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Preparatory Studies for Eco-design Requirements of EuPs

Lot 19: Domestic lighting - Part 2
Directional lamps and household luminaires

Final Task Report
Task 1: Product Definition

Study for European Commission DGTREN unit D3, contact: Andras Toth

Contractor:

Project performed in cooperation with:

Contact Vito: Paul Van Tichelen, info@eup4light.net

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Project team

Vito:
Paul Van Tichelen
An Vercalsteren
Bio Intelligence Service:
Shailendra Mudgal
Benoît Tinetti
Alexander Thornton
Energy Piano:
Casper Kofod
Kreios:
Lieven Vanhooydonck
Laborelec (reflector lamp tests):
Jean-Michel Deswert

Important note:
This report contains the updated draft results of research by the authors and is not to be perceived as the opinion of the European Commission.
This is an updated draft document intended for stakeholder communication.

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0 PREFACE

VITO and its partners are performing the preparatory study for the new upcoming eco-design directive for Energy Using Products (EuP) related to domestic lighting, on behalf of the European Commission (more info http://ec.europa.eu/enterprise/eco_design/index_en.htm).

The environmental impacts of Energy-using Products such as domestic lighting take various forms, including: energy consumption and the related negative contribution to climate change, consumption of materials and natural resources, waste generation and release of hazardous substances. Eco-design, which means the integration of environmental considerations at the design phase, is arguably the best way to improve the environmental performance of products.

The creation of a coherent framework for environmental product policy avoids the adoption of uncoordinated measures that could lead to an overall negative result; for example eliminating a toxic substance from a product, such as mercury from lamps, might lead to increased energy consumption, which could in total have a negative impact on the environment. A Community framework also ensures that divergent national or regional measures, which could hinder the free movement of products and reduce the competitiveness of businesses, are not taken. It is not the intention to decrease the quality of domestic lighting.

The objective of this draft document is to present preliminary data for discussion with stakeholders related to the EuP preparatory study for the lot 19.
You can follow the progress of our study and find general information related to lot 19 on the project website when you register as a stakeholder: http://www.eup4light.net
Please, also consult the website for timing and organisation of the tasks.

Important remark:
It must be clearly stated that this part 2 of the study relies on the draft regulation resulting from part 1 of the study on non-directional light sources. Specific items on non directional lamps that were discussed in part 1 will not be repeated in this part 2. Items that are related to all light sources can be repeated, only to improve the readability.

1 PRODUCT DEFINITION

Scope: This task should define the product category and define the system boundaries of the 'playing field' for eco-design. It is important for a realistic definition of design options and improvement potential and it is also relevant in the context of technically defining any implementing legislation or voluntary measures (if any).

The objective of this task is to discuss definition and scope issues related to the EuP preparatory study for the lot 19. It consists of categorisation of products, description of product definitions, scope definition as well as identification of key parameters for the selection of relevant products to perform detailed analysis and assessment during the next steps of the study.

Further, the harmonised test standards and additional sector-specific procedures for product-testing are identified and discussed, covering the test protocols for:

- Primary and secondary functional performance parameters;
- Resource use (energy, etc.) during product-life;
- Safety (electricity, EMC, stability of the product, etc.);
- Other product specific test procedures.

Finally, it aims to identify existing legislations, voluntary agreements and labelling initiatives at the EU level, in the Member States and outside Europe.

1.1 Product category and performance assessment

1.1.1 System boundary and technical product definition

Proposed product definition, scope and system boundary:

The proposal is to use a product definition derived from existing European standards and the Prodcom classification.

A 'domestic lighting' product system can more generally be considered as 'lighting equipment' as defined in standard EN 12665 (Light and lighting - Basic terms and criteria for specifying lighting requirements) for domestic application, containing:

1. A "*lamp"* as "*source made in order to produce an optical radiation, usually visible*";
2. A *"luminaire*" as "*apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting the lamps to the electric supply"*.

In this study, "lamp" means a source made in order to produce an optical radiation, usually visible, including any additional components necessary for starting, power supply or stable operation of the lamp or for the distribution, filtering or transformation of the optical radiation, where those components cannot be removed without permanently damaging the unit.

It must be explicitly stated that only lamps and luminaires for general lighting that use electrical energy are in the scope of this study; lamps for torches, bicycles, motorcycles and motor vehicles are excluded.

Furthermore it is proposed to exclude coloured lamps that are typically used for decorative purposes, therefore the definition of a white light source in part 1 is used.

It is important to note that the definition of domestic lighting in this eco-design study covers products with similar characteristics. Moreover, many so-called 'domestic lighting' products are also used in other areas (e.g. hotels, shops, offices). According to the MEEuP Methodology Report, these product groups that are functionally similar have to be envisaged. As a consequence all that products that are based on the same technology will be included in this study.

The 'domestic lighting' is not a lighting specifiers market, this means that the technical lighting requirements (e.g. illuminance levels) are not specified by the consumer before installation according to technical standards. Therefore the approach is different from the previous EuP studies for office and street lighting. In this study, a lamp technology based approach is proposed. This means a focus on the lighting technology that is most commonly used in the domestic market. The advantage of this approach is that the Prodcom classification according to lamp technology can directly be adopted and possible implementing measures can easily be followed up.

Luminaires are considered as being part of the system environment. Therefore it is proposed to not consider the complete luminaire as such but to consider only the impact of the following specific functional elements incorporated in the luminaire or sold together as one unit:

- sockets,
- built-in light source control gear,
- external light source control gear (non-mounted),
- dimming control,
- optical reflector.

The supporting structure (boxes, bars etc.) of a luminaire will only be taken into account if necessary for the assessment of an improvement, and even then with the bare minimum elements of the most simple luminaire in each category, as it is impossible to analyse all decorative elements found in domestic luminaries on the market (gold plating, crystal, ..).

For the eco-reports and the LCA’s, the data from former EuP-studies will be used if available: for halogen transformers the study on power supplies (Lot 7), for ballasts and dimming control the studies on public street lighting and office lighting (Lot 8 and 9).

External mounted dimmers (wall mounted) are considered as part of the external system. Only requirements for compatibility will be discussed.

Also functional properties will be considered that enable energy efficient light sources or light use (lamp compartment properties, ..). For the found system-related improvement options (if

any) environmental impact assessment and LCC impact assessment will be made in task 8 at product level.

Additional definitions for LED-applications:

A 'retrofit LED lamp' in this study has been defined as a self-ballasted lamp, incorporating a LED light source and any additional elements necessary for a stable operation of the light source; it is provided with a lamp cap conform IEC 60061-1, which cannot be dismantled without permanent damage (see EN 62560: '*Safety Requirements for Self-ballasted LED lamps'* and IEC/PAS 62612 Ed.1: '*Performance requirements for Self-ballasted LED-lamps for general lighting services > 50 V*').

