Umwelt Bundesamt
Federal Environment Agency
Germany
Dessau-Roßlau

28 February 2015

Comments of the Federal Environment Agency (UBA)

on the Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling requirements, Tasks 0 to 3

Task 1

Point "1.2.3 Discussion on the definitions of LEDs"

On page 1-14 it is said that "*As regards the definition of 'Light emitting diode (LED)', a major issue is whether the specification 'of inorganic material' should be present. In Regulation 1194/2012 this dictation IS present while in Regulation 874/2012 it is NOT.*"

We see two questions: 1st should OLED be included in the scope and 2nd what wording should be used?

Concerning the wording we see that the common parlance is somewhat unclear: usually anorganic light emitting diodes are called "LED" and organic light emitting diodes are called "OLED". But both are light emitting diode, thus both are LED. That is to say, common parlance is like thinking on apples, but saying "fruits" and thinking von pears and saying "pears". We should not do so. When speaking about anorganic LED (apples), we should say ALED [1] and solely when speaking about light emitting diodes in general –including anorganic and organic ones– (fruits), we should say "LED"; and organic LED (pears) still OLED.

A regulation, or a part of it, concerning solely anorganic LED (ALED) should be entitled using the wording "ALED" to avoid misunderstanding. A title like "*Commission regulation No 1194/2012 (…) ecodesign requirements for (…) light emitting diode lamps*" may mislead persons with some physics knowledge to believe that OLED are affected by the regulation too, although that is not the case.

Exemptions

Task 1 p. 76 ff.:

For "Scientific lamps" the rationale for excluding them is as follows: "According to the (rough) estimates in Annex D.15, the total electric energy consumption for lamps with a scientific purpose in EU-28 is negligible and sales volume are below the 200,000 criterion of 2009/125/EC article 15. It is proposed to exclude these lamps from the current study because sales volumes do not meet the eligibility criterion. Additional attention is required to correctly define scientific lamps." This

1 or inorganic (ILED) if that is correct English

reasoning is problematic since the 200,000 unit criterion is not intended to be applied to each sub-group but to product groups as a whole, and no precedence should be established here to change this rule. It still makes sense to exempt these very specific lamps from the study. However a precise definition based on technical properties is needed for such an exemption.

Task 2

We wonder why no specific research has been made to collect data for ballasts, control gears, lighting controls, dimmers, luminaires and other lighting related products. As far as we understood lighting related products are at least to some extent also part of the study. At least ballasts are covered by regulation 245/2009. Market data of these lighting-related products might be needed in later tasks.

Task 3

Environmental impacts

For the analysis of other environmental impacts we would like to refer to a study of Ökopol: http://www.oekopol.de/archiv/material/551_1_Oekopol_LED_Endbericht_Aug%202013.pdf. However it is only available in German, but has at least an English summary.

Life-time information on LEDs

It should be analysed, if life-time information can be confusing for consumers as the declared values for LEDs might not be achieved in practice, because they do not rely on measurements. The study should thus consider information requirements specifically for LED-based light sources which take this into account.

Compatibility of luminaires with LED-Lamps concerning heat management and lamp lifetime

In the consultation forum on 25 November 2013 (stage 6, regulation 244/2009) industry representatives showed a number of luminaires which are not suitable to be operated with LED-Lamps due to the fact that these luminaires do not allow an adequate heat management. A combination of particular LED lamps with luminaires which are not designed for LED lamps may result in temperatures inside the luminaire which are too high for LED-lamps, thus leading to a significant shorter lifetime of these lamps. As a consequence, concerning consumer's point of view, that may reflect negatively on LED technology as a whole. This fact in its turn may induce consumers to go back to conventional techniques which are easier to handle – but much less energy efficient.

We prepared a technical background paper on this issue with illustrations and possible solutions. Details can be found in the annex A to this comment paper.

