result in higher energy consumption. The reason for this shorter SHR is because of the Brewster angle effect, that increases the internal reflection and reduces the angle the light hitting the road surface.

The researchers indicated initially also that FCOs will reflect more light and send more light straight to the sky. Initially they claim that this will result in more skyglow.

Experience has shown that in regions where legislation requires FCO luminaires, the lighting industry resolves this problem in a short time. In Lombardy several luminaires with flat glasses have a SHR of 1:5 to 1:5.7. The difference is in the use of an anti-reflection coating to reduce internal reflection. The EuP report does not recommend this technique because it is still not yet commonly available in Europe. IDA Europe found that a bad choice, because practice showed that insisting on it results in a short life of luminaires with this technique. Lighting manufacturers declared that they do not offer that everywhere, because the coating is protected by a patent. The patent was established in 1978 and is now already long since expired.

The reflection of more light is because more light is hitting the target area. This can be solved by dimming the light to the required light level.

As Best Not Available Technique (BNAT) the EuP street lighting report refers to street luminaires with LED lighting. They could be very energy efficient in the near future. Manufacturing LEDs requires a lot of polluting materials and is a very energy consuming process. The study has not checked whether, with these problems, LEDs will still be an eco-design solution in the future.

Recommendations

The report has several recommendations for better lighting with, in the first place, less energy consumption. I will in this proceeding speak only about light-pollution-related recommendations.

A first recommendation is providing a kind of label on the boxes of the luminaires. This label would be a required information sheet for the luminaire with the following eco-design parameters:

- Street light indication + road category
- Photometric data
- LMF for first 4 years
- Maintenance instructions.
- UF for standard road conditions.
- Installation instructions for optimizing UF
- Installation instructions to minimize light pollution.



Most of this information is already available in the boxes or catalogues of the manufacturers. In most cases the persons for whom the information is intended do not know how to interpret the data. Without good education of the users, this recommendation will not have much result.

The report also advises the provision of generic eco-design requirements on reducing light pollution. It is not specified what this has to include. It requests the manufacturers to do research for solutions reducing light pollution. These techniques could only be implemented when having no negative effect on the energy efficiency of the luminaires. When more evidence is available about environmental consequences, standardization commissions have to develop harmonized standards to reduce light pollution.

The report also defines limitations for the ULOR and a minimum DLOR to increase the efficiency of the luminaires. In the report this is defined in the table below. When putting these values in the formula $ULOR/(ULOR+DLOR)$ you get the Upward Flux Ratio (UFR). They are put in the last column of the table, after values recommended by the report.

This could not be accepted as a good recommendation for reducing light pollution or energy saving by IDA Europe. In all situations a lot of energy is wasted and sent to the sky at angles causing most skyglow. While FCO solutions with better energy per-

formance are available on the market. For slow road category and lamp wattage of less than 50 watts it is allowed to waste up to of the energy. Discussion with the researchers showed that this is allowed to not exclude decorative lighting. IDA Europe notice that several 35W

	ULOR max	DLOR min	UFR
luminaires cat F+M			
all lamp wattages	5%	75%	6.25%
luminaires cat S			
150W lamp	5%	75%	6.25%
100W lamp < 150W	10%	75%	11.76%
50W lamp < 100W	15%	70%	17.65%
lamp < 50W	20%	65%	23.53%

luminaires for functional lighting are on the market with a UFR of 20%. There are more and more energy efficient light sources, that will result in more light to the sky by this definition. For decorative lighting it would be better to limit also the maximum lumen output of the lamps. Otherwise this will not result in less energy consumption, and in more light pollution. For all other situations a UFR of 0% is necessary.

Apart from light spilling into the sky, spilling energy, this will also cause a lot of glare what is bad for visibility and thus for traffic safety. This is for places with slow traffic. That means that there are also a lot of pedestrians and bicycles and so visibility is even more important for traffic safety. While the study has the intention to propose solutions with ecological benefits, there is a proposal where a lot of light is spilled in the sky and causing light pollution - which has several ecological and health consequences, spilling a lot of energy while energy savings would be a better ecological solution and allow solutions that cause less visibility and traffic safety.

A UFF from 6.25% is also allowed for road categories F and M. It is also declared that this will reduce light pollution. That is true, but only a smaller part is reduced. This will send light into the sky at small angles. Scientific research has shown that this light will cause more light pollution and over a wider distance.

The report recommends also the use of dimmable ballasts. It is recommended to require this for new luminaires intended for road categories F+M before 2010. For others it will be recommended to do it before 2015. This recommendation is useful to reduce light pollution as a result of reflection, because it can better control maximum lighting and avoid overlighting. Also, it is possible later in the night with lower traffic density to reduce the lighting level.

One additional recommendation is mentioned in the report. It is not adopted as a real recommendation because it is not product-related. The report requests to change the standard EN-13201 in such a way that also maximum lighting levels are adopted. That can avoid the possibility for overlighting in an easy way. At the other hand is also requested to specify the road categories not on the basis of daily traffic densities but on hourly traffic density. This makes it easier to reduce lighting later in the night when less traffic is still on the roads.

In the scenarios, we can see that, when no recommendations are implemented, the energy consumption increases all the time. When implementing all BAT techniques, the researchers expect that the energy consumption will be markedly reduced from 2010.

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