A 'LED-luminaire' is a luminaire incorporating one or more LED light sources and all additional elements necessary for stable operation of the light sources and in which no LED light source or other element can be replaced or changed by the consumer. The luminaire can be installed as a whole, just like a normal luminaire.

A 'LED-module' is a combination of two (or more) seperate parts i.e. a LED light source and a part containing all additional elements necessary for a stable operation of the accompanying LED light source. This LED module is not intended to be sold as such to an end consumer but only to luminaire manufacturers and specialized installers.

1.1.2 Classification of domestic lamps and luminaires

Please note that in Eurostat's product-specific statistics for trade and production (the so-called Europroms[1]-Prodcom[2] statistics) domestic lighting can be reported in two manners:

1. According to lamp technology.
2. According to function of the luminaire.

Prodcom is a valuable source of information in total number of sales and average price. This level of aggregation is rather raw. For the purpose of the eco-design analysis extra sub-categories will be therefore added.

1.1.2.1 Lamps applicable in domestic lighting

The PRODCOM segmentation for lamps related to domestic lighting is displayed in Table 1.1.

[1] Europroms is the name given to published Prodcom data. It differs from Prodcom in that it combines production data from Prodcom with import and export data from the Foreign Trade database.
[2] Prodcom originates from the French "PRODuction COMmunautaire"

Table 1.1: Prodcom segmentation for lamps related to domestic lighting

31.50.12.93	Tungsten halogen filament lamps, for a voltage > 100V Excluding: - ultraviolet and infra-red lamps - for motorcycles and motor vehicles
31.50.12.95	Tungsten halogen filament lamps for a voltage ≤ 100V Excluding: - ultraviolet and infrared lamps - for motorcycles and motor vehicles
31.50.13.00	Filament lamps of a power ≤ 200W and for a voltage > 100V Including: - reflector lamps Excluding: - ultraviolet and infrared lamps - tungsten halogen filament lamps - sealed beam lamp units
31.50.15.10	Fluorescent hot cathode discharge lamps, with double ended cap Excluding: - ultraviolet lamps
31.50.15.30	Fluorescent hot cathode discharge lamps Excluding: - ultraviolet lamps - lamps with double ended cap
31.50.15.53	Mercury vapour discharge lamps Excluding: - ultraviolet lamps - dual lamps (Including : metal halide lamps)

As mentioned before, for the purpose of the eco-design analysis, extra sub- categories will be added; the complete list of lamp types is included in Table 1.2.

In this study directional light sources (DLS) or directional lamps (e.g. reflector lamps) and non-directional light sources (NDLS) or non-directional lamps will be discriminated, because the performance data provided by manufacturers are different for both lamp types and it allows to execute the study in two phases. Within directional light sources, further discrimination can be made according to light distribution or beam angle.

The base line proposal for defining these directional and non-directional light sources is based on the light distribution per solid angle. The unit for a solid angle is the steradian [sr]; a complete solid angle can e.g. be visualized as a sphere and counts 4π sr (see Figure 1.1).

Figure 1.1: Visualization of a complete solid angle.

According to the definition in part 1 of the study and Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps, discrimination of light sources is made in the following categories:

- 'Directional Light Source' or DLS means a light source having at least 80% light output within a solid angle of π sr (corresponding to a cone with angle of 120°). A DLS uses a reflector or an optical component (e.g. lens for LED) to align the luminous flux.
- 'Non-Directional Light Source' or NDLS means a light source that is not a directional light source.

As a consequence, although they are 'reflector' lamps, there currently are probably no CFLi-R with small diameter on the market that meet this definition of directional light source; they only can be found in the wider diameters. In this part 2 of the study, two categories of CFLi-R will be discriminated namely CFLi-R-NDLS and CFLi-R-DLS. CFLi-R-NDLS have to fulfil the requirements of the non-directional light sources that are entered in Commission Regulation (EC) 244/2009.

Table 1.2: Overview of directional lamp types to be discussed in this study

PRODCOM Code	Definition Prodcom	Voltage [V]	Wattage [W]	Low luminance Frosted High luminance Clear	Directional / Non-Directional Llight Source	Socket type	Application	Other names	Acronym in this study
31.50.13.00 	Filament lamps of a power ≤ 200W and for a voltage > 100V Including: -reflector lamps Excluding: -ultraviolet and infrared lamps -tungsten halogen filament lamps -sealed beam lamp units .	230 - 240	≤200		DLS	E14 E27 B15d B22d		Incandescent reflector lamp or General Lighting Service reflector lamp	GLS-R

PRODCOM Code	Definition Prodcom	Voltage [V]	Wattage [W]	Low luminance Frosted High luminance Clear	Directional / Non-Directional Llight Source	Socket type	Application	Other names	Acronym in this study
31.50.13.00 31.50.14.93 	Filament lamps for a voltage > 100V Excluding: -ultraviolet and infrared lamps -tungsten halogen filament lamps -those of a power ≤ 200W -for motorcycles and motor vehicles -sealed beam lamp units	230 - 240	>200		DLS	E40	Floodlighting In general, not used for domestic lighting	Incandescent reflector lamp or General Lighting Service reflector lamp High Wattage	GLS-R-HW
31.50.14.93  			300		DLS	MP GX16d	Traffic signalling flash lamp In general, not used for domestic lighting		GLS-R-special
31.50.12.95  	Tungsten halogen filament lamps for a voltage ≤100V Excluding: -ultraviolet and infrared lamps -for motorcycles and motor vehicles	12	12 - 100		DLS	GU4 GU5,3 G53 GY4		Halogen reflector lamp	HL-LV-R
						B15 Ba15d	In general, not used for domestic lighting		

PRODCOM Code	Definition Prodcom	Voltage [V]	Wattage [W]	Low luminance Frosted High luminance Clear	Directional / Non-Directional Llight Source	Socket type	Application	Other names	Acronym in this study
31.50.12.93 	Tungsten halogen filament lamps, for a voltage > 100V Excluding: - ultraviolet and infra-red lamps - for motorcycles and motor vehicles	230	20 - 100		DLS	GU10 GZ10 E14 E27 G9		Halogen reflector lamp	HL-MV-R HL-MV-R-HW
31.50.15.30 	Fluorescent hot cathode discharge lamps Excluding: -ultraviolet lamps -with double ended cap	230	9 - 23		DLS	E14 E27 GU10	Domestic, hotel and general lighting retrofit for incandescent or halogen reflector lamp	Compact Fluorescent Reflector Lamp with integrated ballast Note: these lamps can be either DLS or NLDS (part 1 of the study).	CFLi-R, CFLi-R-DLS, CFLi-R-NDLS
(31.50.15.59 ?) 	Discharge lamps Excluding: -fluorescent hot cathode lamps -dual lamps -mercury or sodium vapour lamps -ultraviolet lamps	230	23		DLS	E27 B22d	Domestic (etc.) retrofit for incandescent and halogen reflector lamp	Electrodeless induction reflector lamp with integrated ballast.	