Built in-LEDs

The study does so far not consider the tendency of LED modules being built into furniture and other products without the possibility to replace them (at least not with reasonable effort). As consumers are asking questions regarding this problem increasingly often, this issue should be covered in the study and it should be discussed briefly whether measures could be taken to deal with it (e.g., a requirement for an built-in LED modules to be replaceable or information requirements).

Point "3.6 Luminous efficacy" and others: Efficiency Index EEI vs. Efficacy (lm/w)

During the meeting in Brussels on February 5th 2015 Casper Koford (Energy Piano, Denmark) proposed to use efficacy (lumen per watts) instead of the square root function ($0.88\times\sqrt{\Phi} + 0.049\times\Phi$).

Oftenly, in this context it is argued that for LEDs, efficacy would be the better choice to describe the efficiency, because LED light sources consists just of a number of identic LEDs; thus the efficacy of the whole is the same as the efficacy of the individual.

- Regarding a wide range of luminous flux shows, that for higher lumen values the curve of the square root function and the curve of the efficacy move towards each other [2]. That means: A relevant difference is restricted to low lumen values.
- When looking on product data, we find that there are LED lamp types for which the square root function fits better to describe the efficiency and others for which the efficacy is the best [2].

Light source data do not verify the argument, mentioned above. But they do not give a clear picture. Thus further study is needed. We work on that issue and will deliver more information about it.

In the study a number of efficiency values are mentioned as efficacy. That makes it a bit difficult to compare theses values with limits, set in the regulations. Therefore we ask to present results as EEI.

Point "3.6 Luminous efficacy"

That chapter refers mainly to efficacy (lumen/watts), saying few words about other efficiency values. Regulations 244/2009, 1194/2012 and 874/2012 do not base on efficacy but on the Energy Efficiency Index (EEI). Therefore we ask to rename that chapter and to treat all relevant efficiency values within it.

2 Details can be found in the annex B to this comment paper.

Point "3.6.1 Introduction"

On page 3-67 it is said "*The EEI can be interpreted as an inverse statement of lamp efficacy. Lamp efficacy is expressed as luminous flux per electrical Watt. EEI is expressed inversely to this, with power as the numerator, and (a function of) luminous flux as the denominator.*" We would not follow that quite gross simplification. The EEI is not just the reversed efficacy, as the following equation shows.

$$\text{efficacy } \eta = \frac{\Phi}{P} \neq \frac{1}{EEI} = \frac{0.88 \times \sqrt{\Phi} + 0.049 \times \Phi}{P}$$

$$\Phi \neq 0.88 \times \sqrt{\Phi} + 0.049 \times \Phi$$

To become equal, the factor 0.88 in front of the square root term would have to be changed into 0 and the factor 0.049 into 1. Indeed, in EEI these factors are far from that.

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Annex A

to the comments of the Federal Environment Agency (UBA) on the Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling requirements, Tasks 0 to 3

Compatibility of luminaires with LED-Lamps concerning heat management and lamp lifetime

Existing problem/risk

A large proportion of power consumed by a LED lamp is transformed into heat. LED lamps need to dissipate that heat to their immediate surroundings. In case of a LED lamp applied in a luminaire which hinders heat dissipation of the lamp, heat build-up 3 can occur, e.g. in small closed luminaires. That can lead to a situation where the temperature within the lamp (junction temperature 4) gets very high. High junction temperatures have a negative impact on lifetime. Figure 1 shows exemplary for an individual lamp lifetime versus junction temperature. "Mean L70 Lifetime" means in that case the time at which the luminous flux of the lamp has decreased to 70 % of its initial value. The figure shows:

1st The higher the ambient air temperature, the lower the lifetime: starting with low temperature (red curve) up to high temperatures (purple curve).

2nd The higher the junction temperature (x-achsis), the lower the lifetime.

