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Concerning

- **Ecodesing Working Document for discussion on 5 July 2011 – Ecodesign requirements for directional lamps, light emitting diode lamps and halogen lighting converters**
- **Energy Labelling Working Document 2 for discussion on 5 July 2011 – Draft – Commission Delegated Regulation (EU) […] implementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of general lighting lamps and household luminaires**

Background information on methods to draw limits of efficiency classes

In the Explanatory Notes concerning the Working Document on labelling it is written that "*the precise method to draw the limits of the classes needs to be discussed in the meeting on 5 July*".
This paper gives some background information on base of lamp data.

1 General aspects

There are different ways to deal with efficiency of lamps.

- The efficacy is a very common one. It expresses efficiency in the narrower sense as the relation of output to input, i.e. luminous flux (lumens) to power (watts). Figure 1 shows the efficacy values for standard GLS lamps of various luminous flux [1].
  The higher the efficacy of a lamp, the better.
  The efficacy as an efficiency index has a number of disadvantages.

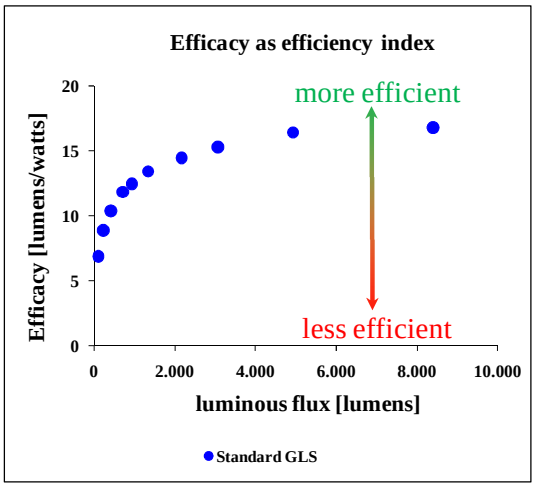

Figure 1: Efficacy as efficiency index [UBA]

- Another way to deal with efficiency is used in the labelling regulation 98/11/EC. Maximum limits for the power are set, expressed as the relation of power to a reference value which is calculated on base of the luminous flux [2]. Directive 244/2009/EC does the same for ecodesign. In the working document for energy labelling, to be discussed on July 5th 2011, the same is proposed for lamps with a luminous flux < 1.300 lumens.
  Figure 2 shows for the same standard GLS lamps as above the efficiency index EEI_{98} [3] versus luminous flux. The lower the EEI_{98}, the less power (input) is needed to deliver the same luminous flux (output), i.e. the lower the EEI_{98} of a lamp, the better.

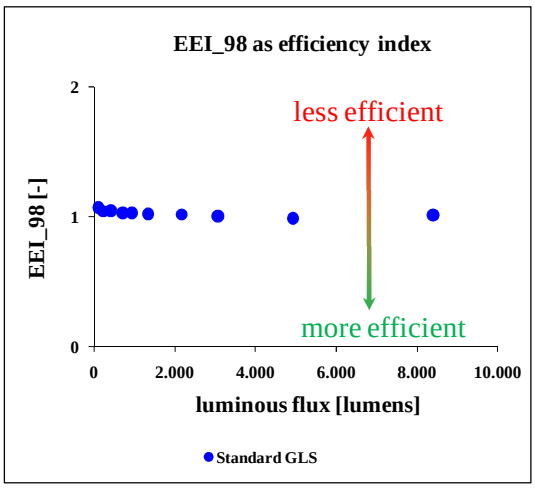

Figure 2: EEI_{98} as efficiency index [UBA]

For various reasons it is better to use an index like EEI_{98} than to use efficacy values [4].

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1 Values of the luminous flux used here have been averaged on base of values taken from catalogues of a number of manufacturers (GE, Narva, Osram, Philips, Radium and Sylvania).

2 reference value = $0{,}88\times\sqrt{\Phi} + 0{,}049\times\Phi$, where Φ is the total luminous flux of the lamp

3 EEI_{98} = power / $[0{,}88\times\sqrt{\Phi} + 0{,}049\times\Phi]$, where Φ is the total luminous flux of the lamp
Index 98 because of Regulation 98/11/EC.