PRODCOM Code	Definition Prodcom	Voltage [V]	Wattage [W]	Low luminance Frosted High luminance Clear	Directional / Non-Directional Llight Source	Socket type	Application	Other names	Acronym in this study
31.50.15.53  	Mercury vapour discharge lamps Excluding: -ultraviolet lamps -dual lamps *(Including: metalhalide lamps)*		20 - 150 20 35 70	High Clear	DLS	GX8.5 GX10 E27 B22d	Tertiary lighting	Metalhalide reflector lamp	MH-R
31.50.15.53 	Mercury vapour discharge lamps Excluding: -ultraviolet lamps -dual lamps *(Including: metalhalide lamps)*	230	20	High Clear	DLS	E27 B22d	Domestic, hotel and general lighting retrofit for incandescent or halogen reflector lamp	Metal halide reflector lamp with integrated ballast.	MHi-R
No specific code (to be confirmed) 	White, Light Emitting Diode Retrofit Directional lamp	230	0,01 - 100		DLS	GU10 E27 /B22d etc.	Domestic, hotel and general lighting retrofit for incandescent or halogen reflector lamp	WLED Retrofit Directional Lamp with integrated power supply White Light Solid State Retrofit Directional r Lamp with integrated power supply	WLEDi-DLS

PRODCOM Code	Definition Prodcom	Voltage [V]	Wattage [W]	Low luminance Frosted High luminance Clear	Directional / Non-Directional Llight Source	Socket type	Application	Other names	Acronym in this study
No specific code (to be confirmed) 	White, Light Emitting Diode Retrofit Directional lamp	12V	0.01 - 100		DLS	G4 GU5,3 etc.	Domestic, hotel and general lighting retrofit for low voltage halogen reflector lamp	WLED Retrofit Directional Lamp White Light Solid State Retrofit Directional Lamp	WLED-LV-DLS
No specific code (to be confirmed) 		misc	?		DLS	No cap	General lighting	WLED module	

PRODCOM Code	Definition Prodcom	Voltage [V]	Wattage [W]	Low luminance Frosted High luminance Clear	Directional / Non-Directional Llight Source	Socket type	Application	Other names	Acronym in this study
No specific code (to be confirmed)    detail:	?	230	1 - ??		DLS NDLS	No cap	Residential and general lighting	Integrated LED-luminaire	

Remarks:

- The following lamps were also part of the previous EuP studies on Office and Street Lighting:
  - linear fluorescent lamps
  - CFLni (compact fluorescent lamps with non integrated ballast
  - HID lamps.

  Although they are not again part of all tasks in this study, they will be considered as BAT in task 6.
- HID lamps with high colour rendering index, especially MH-lamps, will be included in this study (task 6) because they form an energy efficient alternative for halogen lamps. MH-lamps are nowadays rarely or not used in domestic lighting; they are mainly used in professional lighting applications (shops, sport fields, etc.). However they will be considered as BNAT or BAT (task 6) because of their potential to replace halogen lamps. Please also note that the Prodcom code 31.50.15.53 covers the complete group of mercury vapour discharge lamps. The Prodcom data are therefore not relevant for this study.
- Normal HPM lamps, included in the same Prodcom code 31.50.15.53 are not used in domestic lighting applications and phasing out was already proposed in the EuP preparatory study on street lighting.

1.1.2.2 Luminaires applicable in domestic lighting

Prodcom segmentation for domestic luminaires is represented in Table 1.3.

Table 1.3: Prodcom segmentation for domestic luminaires.

31.50.22.00	Electric table, desk, bedside or floor standing lamps
31.50.22.03	Domestic and residentials luminaires (excl. spots): for incandescent lamps
31.50.22.05	Domestic and residentials luminaires (excl. spots): for discharge lamps
31.50.22.09	Domestic and residentials luminaires (excl. spots): for other lamps
31.50.25.30	Chandeliers and other electric ceiling or wall lighting fittings (excl. those used for lighting public open spaces or thoroughfares)
31.50.25.31	Luminaires for domestic and residential (excl. spots): for incandescent lamps
31.50.25.32	Luminaires for domestic and residential (excl. spots): for halogen lamps
31.50.25.33	Luminaires for domestic and residential (excl. spots): for compact fluorescent lamps
31.50.25.34	Luminaires for domestic and residential (excl. spots): for other lamps
31.50.25.47	Spots, display lighting: for incandescent lamps
31.50.25.48	Spots, display lighting: for other lamps
31.50.25.79	Other lighting fixtures: luminaires (interior), n.e.c.
31.50.34.30	Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular fluorescent lamps
31.50.34.35	Exterior luminaires for houses and gardens : for incandescent lamps
31.50.34.37	Exterior luminaires for houses and gardens : for other lamps
31.50.42.50	Parts (excl. of glass or plastics) of lamps and lighting fittings, etc.

It can be stated that this segmentation is not very suitable for the technical analysis in this study.

On the one hand, the categories 'for incandescent lamps' should include all lamps that can be directly operated on the 230V with E14/E27 and B15d/B22d caps as there are: CFLi, WLEDi and certain HL-MV.
On the other hand, the categories for discharge lamps include all fluorescent lamps (LFL and CFLni) as well as HID lamps.
Also the statement 'for other lamps' is not identical for all categories of luminaires: sometimes there is a special category for halogen lamps and sometimes they are included in the category 'other lamps'.

Table 1.4 gives an overview of the domestic luminaire categories as they will be used in this study, this table was agreed with the sector organisation(CELMA)[3]. This categorisation is therefore in line with the terminology used in the sector and linked to technical parameters.

Remark: Luminaires with ballast, suitable for HID-lamps are rarely used for domestic applications. Moreover, they were already partly discussed in the EuP-study on public street lighting and included in Commission Regulation 245/2009; they will not be discussed again in this study.