[3] DE: *Wärmestau*; FR: *accumulation de chaleur*
[4] DE: *Temperatur am Halbleiter*

Figure 1; source: "Cree XLamp Long-Term Lumen Maintenance", July 2009

Condensed:

► If a LED lamp is applied in a luminaire which hinders heat dissipation of the lamp, particularly in small closed luminaires, junction temperatures may occur which are too high thus leading to a significant shorter lifetime of the lamp.

Most LED lamps bought nowadays are applied in luminaires which have not been designed for lamps of that technology. Average consumers know little about heat management. The risk therefore is that a significant number of consumers will combine lamps and luminaires in a way which is not suitable. The result is a significant number of premature failure and disappointed consumers. Thus consumers may consider LED at a whole as an unsuitable technology. This fact in its turn may induce consumers to go back to conventional techniques which are easier to handle – but much less energy efficient.

Conclusion:

► In order to prevent such a setback, unsuitable combinations of LED lamps and luminaires must be avoided.

Considerations

There are a huge number of LED-Lamps and luminaires which can be combined. The following figures show some examples. The brown arrows show the expected air flow and the red ones show the expected main direction of heat dissipation. Please notice that only few finite elements of flow [5] are shown here.

Figure 2 shows a lamp outside a luminaire. Heat dissipation should be no problem. Same in case of an open luminaire as shown in figure 3. If a LED lamp is applied in a closed luminaire (figure 4) which is big enough, a heat build-up may be prevented. Small, closed luminaires as in figure 5 may hinder heat dissipation.

Figure **6** shows air temperature within a luminaire for the time after the lamp has been switched on. The lamp heats up the luminaire until an (thermal) steady state condition [6] is reached.

The higher the temperature of the lamps immediate surroundings under steady state condition, the higher the junction temperature and the higher the risk of premature failure.