4 A more detailed rationale can be delivered if needed (christoph.mordziol@uba.de).

The following figures show two examples for how the EEI_{98} can be used:

Energy labelling: Figure 3 shows class limits due to Regulation 98/11/EC.

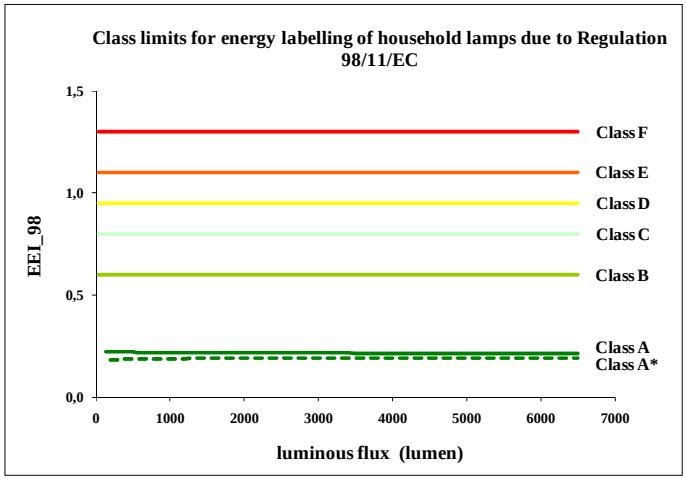

Figure 3: EEI_{98} used to show class limits of the recent energy labelling [UBA]

Ecodesign: Figure 4 shows the phase out stages for clear glass lamps in Directive 244/209/EC. Example stage 1: All lamps above the blue line have been phased out at September 1st 2009.

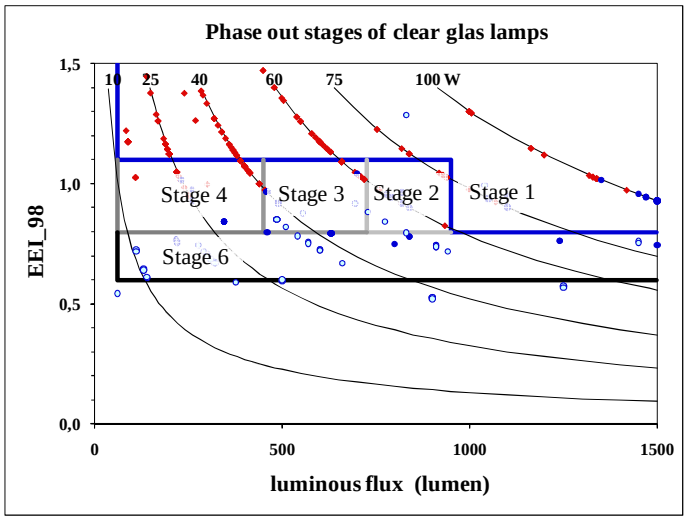

Figure 4: EEI_{98} used to show the phase out stages for clear glass lamps due to Directive 244/209/EC. Red points stand for incandescent lamps and blue for halogen lamps. [UBA]

2 Calculation of Energy Efficiency Index (Working Document on Labelling, Annex VII, point 1)

In the explanatory note on the working document for energy labelling of the Commission it is said that "*the energy label was designed with incandescent/ halogen bulbs in mind, for which it is true that the more light that lamps of exactly the same technology (filament, filling gas) produce, the more efficient they are. (…) fluorescent, HID and LED light sources do not obey the rule on efficiency increasing with light output. Their efficiency has only limited links to their light output*". The commission draws the conclusion that "*it would be appropriate to set a single lumen/watt requirement for each class"*.
The following figure shows curves for lamps of different technologies:

- Beside filament lamps (incandescent and halogen),
- Metal Halide Reflector and Non-Reflector lamps,
- Mercury High Intensity lamps,
- Compact and Linear Fluorescent lamps and
- Sodium High Pressure and Low Pressure lamps.