Table 1.4: Overview of luminaire categories according to commercial terminology (catalogues, websites)

Luminaire category	Mounting method	Electrical connection	Light distribution	Ingress protection
Downlights (recessed mounted)	ceiling integrated	fixed (wired)	Directional light distribution	≥IP2X
Suspension (chandeliers)	ceiling suspended	fixed (wired)	Any	≥IP2X
wall&ceiling	surface mounted	fixed (wired)	Any (excluding Narrow beam spotlights)	≥IP2X
Desk	free surface standing	plug	Directional light distribution	≥IP2X
Table	free surface standing	plug	Non directional light distribution	≥IP2X
Floor	free surface standing	plug	Any	≥IP2X
Spotlights	surface mounted	fixed (wired)	Narrow beam directional light distribution	≥IP2X
Outdoor	surface mounted/floor standing	fixed (wired)	Directional light distribution(often) or non(rare)	≥IP44

1.1.3 General lamp and luminaire performance specification parameters

1.1.3.1 General lamp performance specification parameters

Each lamp has its own specific characteristics; the important performance assessment parameters are (EN 12665(2002))[4]:

- a "rated value" is the value of a quantity used for specification purposes, established for a specified set of operating conditions of a product. Unless stated otherwise, all requirements are set in rated values;
- a "nominal value" is the value of a quantity used to designate and identify a product;

[3] www.celma.org
[4] The definitions of 'nominal' and 'rated' value are not mentioned in this standard but in several other standards such as EN 60081 and EN 50294.

- rated luminous flux Φ [lm]: quantity value of the initial luminous flux of the lamp, for specified operating conditions. The value and conditions are specified in the relevant standard, corresponding unit: lumen [lm];
- nominal luminous flux Φ [lm]: a suitable approximate quantity value of the initial luminous flux of the lamp, corresponding unit: lumen [lm];
- “Switching cycle” is the sequence of switching on and switching off the lamp with defined intervals;
- "Premature failure" is when a lamp reaches its end of life after a period in operation which is less than the rated life time stated in the technical documentation;
- “Lamp cap” means that part of a lamp which provides connection to the electrical supply by means of a socket or lamp connector and, in most cases, also serves to retain the lamp in the holder;
- “Lamp holder” or “socket” means a device which holds the lamp in position, usually by having the cap inserted in it, in which case it also provides the means of connecting the lamp to the electric supply;
- "Light source control gear" means one or more components between the supply and one or more light sources which may serve to transform the supply voltage, limit the current of the lamp(s) to the required value, provide starting voltage and preheating current, prevent cold starting, correct power factor or reduce radio interference. Ballasts, halogen convertors and transformers and Light Emitting Diode (LED) drivers are examples of light source control gears;
- an electrical switch is a device that switches off the electrical supply, it can be electronic or mechanical and can also include dimming functions, presence detection etc.;
- Luminous Intensity (I) of a source in a given direction: quotient of the luminous flux dΦ leaving the source and propagated in the element of solid angle dΩ

  $I = \frac{d\Phi}{d\Omega}$, corresponding unit: candela [cd] , cd = lm . sr^{-1} ;
- Rated lamp power (Plamp [W]): quantity value of the power consumed by the lamp for specified operating conditions. The value and conditions are specified in the relevant standard, corresponding unit: Watt [W];
- Nominal lamp power (Plamp [W]): a suitable approximate quantity value of the power consumed by the lamp, corresponding unit: Watt [W];
- Lamp Survival Factor (LSF): fraction of the total number of lamps which continue to operate at a given time under defined conditions and switching frequency;
- Lamp Lumen Maintenance Factor (LLMF): ratio of the luminous flux emitted by the lamp at a given time in its life to the initial luminous flux;
- Operational lifetime (a combination of LSF and LLMF newly introduced in some draft standards e.g. draft EN 62612): length of time during wich a lamp provides more than xx% of the original, rated luminous flux (e.g. LLMF ≥ 0,70 or ≥ 0,50 indicated as L_{70} or L_{50}) and the maximum failure rate[5] is still lower than yy% (e.g. LSF ≥ 0,5 or ≥ 0,9 indicated as F_{50} or F_{10});
- Luminous efficacy of a NDLS-lamp (ηlamp): quotient luminous flux emitted by the power consumed by the source, unit lumen per Watt [lm/W];

[5] Failure rate F_x is the percentage of a number of tested lamps that have reached the end of their individual lifes; $F_x = 100\ (1 - LSF)$.

- Luminous efficacy of a DLS-lamp (ηlamp): quotient of the luminous flux emitted in a solid angle of 0.6π or a cone with an angle of 90°, by the power consumed by the source, unit lumen per Watt [lm/W];
- Colour Rendering: the effect of an illuminant on the colour appearance of objects by conscious or subconscious comparison with their colour appearance under a reference illuminant.
- CIE general colour rendering index CRI [R_a]: mean of the CIE special colour rendering indices for a specific set of eight (a = 8) test colour samples. (If the colour rendering index is based on more colour samples, 'a' must be specified, e.g. R_{14} or R_{20}.) For a source like a low-pressure sodium vapour lamp, which is monochromatic, the R_a is nearly zero, but for a source like an incandescent light bulb, which emits essentially black body radiation, R_a is assumed to be one hundred. (see also CIE 13.3). *Remark:* It must be stated that the R_a value of any lamp is referred to the Planckian black body radiator with the identical colour temperature. As mentioned before, the colour rendering of the incandescent lamp is assumed to be 100. In fact, real colour rendering should be based on the illumination of the sun. Compared to the sun, the light spectrum of an incandescent lamp contains much more red components and therefore some scientists have doubts on these R_a values. Also for LED's, this definition of CRI is not suitable and a working group in CIE 177 is working on a new proposal.
- Chromaticity coordinates (x, y): these are coordinates which characterise a colour stimulus (e.g. a lamp) by a ratio of each set of tristimulus values to their sum. Tristimulus values means the amounts of the three reference colour stimuli required to match the colour of the stimulus considered (e.g. a lamp). As the sum of three chromaticity coordinates equals 1, two of them are sufficient to define a chromaticity. The CIE defined different colour spaces with its own coordinates, for light sources the most common system is 'CIE xy' also known as 'CIE 1931 colour space'. The gamut of all visible chromaticities on the CIE plot is tongue-shaped or horseshoe-shaped shown in colour in Figure 1.2. In more general terms, a distance on the xy chromaticity diagram does not correspond to the 'degree' of 'perceived' difference between two colours. Other colour spaces (CIELuv and CIELab in particular) have been designed to reduce this problem but there is currently no single solution. Light with a flat energy spectrum (white) corresponds to the point (x,y) = (0.33 ,0.33).