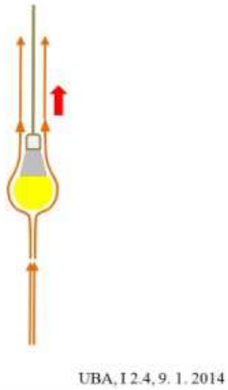

Figure 2: lamp outside luminaire

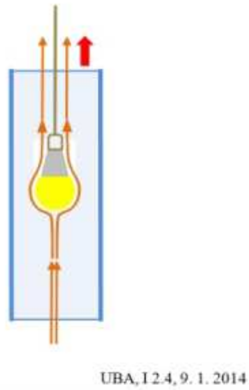

Figure 3: lamp in open luminaire

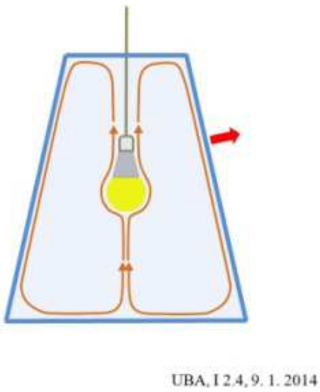

Figure 4: lamp in big, closed luminaire

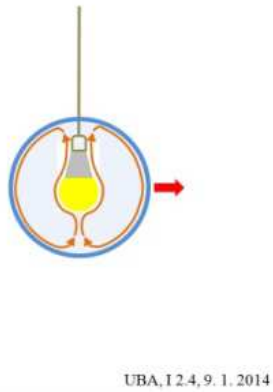

Figure 5: lamp in small, closed luminaire

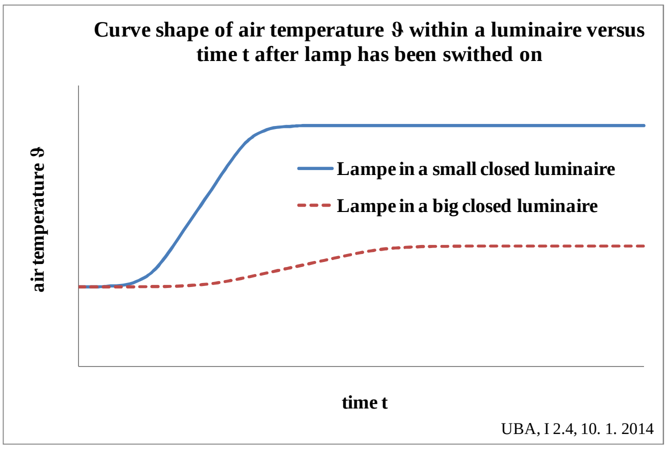

Figure 6: Lamp heats up a luminaire

If there is a risk of heat build-up for a given combination of lamp and luminaire or not, depends on the design of the luminaire and the relation between electric power of the lamp and the dimensions of the luminaire.

[5] DE: *Strömungsfäden*
[6] DE: *Beharrungszustand*; FR: *état thermiquement stable*; *stabilisation de système*; *régime stabilisé*

Conclusion:

► A globalised assessment of luminaires as suitable or not suitable for LED lamps would be the wrong way.

The number of combinations which can be chosen is very high. The number of new products is growing day-to-day, thus the number of combinations too. To assess each combination would be an extremely high burden for industry and would lead to long lists which could not been handled by consumers.

Conclusion:

► An assessment of each individual combination of lamps and luminaires as suitable or not suitable would be the wrong way.

A lamp manufacturer does not know in which luminaire the lamp he sold, will be inserted. But he knows referring to which junction temperature he declared values like lifetime etc. He should know which maximum value the temperature of the lamps immediate surroundings under steady state condition $\vartheta_{U,Lp.max}$ should not exceed if the junction temperature should not get too high.

A luminaire manufacturer does not know which lamp will be inserted into the luminaire he sold. But he should be able to determine which value the electric power of a lamp may have if $\vartheta_{U,Lp.max}$ should not be exceeded. Caution advices e.g. like "**Max. 40 W**" can be found on luminaires already today. A simple additional advice concerning maximum electric power of a LED lamp could be added.

<u>**Proposal**</u>

On base of the considerations described above we propose the following steps:

1st ***Lamp manufacturers define a standard maximum value for air temperature in immediate proximity to LED lamps. This maximum value is to be set in such a way that under steady state conditions, inside the LED lamp a junction temperature exists at which the declared values of lifetime etc. can be obtained.***

2nd ***Luminaire manufacturers determine for each of their products the maximum power (W) a lamp may have without exceeding under steady state condition the temperature defined in the 1st step.***

3rd ***Based on a product information requirement, luminaire manufacturers declare the maximum power value, determined in step 2, on their products and in product documents, e.g. in the following format:***

"**LED: 60 °C ➡ max. 20 W**" (where 60 °C is to be replaced by the actual agreed temperature)

The following pictures show some examples how such a labelling could look like. Please notice: values for temperature and power have been chosen for illustrative purposes only.

Figure 7: Desk luminaire [source: [7]]

[7] Christoph Mordziol, Roßlau (DE)