The raw data have been taken from catalogues of different manufacturers. For each technology data of a particular lamp type series had been chosen.
The figure shows the class limits A^{++} to D for non-directional lamps, as proposed in the working document for lamps with luminous flux < 1.300 lumens, as well.
In a figure showing IIE_{98} versus luminous flux (as used above), lamps with increasing efficiency at higher lumen output show curves running more or less parallel to the class limits. In contrast, lamps with non-increasing efficiency at higher lumen output (as stated in the working document) show curves which clearly rise.

In order to make the differences better visible, both axes are logarithmic.

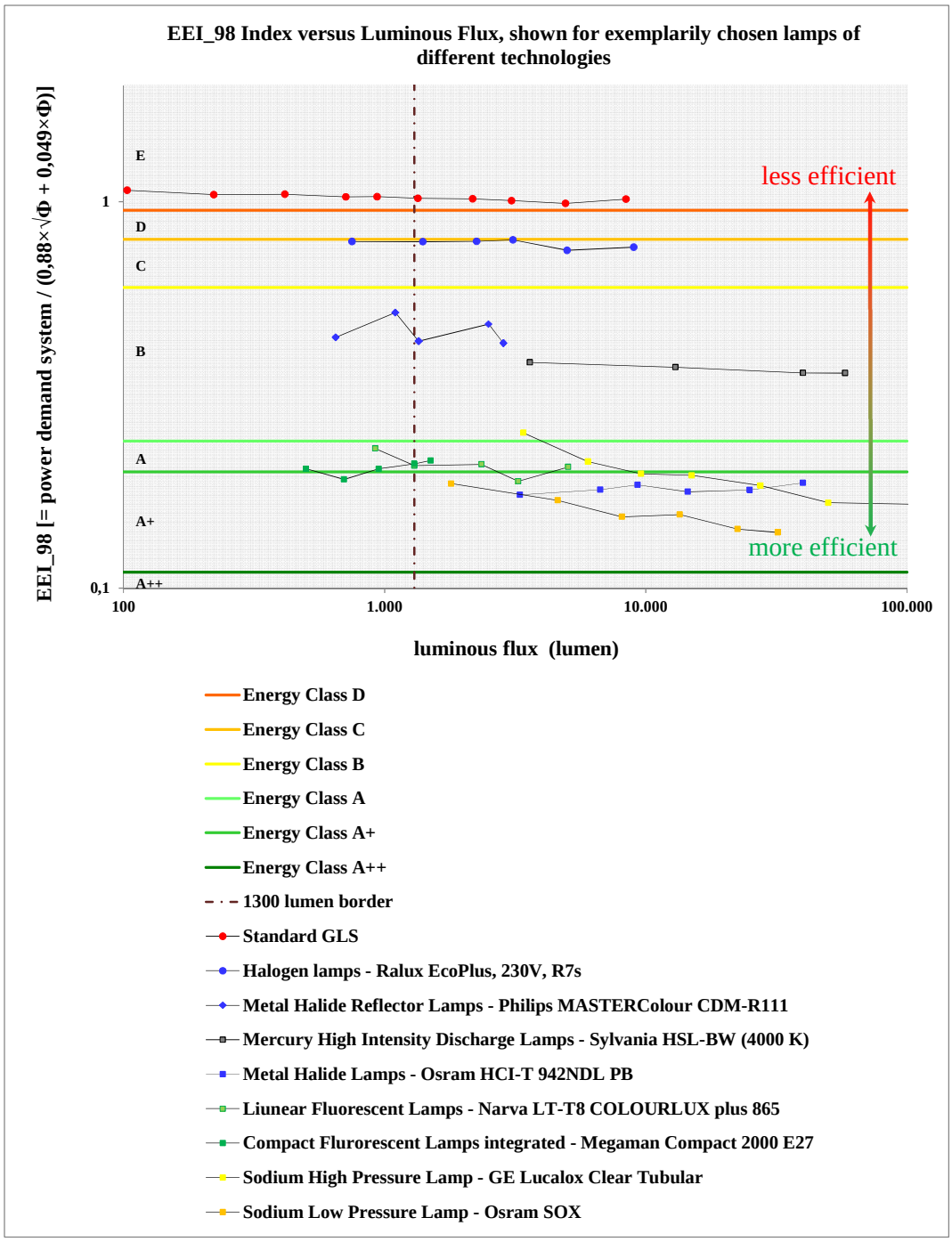

Figure 5: EEI_{98} Index of non-LED lamps versus luminous flux [UBA]

