Light quality of retrofit LED products – meeting expectations?

Solid state lighting products were tested for light quality and energy efficiency, and many were found wanting compared to government recommendations.

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The rapid development in flux and efficiency of Light Emitting Diodes (LED) has resulted in a flooding of the lighting market with Solid State Lighting (SSL) products. Many traditional light sources can advantageously be replaced by SSL products. We found, however, that there are large variations in the quality of these products, and some are not better than the ones they are supposed to replace.

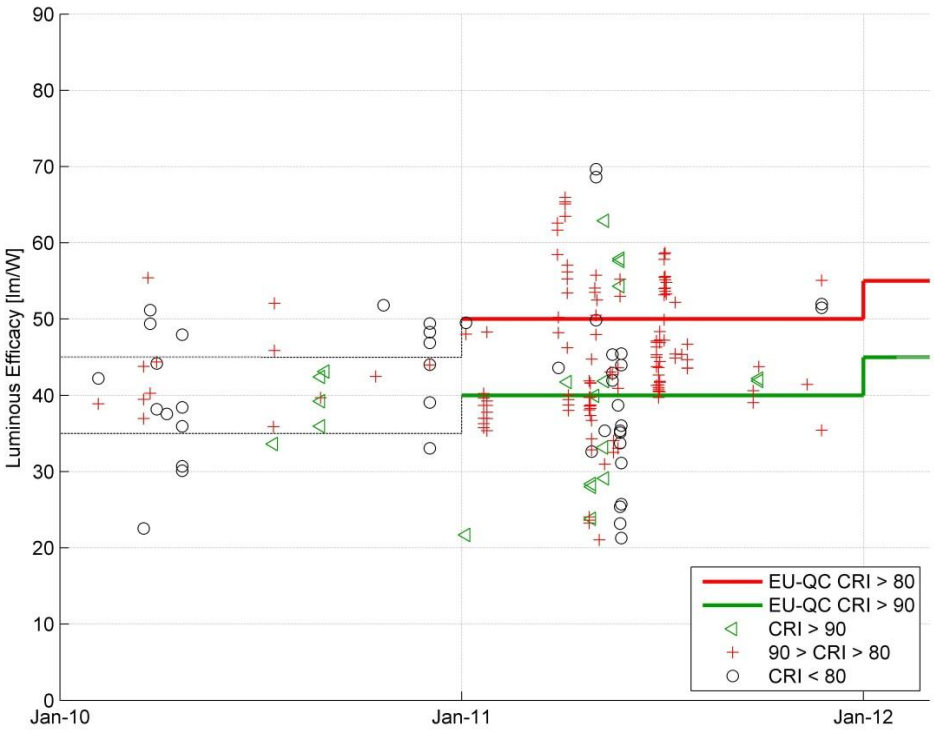

Figure 1 Luminous efficacy as a function of the time of the first measurement, for the directional and non-directional light sources). The colored lines show the requirement for inclusion in the EU Quality charter. The black lines show a backward extrapolation of the EUQC requirements.

We conducted a two year study from January 2010 to January 2012, to investigating SSL products on the Danish market. The focus was on SSL products for replacement of incandescent lamps and halogen spotlights. 266 SSL replacement lamps were collected from lighting companies in Denmark and random samples from stores in the Copenhagen area (Capital of Denmark). The lamps were of the 230 V AC type -

95 directional and 49 non-directional, and the 12 V DC type with 99 directional and 23 non-directional. Each light source was tested once for luminous flux, power consumption and spectral light quality, with an integrating sphere spectrometer, using standard measurement guidelines [1]. 48 products were selected for long term maintenance test, with several measurements conducted at approximately 1000 hour intervals.