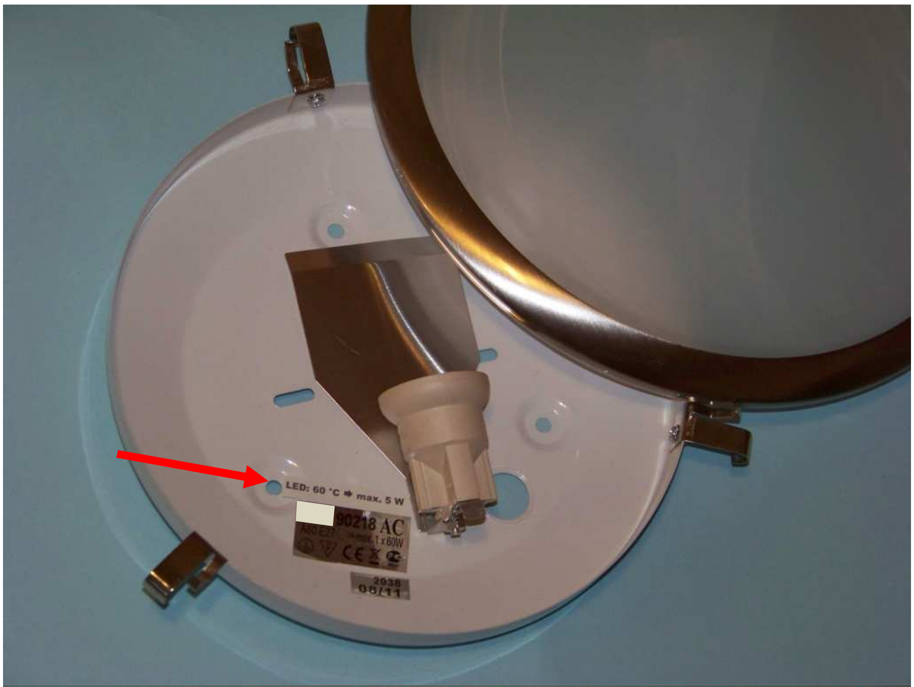

Figure 8: Closed luminaire [source: 7]

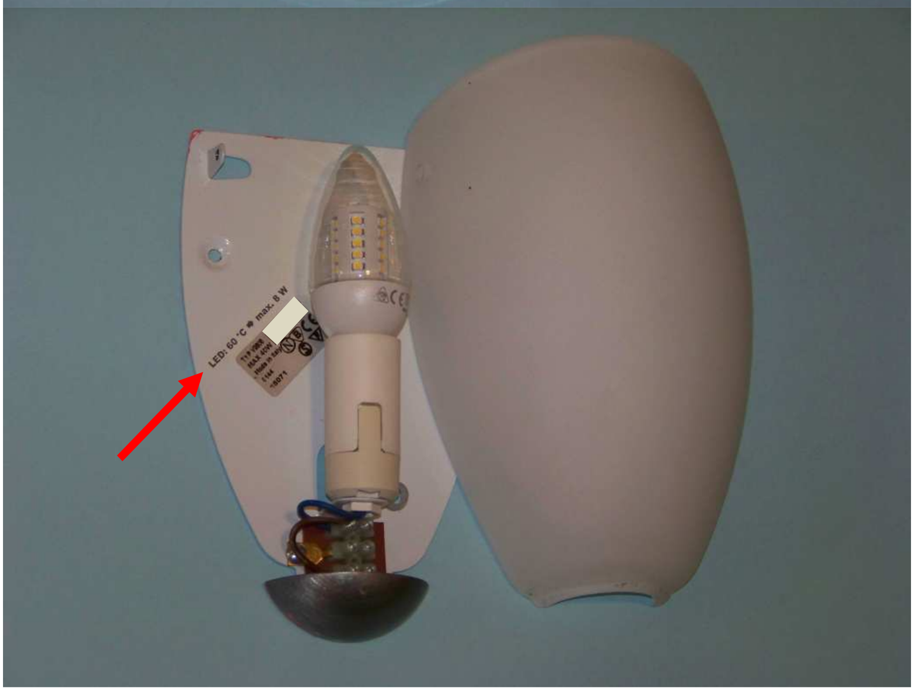

Figure 9: Luminaire with opening facing upwards [source: 7]

Figure 10 [source: 7]