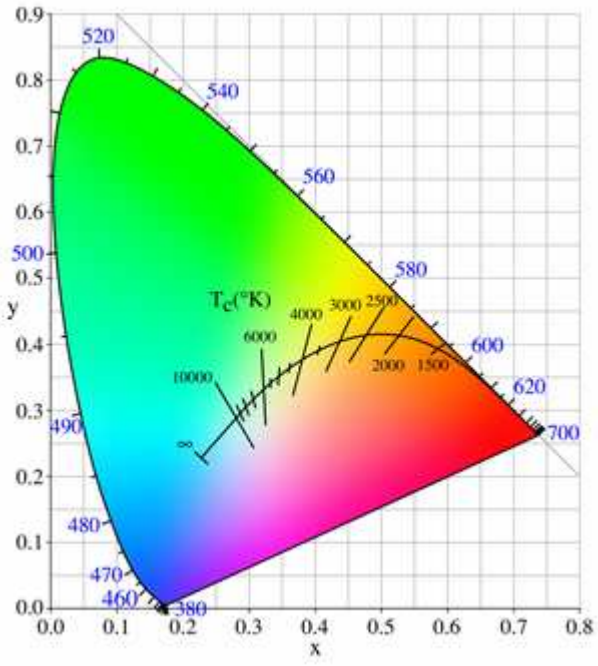

Figure 1.2 The CIE 1931 x,y chromaticity space, also showing the chromaticities of black-body light sources of various colour temperatures (Tc), and lines of constant correlated colour temperature (Tcp).

- Colour temperature Tc: temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus, unit [K].
- Correlated colour temperature (Tcp [K]): temperature of a Planckian (black body) radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions. The recommended method for calculation is included in CIE publication 15[6]. Please note that a black body absorbs all electromagnetic radiation that falls onto it and the amount and wavelength (colour) of electromagnetic radiation they emit is directly related to their temperature (see also Figure 1.2). Incandescent lamps (non coloured) are Planckian (black body) radiators and are located exactly on the black body locus (see Figure 1.2). Other light sources can have coordinates that are not exactly located on the black body locus, therefore they have a 'correlated' colour temperature. Please note also that the chromaticity of these light sources (e.g. CFL) is therefore not identified by a single parameter such as correlated colour temperature, this means that for example CFL lamps can appear with different colour but have the same correlated colour temperature[7].
- MacAdam Ellipses: MacAdam ellipse is the region on a chromaticity diagram which contains all colours which are indistinguishable, to the average human eye, from the colour at the centre of the ellipse. MacAdam ellipses are described as having 'steps' which really means 'standard deviations'. If a large sample of the population were used and if a trained observer could reliably repeat his observations, then the steps would translate to probabilities for the general population as follows:1 sd = 68.26 % of the general, colour-normal population 2 sd = 95.44 % “3 sd = 99.44 %. Any point on the boundary of a '1-step' ellipse, drawn around a target, represents 1 standard deviation

[6] CIE 15: 2004 Colorimetry, 3rd ed.

[7] Rensselaer (2003), 'Increasing market acceptance of compact fluorescent lamps (CFLs)',Mariana Figueiro et al., Project Report of Lighting Research Center, Rensselaer Polytechnic Institute, September 30, 2003.

from the target. For a '3-step'ellipse, the boundary represents 3 standard deviations from the target, and so on. These MacAdam Ellipses are included in the standards for fluorescent lamps for describing acceptable colour deviation (EN 60901, EN 60081). Please note that LED lamps don't use these MacAdam Ellipses but defined zones of product groups in the CIE 1931 x,y chromaticity diagram. LEDs are binned for chromaticity in the manufacturing process. These bins, when superimposed on the CIE 1931 Chromaticity Diagram, take the form of quadrangles, as opposed to ellipses (standardisation work in IEC and also in USA[8] is under progress).

Other performance parameters addressed in this study:

- dimmability;
- starting time: time needed for the lamp to start fully and remain alight, after the supply voltage is switched on;
- warm-up time: time needed for the lamp to reach 80% of its full luminous flux, after the supply voltage is switched on (in the ongoing revision of standard EN 60969 a change to limit the warm-up time to 60% is proposed);
- hot restrike capabilities (i.e. start-up after a short switch off time);
- power quality (power factor and harmonic currents e.g. third harmonic line current (%), fifth harmonic line current, current crest factor) see standard EN 61000-3-2;
- unit purchase cost;
- ”Clear lamp” is a lamp (excluding compact fluorescent lamps) with a luminance above 25000 cd/m² for lamps having a luminous flux below 2000 lm and above 100000 cd/m² for lamps having more luminous flux, equipped with only transparent envelopes in which the light producing filament, LED or discharge tube is clearly visible (see part 1, Annex 11.1.1);
- “Non-clear lamp” is a lamp that does not comply with the specifications under the preceding point, including compact fluorescent lamps;
- “Second lamp envelope” is a second outer lamp envelope which is not required for the production of light, such as an external sleeve for preventing mercury and glass release into the environment in case of lamp breakage (see second lamp envelope criterion in part 1, Annex 11.1.5);
- the lamp dimensions and sockets, especially for more energy efficient lamp retrofit solutions.
- the light distribution, especially for more energy efficient lamp retrofit solutions and directional light sources; this distribution can be given in different forms (flux code, polar intensity curve, Cartesian diagram or illuminance cone diagram) but should at least be available as CEN / CIE flux code.

  The CEN (or CIE) flux code (source EN 13032-2) represents the optical characteristics of the luminaire (see Figure 1.3) and consists of 9 whole numbers separated by spaces defined as:
  FCL1/FCL4, FCL2/FCL4, FCL3/FCL4, DFF, LOR, FCU1/FCU4, FCU2/FCU4, FCU3/FCU4, UFF equal to respectively:
  N1, N2, N3, N4, N5, N6, N7, N8, N9.
  UFF is upward flux fraction (= ULOR/LOR= 1-DFF)

[8] Energystar (2007), 'ENERGY STAR® Program Requirements for Solid State Lighting Luminaires Eligibility Criteria – Version 1.0 DRAFT' April 9, 2007.

DFF is downward flux fraction (=DLOR/LOR)
LOR is light output ratio.
FCL1-4 are accumulated luminous fluxes in lower hemisphere for the four zones from 0° to 41.4° (FCL1), 60° (FCL2), 75.5° (FCL3) and 90° (FCL4).
FCU1-4 are accumulated luminous fluxes in upper hemisphere for the four zones from 180° to 138.6° (FCU1), 120° (FCU2), 104.5° (FCU3) and 90° (FCU4).

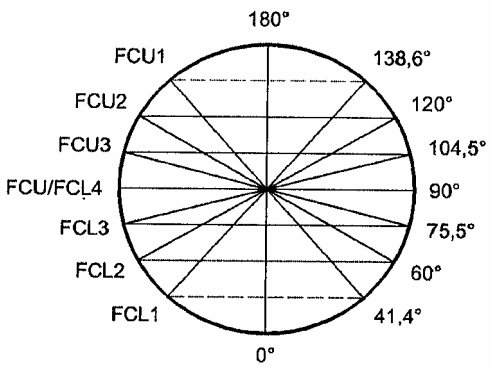

Figure 1.3: Zones for the calculation of accumulated luminous fluxes according to the CEN flux-code.