The EU LED Quality Charter (EUQC) is a voluntary program to promote energy savings in residential lighting sector [2]. We use EUQC requirements as a reference for evaluation of the light sources in the present survey. The efficacy criteria for inclusion under the program increases in steps every year from 2011 to 2015, depending on the color rendering index (CRI) [3] of the light source. The measurements of these quantities are summarized in Figure 1, which shows the luminous efficacy of each product as a function of the time of measurement in the study and the EUQC efficacy requirements. To be included in the EUQC the light source must have an efficacy above the line of the same color code. It can be seen that a large portion of products fall outside the requirements for inclusion in the EUQC. It is found that 48 of 194 directional light sources fall within the criteria while this is only true for 6 out of 72 of the non-directional lamps. The CRI as a function of the luminous efficacy is shown in Figure 2.

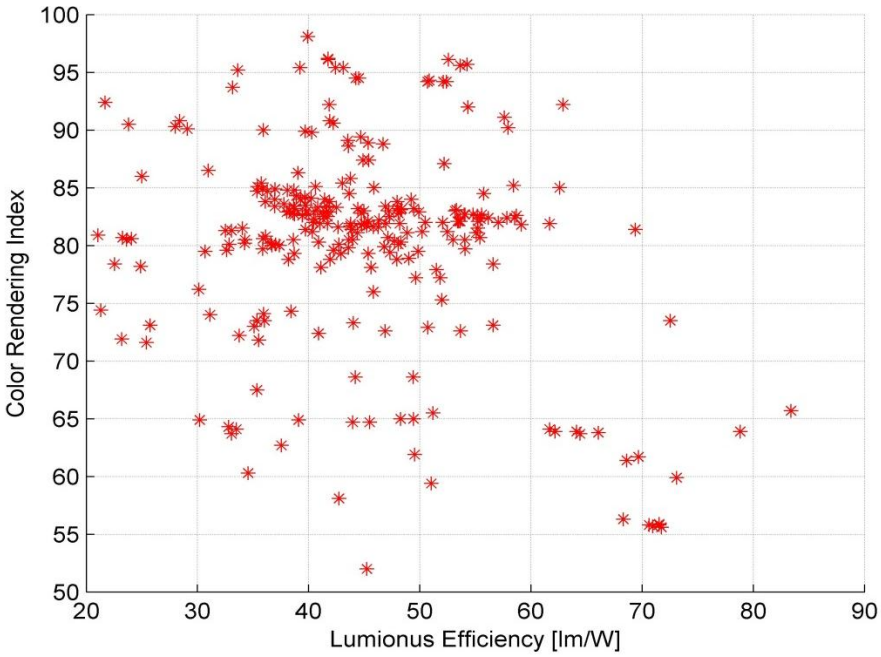

Figure 2 Color rendering as a function of luminous efficacy

48 LED products have been tested in the lifetime procedure. The light sources have been measured, in the integrating sphere spectrometer at 500, 1000, 2000, 3000, 4000, 5000, 6000, and 11000 hours of powered operation. Three of the light sources failed completely within the 3000-7500 hour time span. Examples of the results can be seen in Figure 3.

The present study was conducted in an effort to help consumers, in making informed decisions, and avoid products with unwanted performance characteristics. Focus has been on the energy efficiency, spectral light quality and service life of the products, as these characteristics are essential to long term satisfaction and thereby technology adoption by consumers. The study supports the notion that the market for consumer grade lighting products has a high variation in efficacy and light quality. Many products available do not meet the criteria of the EU Quality Charter. Without proper education of - or information to the consumer about CRI and light quality, it is possible that consumers will find these products to have a light quality that doesn't meet their expectations. However it has been found that the abundance of products tested has a CRI above 80 in accordance with both the EUQC and widely applied regulation of work places [4]. With regards to efficacy there is a large spread in the values, for similar light quality.

In the long term study we see a high degree of stability over time for the directional light. Depreciation is evident after 11000 hours with values from 97% to 80%. This outcome is to be expected even though some of these light sources might not reach the useful life of 50,000 hours, which is widely quoted.