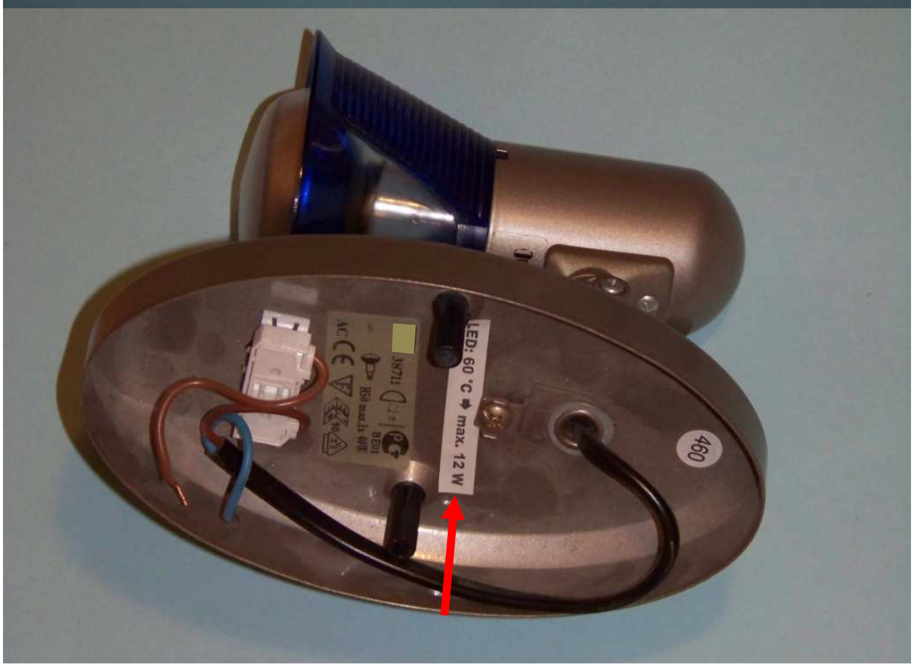

Figure 11: Luminaire with reflector lamp [source: 7]

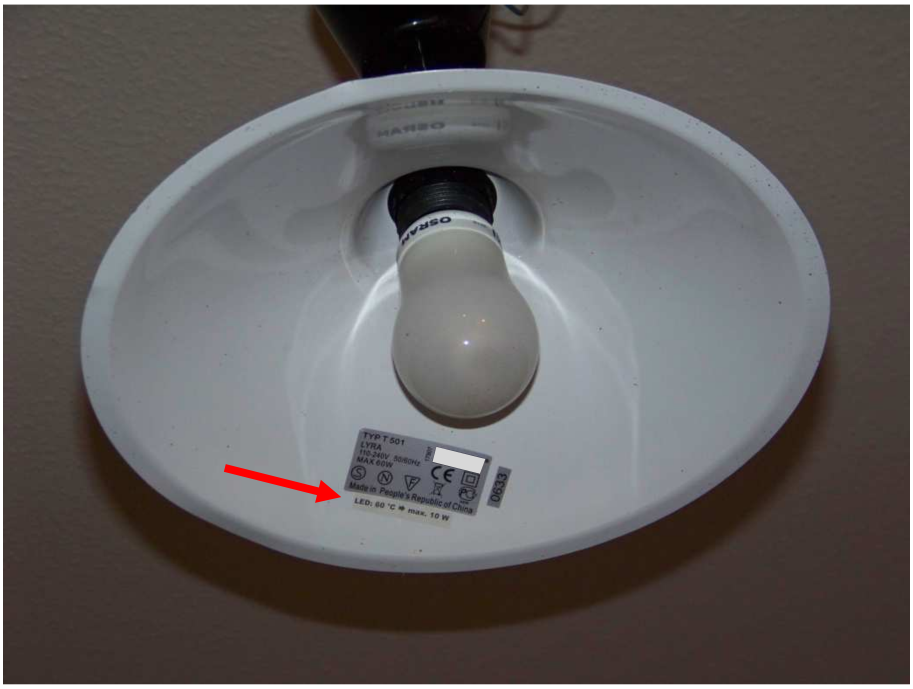

Figure 12: Luminaire with opening facing downwards [source: 7]

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Annex B

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Square root function vs. Efficacy

Is the differences between the square root function and efficacy significant?