A polar intensity curve (see Figure 1.4) illustrates the distribution of luminous intensity, in cd/1000 lm, for diffrent axial planes of the luminaire. The curve provides a visual guide to the type of distribution expected from the luminaire e.g. wide, narrow, direct, indirect etc, in addition to intensity. For a DLS, the distribution is normally symmetric in all planes. This is illustrated in Figure 1.4 where the planes C0-C180 and C90-C270 are covering each other.

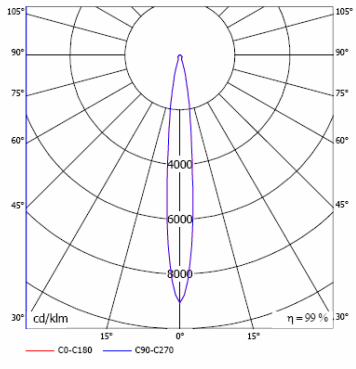

Figure 1.4: Example of a polar intensity curve.

Generally a Cartesian diagram is used for floodlights (see Figure 1.5); this also indicates the distribution of luminous intensity, in cd/1000 lm, for different axial planes of the luminaire and provides a visual guide to the type of distribution expected from the luminaire e.g. narrow or wide beam etc, in addition to intensity.
On this curve the beam angle can easily be defined.

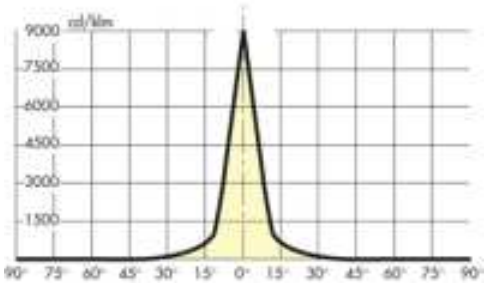

Figure 1.5: Example of a Cartesian light distribution diagram.

An illuminance cone diagram (see Figure 1.6) is usually used for spotlights or lamps with reflectors; the diagram indicates the maximum illuminance, Elux, at different distances, plus the beam angle of the lamp over which the luminous intensity drops to 50%. The beam diameter at 50% peak intensity, relative to distance away, is also shown.

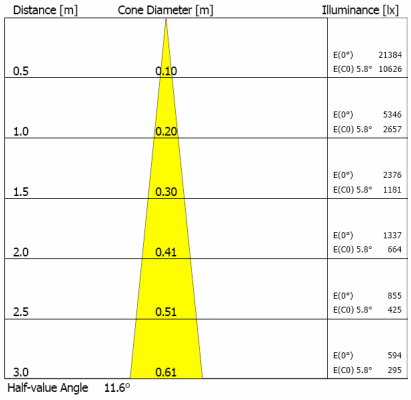

Figure 1.6: Example of an illuminance cone diagram.

- beam angle: the angle between those points on opposite sides of the beam axis where the intensity drops to 50% of the maximum (mostly specified on the Cartesian light distribution diagram);
- the beam can also be defined by a solid angle; the mathematical relationship between the solid angle (Ω) of the beam and the beam angle (θ) in ° is:

$$\Omega\ [\text{sr}] = 2\pi * (1 - \cos \theta/2)$$

- peak intensity in candela [cd]: the maximum luminous intensity (normally in the centre of the beam angle) see standard EN 61341.

1.1.3.2 Definition of a "white light source":

A white light source gives a natural appearance to all different colours. Visible light is the electromagnetic radiation with a wavelength between 380 nm (upper limit of UV) and 780 nm (lower limit of infrared) and all combinations of these wavelengths).

Currently there is no scientific definition nor for a white, neither for a coloured light source. Therefore a definition of a 'white light source' was developed for this study. This definition can be found in Annex 11.1.1 of part 1.

It must be noted that this white light definition is only used in this study to limit the scope of the lamps that will be considered because coloured lamps are excluded. It can never be used as a quality parameter for lamps.

1.1.3.3 General luminaire performance specification parameters:

The important performance assessment parameters for luminaires are (EN 12665(2002)):

- *light output ratio(LOR)*: ratio of the total flux of the luminaire, measured under specified practical conditions with its own lamps and equipment, to the sum of the individual luminous fluxes of the same lamps when operated outside of the luminaire with the same equipment, under specified conditions;
- *light output ratio working (LORw):* ratio of the total flux of the luminaire, measured under specified practical conditions with its own lamps and equipment, to the sum of the individual luminous fluxes of the same lamps when operated outside of the luminaire with a reference ballast, under reference conditions.

Note that great care should be given not to interpret LOR as solely 'the optical efficiency of a luminaire':

- As explained in the lot 8 office lighting study (p.184) the LOR can account in part for an efficacy increase in the lamp when lamp efficacy is influenced by temperature (e.g. with T5 fluorescent lamps and some CFLi's). Double counting should be avoided.
- Some ballasts could drift to a higher power consumption compared to the specified standard conditions for lamp lumen measurement when installed in a luminaire and therefore influence LOR positive or negative.
- There is no input power measurement (P_{in}) done during LOR measurement, however a complementary measurement could be sufficient to calculate a correction factor for temperature sensitive light sources (C_{LOR} = P_{in} lamp/P_{in} lum). P_{in} lamp is measured when measuring the lamp outside the luminaire and P_{in} lum is measured when measuring the luminaire.
- In most cases when lamps have a stable input power, independent of the lamp temperature, C_{LOR} = 1.

Additional performance parameters for luminaires considered in this study:

- *Luminaire Efficiency Rating (LER*): is the Light Output Ratio of the luminaire multiplied with the ballast efficiency and the lamp efficacy.

  $$LER = LOR \times \eta ballast \times \eta lamp \times C_{LOR}$$

  with LOR in luminaire standard working conditions (ambient temperature 25°) and ηlamp at 25°C .

  Note: for luminaires with integrated lamps and ballasts, e.g. some LED luminaires, only LER data is available or needed. The individual data of LOR or power supply loss is unknow and cannot always be measured.;
- *Ballast efficiency (*ηballast): means the ratio between the lamp power (ballast output) and the input power of the lamp-ballast circuit with possible sensors, network connections and other auxiliary loads disconnected

- *Stand-by losses;*
- *Cable losses:* (might be significant for low voltage luminaries (12 V).