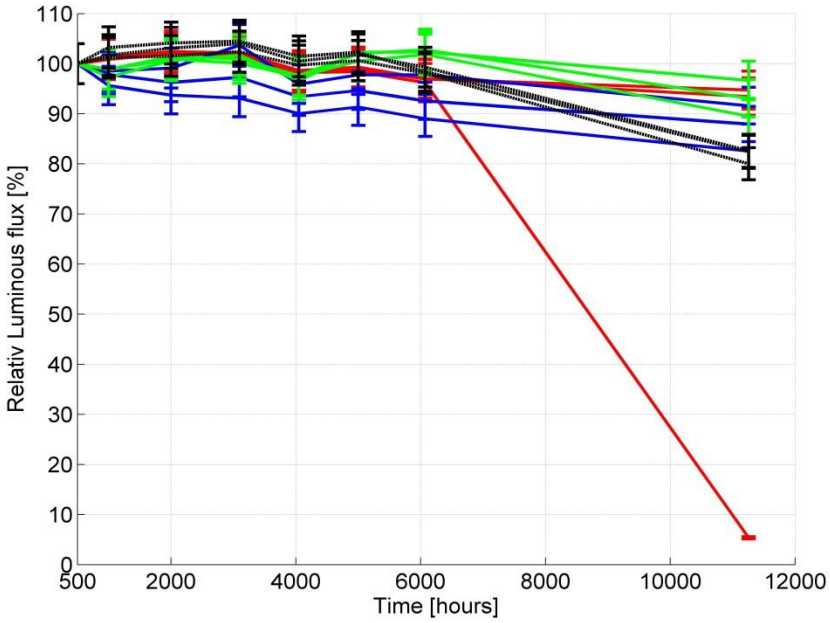

Figure 3 The normalized luminous flux as a function of time for 4 (color/dot coded) series of directional LED lamps.

In the lifetime study the results show the steady depreciation over the 11000 hours span, which was monitored, with many products having high light output after 11000 hours. However, the depreciation has a large degree of variation from product to product; some have a useful life (Light output 70% of the initial output) of less than 10.000 hours, which is in the range of standard compact fluorescent lamps.

As a part of the study a website was development for Danish consumers to access some of the information gathered in this study. A screen capture of the website can be seen in Figure 4. Here consumers should be able to search for the optimal LED replacement for domestically used light sources. A test version of the website was launched on 21 January 2013 at http://www.lednet.dk (Danish), and we hope to be able to update the information contained in it with newer products.

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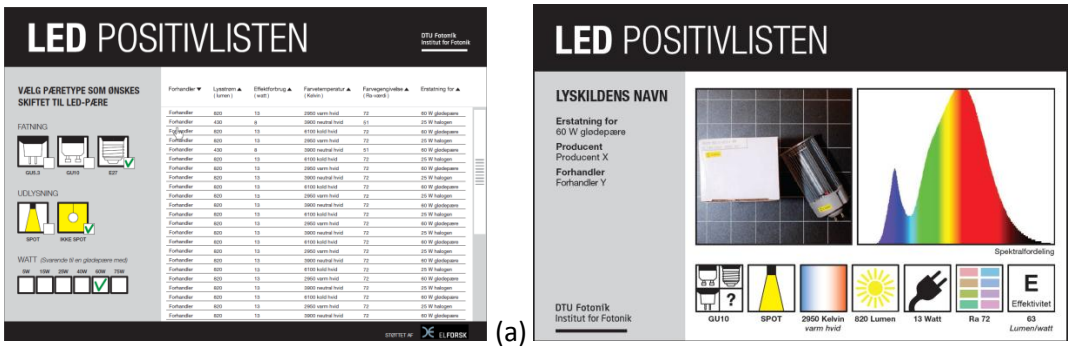

(a)

(b)

Figure 4 An overview of the proposed website (in Danish) showing a list of generic light sources with filters for socket type, directionality, and equivalent incandescent power usage (A). Individual product information and measurement results are shown for each product (B).

References

[1] IES, Electrical and Photometric Measurements of Solid-State Lighting Products, IES LM-79-08, 2007.

[2] JRC, EU, "European LED Quality Charter," *European Commission Joint Research Centre,* february 2011.

[3] CIE, 13.3 Method of measuring and specifying colour rendering properties of light sources, 1995.

[4] E. DIN, *EN DIN 12464-1 Light and lighting-lighting of work places,* Part, 2011.