Regulation 874/2012/EC uses both – square root function and efficacy – stating that the EEI is to be determined on base of the reference power, which has to be calculated as follows:

1st for $\Phi < 1300$ lm (lumens) using the common square root function $0.88\times\sqrt{\Phi} + 0.049\times\Phi$;

2nd for $\Phi \geq 1300$ lm using an equation which stands for a constant efficacy.

Thus at a luminous flux of 1300 lm there is a break, i.e. a switch between “square root-EEI” and “efficacy-EEI”. Since EEI and efficacy are compared here, the EEI of regulation 874/2012 is not used for illustration, but the common square root function $0.88\times\sqrt{\Phi} + 0.049\times\Phi$ for the whole lumen range. The resulting efficiency value is called EEI_{98} because this same square root function was used by the former labelling regulation 98/11/EC for defining energy classes B to F.

Figure 13 shows for efficacy values of 60, 80 and 100 lm/w, respectively, the curve progression for EEI_{98} vs. luminous flux. The figure shows: the higher the luminous flux, the smaller the difference between the efficacy curve and a constant EEI_{98}-value. This is evident e.g. in the case of the 80lm/w- curve and the line of $EEI_{98} = 0.24$.

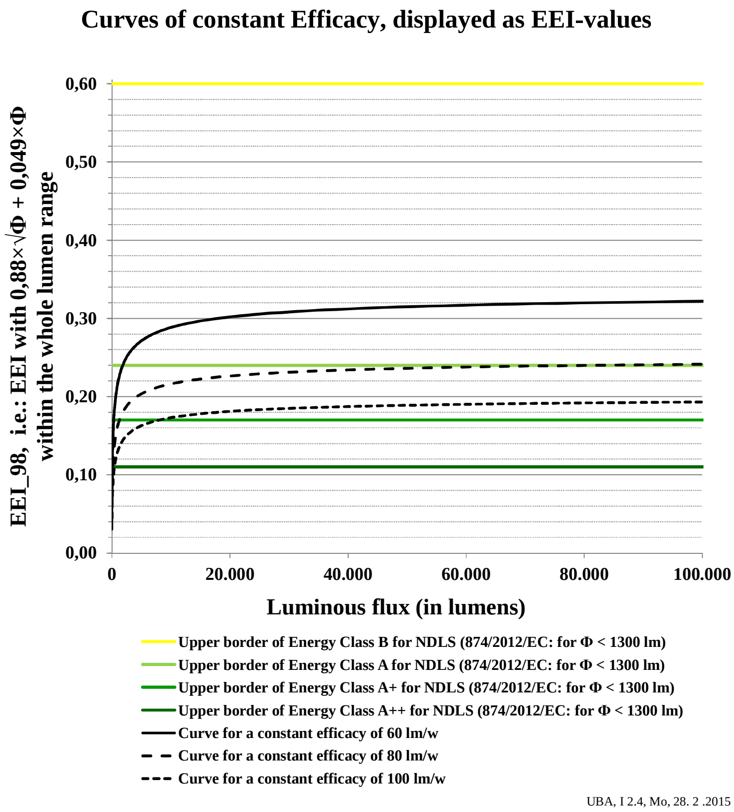

Figure 13: Comparison of curve progression between constant efficacy and constant EEI_{98}

Which of these efficiency values serves the best for LED light sources?

We have looked on a number of lamps from Osram (DE), Philips (NL) , Megaman (DE) and Duralamp (IT): bulb shaped lamps with E27 socket | NDLS lamps with G socket, 12 volts | DLS-lamps | LED tubes |downlights and outdoor floodlights. We compared products with same features: same voltage, same colour temperature, same beam angle and calculated for each group the average EEI_{98} and the average efficacy. After that we calculated for each single product the difference between the individual value of the single product to the average value of the related group.

Result: For some groups it is the square root function which fits better to describe the efficiency because the differences are lower and for some groups the efficacy is the best.