1.1.4 Functional unit for domestic lighting

Knowing the functional product used in this study we now further explain what is called the "functional unit" for domestic lighting. In standard 14040 on life cycle assessment (LCA) the functional unit is defined as "the quantified performance of a product system for use as a reference unit in life cycle assessment study". The primary purpose of the functional unit in this study is to provide a calculation reference to which environmental impacts (such as energy use), costs, etc. can be related and to allow for comparison between functionally equal domestic lighting products with and without options for improvement. Please note that further product segmentations will be introduced in this study in order to allow appropriate equal comparison.

The proposed functional parameter (FP) for non-directional lamps (NDLS) in this study is:

"1 lumen provided by a lamp during 1 hour of operation in any direction".

(As defined in the applicable standards, the measurement of the lumen output shall be performed after the lamp has burned for the defined hours, mostly 100 hours.)

The proposed functional parameter (FP) for DLS (GLS-R, HL-MV-R, HL-LV-R, MHi-R, CFLi-R, halogen reflector retrofit LED lamps) in this study is:

"1 lumen provided by a spot lamp during 1 hour of operation in the functional solid angle of 0,6π or cone of 90°".

The proposed functional parameter (FP) for DLS (i.e. luminaires with integrated lamps e.g. LED-downlighters, LED modules, CFLi-R not sold for retrofitting reflector lamps) in this study is:

"1 lumen provided by a lamp during 1 hour of operation in the functional solid angle of π.".

1.1.5 Rationale and comparison of the functional unit for domestic lighting in part 1 and part 2 and for street lighting and office lighting

The following Table 1.5 gives a comparison of the different functional units that were used in the preparatory studies on lighting: lot 8 (office), lot 9 (street), lot 19 (domestic).

Table 1.5: Comparison of different functional units used in the preparatory studies on lighting

Lighting study	Product boundary	System	Functional unit	Functional lumen
Domestic (lot 19) Part 1	Lamp (NDLS)	Luminaire, room, wiring	**Lumen*h** (luminous flux in one hour)	All lumen (4π sr)
Domestic (lot 19) Part 2	Lamp (DLS)	Luminaire, room, wiring	**Lumen*h** (luminous flux in one hour)	Directed lumen (0.59π s, π sr)
Tertiary (lot 8&9) Street&office	Luminaire+lamp	Room, task area, wiring	**Lumen*h/m² = lx*h** (illuminance in one hour)	Lumen in task area

In the studies on tertiary lighting, the chosen functional unit was the '*provided illuminance in one hour operation'* or in particular cases of street lighting the *'provided luminance illuminance in one hour operation'*. This matched well with the practice of professional lighting design found in those sectors. In professional design, those units are primary parameters (besides glare reduction, uniformity, etc.). This approach and many of the conclusions of those studies can be used in the tertiary lighting sector, they will not be repeated here.

On the other hand, this approach is rarely applied in domestic lighting and only for the so-called architectural lighting, based on a virtual simulation of the interior, where professional designers are involved. Because the use of lamps is not limited to one sector, conclusions of both studies can overlap.

Moreover an illuminance based approach is not useful to evaluate the function to create a visual ambience with lighting, hereafter also referred to as "ambient lighting". In the case of ambient lighting the focus is not to provide illumination in a task area but to provide the proper luminance of a variety of elements in the interior including the luminaire itself. The luminance then depends on the reflection properties of the objects. Nevertheless, the luminance approach was possible in street lighting (fast traffic) where the purpose is to see the road. The road surface properties and orientation is easy to quantify. In ambient interior lighting, due to the very different nature of interior objects and their orientation, it is difficult to quantify and there is no general rule or base case. The same often applies to Horeca and shop lighting. Also on those applications the number of tasks, their time duration and their area can vary strongly which would make a meaningful quantification difficult.

Finally, part of the light generated within a luminaire is used to provide luminance on the decorative ornaments of the luminaire itself which is hard to quantify, as such it cannot be considered as waisted light.

Therefore in this study on domestic lighting, the *'functional lumen'* was preferred because this is very close to the holistic approach found in domestic lighting. As stated before, here no illuminance calculations are made and the light is mostly not intended to illuminate only a task area but it is generally used for ambient lighting and decorative purposes.

For general, domestic illumination, non-directional light sources (NDLS) are most suitable and all emitted lumens are functional. For directional light sources (DLS) that are intended for accent lighting, only the lumens that are emitted in a certain cone are functional. The cone of 90° was chosen for defining the DLS functional lumens (see Figure 1.7) because this fits particular well with the current reflector lamps. This will be demonstrated in chapter 4 where data of a cone of 120° (π sr) are compared to a 90° (0.59π sr) cone. Another benefit of a 90° compared to a 120° cone is the lower cost for market surveillance because it can reduce the lumens to be measured with a goniometer.

In theory the cone of 82,8° (π/2 sr) could be interesting because it is included in the CEN flux code (EN 13032-2) of standard photometric files. Nevertheless after consulting stakeholders with measurement data this narrower cone would reject useful lumens and was therefore not used.