Result:

➔ **The more light lamps of exactly the same technology (as listed above) produce, the more efficient they are.**

The next figure shows the same data as above (blue dashed lines), supplemented by data of three LED lamp type series (red lines):

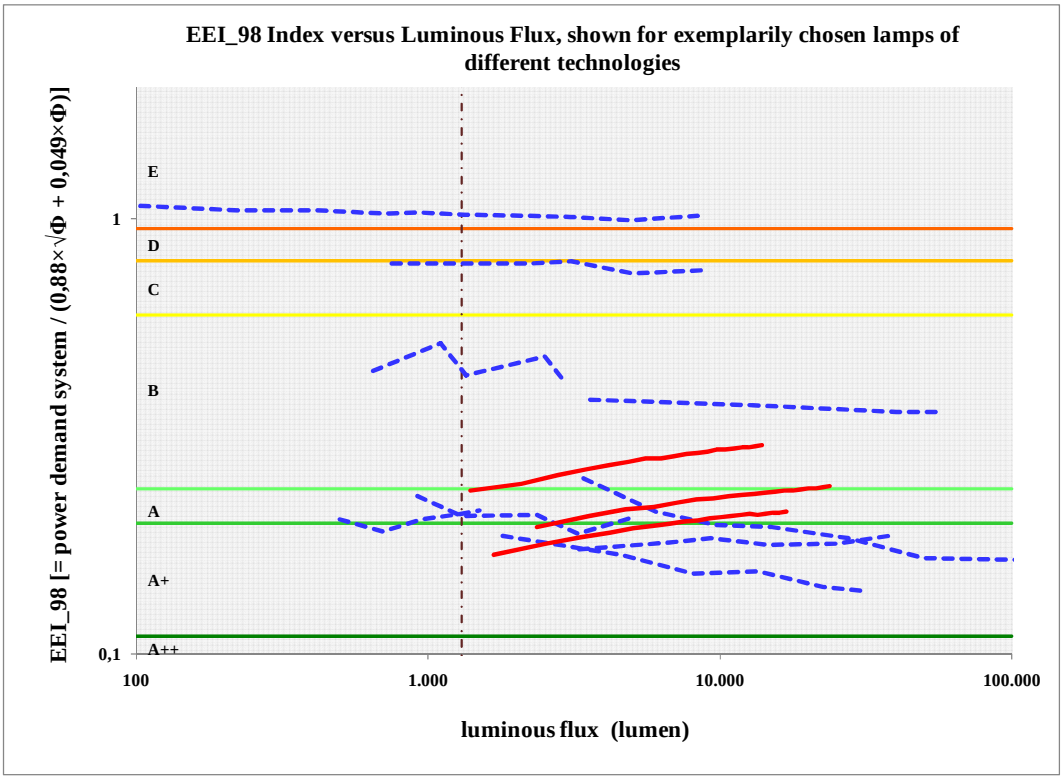

Figure 6: EEI_{98} Index of LED and non-LED lamps versus luminous flux [UBA]

Results:

- ➔ **Differing from other technologies LED-lamps do not show increasing efficiency at higher lumen output.**
- ➔ **The absolute efficiency of LED-lamps is not lower at high lumen output, but the relative efficiency is lower, i.e. compared to other technologies.**
- ➔ **While lamp series of non-LED technology stay in the same energy class at high lumen output or even move to better classes, LED lamp series may change to a worse class.**

The next figure shows the same data as above, but the class limits in the range > 1.300 lumens follow the proposal in the working document.

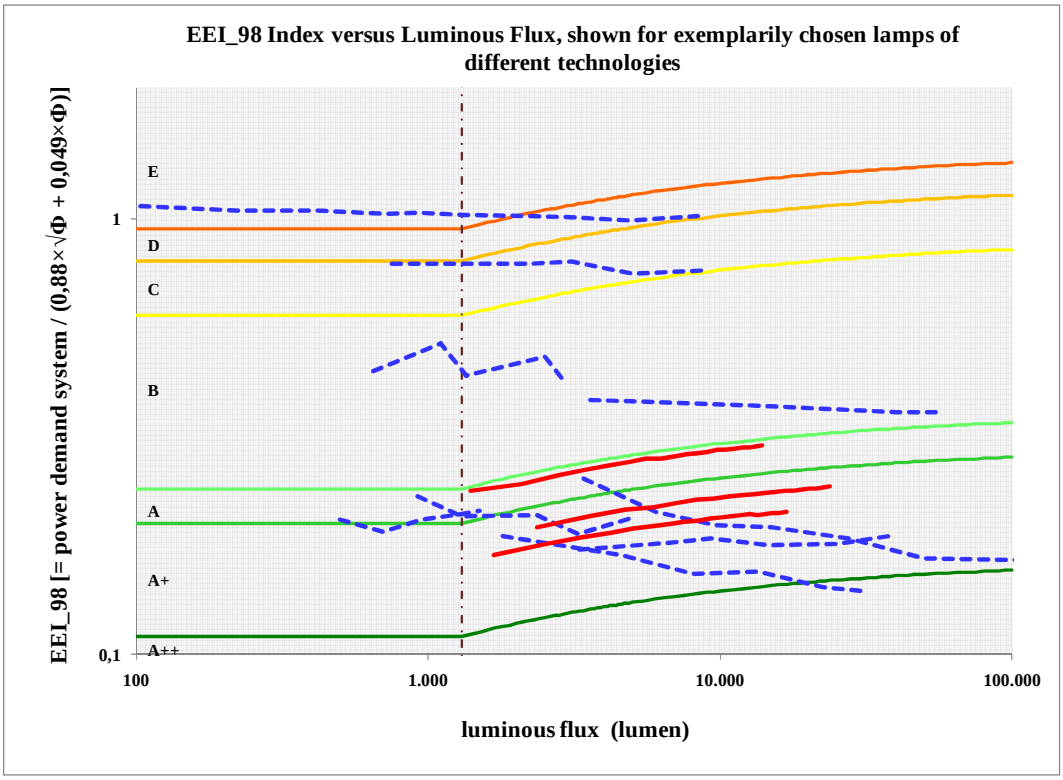

Figure 7: EEI_{98} Index of LED and non-LED lamps versus luminous flux in relation to class limits ass proposed in the working document for lamps ≥ 1.300 lumens [UBA]

Result:

- **Using the differing formula to calculate the class limits in the range > 1.300 lumens, leads to the following situation: LED-lamps may stay in the same class at high lumen output although their efficiency is lower, compared to other technologies. The differing formula hides that – which is not intended, supposably.**
- **Energy labelling should serve to classify efficiency levels, comparing different products/technologies. The differing formula should not been used.**

3 Energy Efficiency Classes for General Lighting Lamps (Working Document on Labelling, Annex VI, point 1)

The working document mentions a proposal of ELC concerning the class limits for directional lamps as follows:

Energy efficiency class	Energy Efficiency Index (EEI) for non-directional lamps	Energy Efficiency Index (EEI) for directional lamps
A++ (most efficient)	EEI ≤ 0.11	EEI ≤ 0.15
A+	0.11 < EEI ≤ 0.20	0.15 < EEI ≤ 0.34
A	0.20 < EEI ≤ 0.24	0.34 < EEI ≤ 0.65
B	0.24 < EEI ≤ 0.6	0.65 < EEI ≤ 1.20
C	0.6 < EEI ≤ 0.8	1.20 < EEI ≤ 1.75
D	0.8 < EEI ≤ 0.95	1.75 < EEI ≤ 2.00
E (least efficient)	EEI >0.95	EEI > 2.00

In order to compare the level of ambition of ELC's proposal, the following figure shows data of about 230 directional lamps.

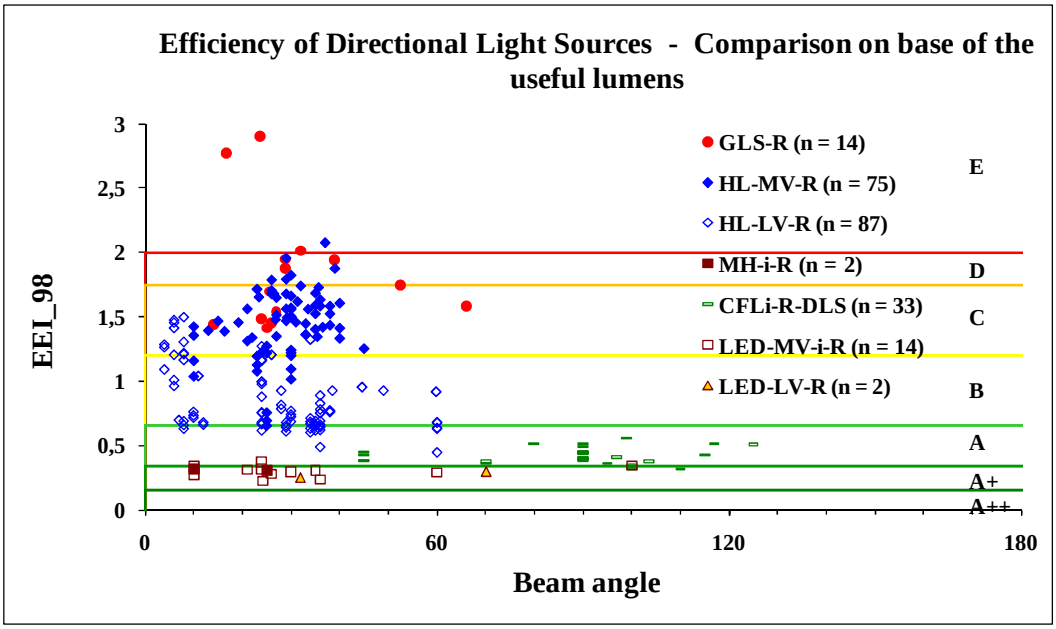

Figure 8: EEI_{98} Index of directional lamps [UBA]

There are only 4 lamps within class E.

In order to compare the level of class limits of the recent labelling with the class limits, proposed by ELC for directional lamps, Figure 9 shows on the left side the same data for directional lamps as before, supplemented with data of 39 CLFi reflector lamps, which are classified as non-directional lamps due to Directive 244/2009/EC and on the right side data of a huge number on lamps.

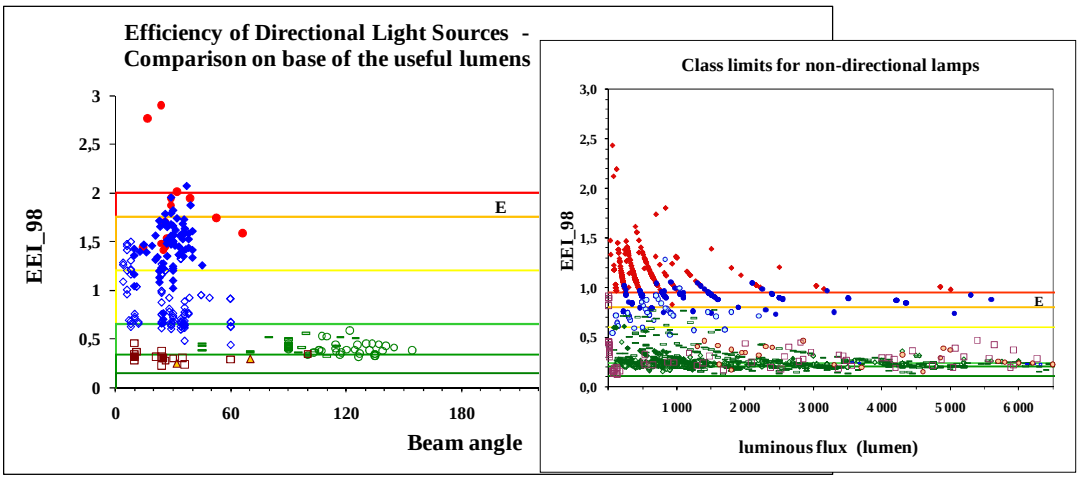

Figure 9: EEI_{98} Index of directional and non-directional lamps versus beam angle (left side) and of non-directional lamps versus lumen output (right side) [UBA]

Following ELD proposal the class limit of e.g. class E would be more than twice for directional lamps than for non-directional lamps.