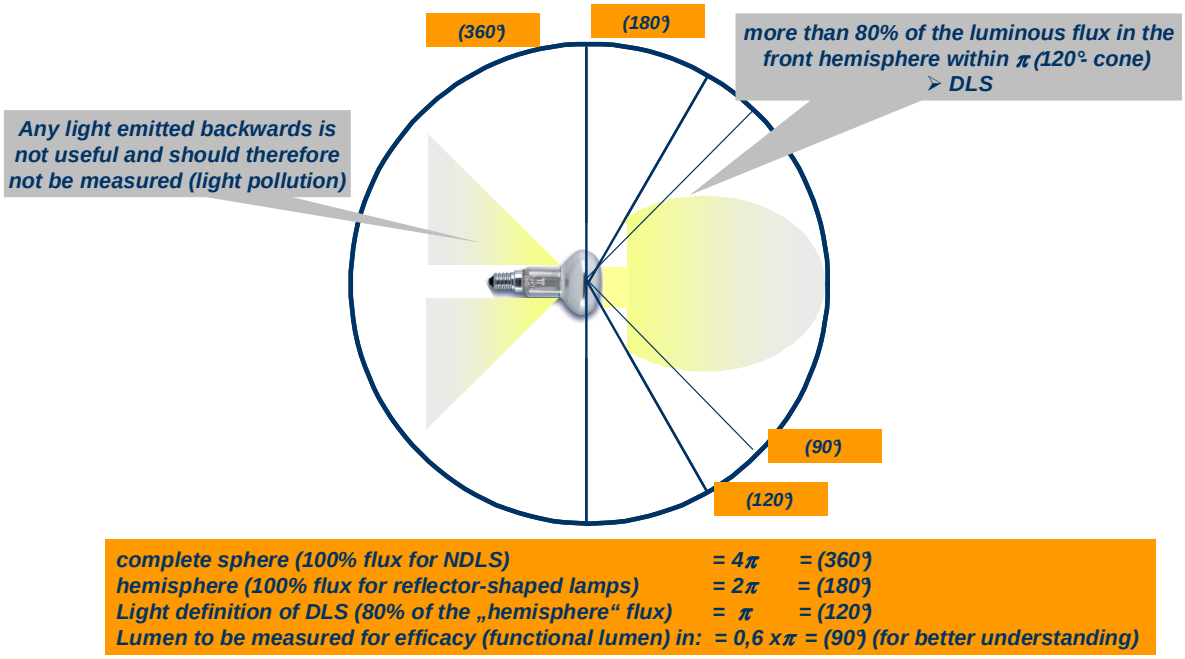

Figure 1.7 Definition of the functional lumen for DLS reflector lamps

1.1.6 How to deal with the 'Light Output Ratio' (LOR) and 'Light Output Function'(LOF) for decorative luminaires with lamps used in domestic and service sector lighting

Luminaires that are used for functional lighting in the tertiary sector (e.g. office and street lighting) have photometric data that include the LOR. In that case the LOR is a dominant parameter related to the luminaire efficiency.
Nevertheless, this approach to quantify the luminaire efficiency by its LOR cannot be applied one to one on decorative luminaires used for lamps within the scope of this study.
The main reason is explained in section 1.1.5, i.e. part of the light transmitted through the luminaire shield is used to provide luminance on the decorative ornaments (of different transmittance) of the luminaire itself (another part of the light is absorbed in the luminaire and lost as heat).
It is also not common practice to provide LOR data for those luminaires (CELMA communication in 2009), only very few manufacturers do so and mainly for the purpose of application in photometric simulation tools with high end architectural luminaires.
Moreover the reproduction and reliability of LOR data of decorative luminaire that rely on hand crafted parts (painting, glass, ..) will be very unreliable.
Finally LOR might also rely on the used lamp type.

For luminaires with DLS lamps (e.g. reflector lamps) there is normally no lumen loss within the luminaire compared to the defined functional unit for DLS lamps, because those lamps are normally not shielded.
For decorative luminaires with NDLS lamps the 'Light Output Function' (LOF) of a luminaire could be seen as the lumen output from the luminaire characterised by its LOR together with the luminance of the decorative ornaments. The LOF is hard to quantify in absolute terms and is connected to lumens that are wasted by excessive light absorption on invisible reflective parts or visible transparent parts.

As a conclusion we will further talk about the 'Light Output Function' (LOF) knowing that the absolute performance of the whole picture of EU27 installed and sold luminaires is impossible to quantify.
This LOF and its potential improvement is only relevant for the impact scenarios calculated in part 1, because it is related to the installed base of NDLS lamps. Hence it could only result in a correction factor applicable to the part 1 scenarios and their improvement options (if any). These improvement options(if any) will be considered for luminaires having equal 'Light Output Function' and only the ratio on saved power consumption will be assessed.
Nevertheless, the LOR value of domestic NDLS luminaires is useful in quantifying how much light is actually going into illuminating the room (disregarding the light spent on illuminating the decorative ornaments of the luminaire itself). Taken on its own, LOR could for example be used to establish minimum criteria for luminaires that manufacturers want to claim as particularly efficient.

1.2 Lighting test standards or guidelines

This paragraph identifies and shortly describes the 'test standards or guidelines' that are related to the functional unit, resource use (energy, materials, ..), safety and other lighting product specific standards.
A "test standard or guideline" is defined in the context of this study as a standard or guideline that sets out a test method, but that does not indicate what result is required when performing that test. Therefore, strictly speaking, a test standard can be different from a "technical standard". Especially 'technical standards' that are a specification against which all others may be measured are not discussed hereafter(e.g. the measurement of power, luminous flux, ..). In addition to "official" test standards, there are other sector specific procedures for product testing that are compiled by industry associations or other stakeholders for specific purposes included in this section. Also ongoing work for the development of new standards or guidelines is discussed together with recommendations for new ones.

The following references are made to:
- EN, European standard ratified by either CEN (European Committee for Standardization) or CENELEC (European Committee for Electro-technical Standardization),
- IEC, International Electro-technical Commission,
- CIE, International Commission on Illumination.

Identified gap: None of the EN or IEC standards relate specifically to reflector lamps.

1.2.1 Standards and guidelines related to the functional unit

- *EN 60064: 'Tungsten filament lamps for domestic and similar general lighting purposes - Performance requirements*'.

Scope:

This standard applies to tungsten filament incandescent lamps for general lighting services (GLS) which comply with the safety requirements in EN 60432-1.

- *EN 60357: 'Tungsten halogen lamps (non-vehicle) - Performance specifications*'.

Scope:

This standard specifies the performance requirements for single-capped and double-capped tungsten halogen lamps, having rated voltages of up to 250 V, used for the following applications:

- projection (including cinematograph and still projection)
- photographic (including studio)
- floodlighting
- special purpose
- general purpose
- stage lighting.

This third edition cancels and replaces the second edition published in 1982 and amendments.

- *EN 60969 : 'Self-ballasted lamps for general lighting services - Performance requirements*'.

Scope:

This Standard specifies the performance requirements, together with the test methods and conditions, required to show compliance of tubular fluorescent and other gas-discharge lamps with integral means for controlling starting and stable operation (self-ballasted lamps) intended for domestic and similar general lighting purposes.

- *EN 60081 : 'Double-capped fluorescent lamps - Performance specifications'*.

Scope:

This International Standard specifies the performance requirements for double-capped fluorescent lamps for general lighting service.

The requirements of this standard relate only to type testing. Conditions of compliance, including methods of statistical assessment, are under consideration.

The following lamp types and modes of operation are included:

a) lamps having preheated cathodes, designed for operation on a.c. mains frequencies with the use of a starter, and additionally operating on high frequency;
b) lamps having preheated high-resistance cathodes, designed for operation on a.c. mains frequencies without the use of a starter (starter less), and additionally operating on high frequency;

c) lamps having preheated low-resistance cathodes, designed for operation on a.c. mains frequencies without the use of a starter (starter less), and additionally operating on high frequency;
d) lamps having preheated cathodes, designed for operation on high frequency;
e) lamps having non-preheated cathodes, designed for operation on a.c. mains frequencies;
f) lamps having non-preheated cathodes, designed for operation on high frequency.

For some of the requirements given in this standard, reference is made to "the relevant lamp data sheet". For some lamps these data sheets are contained in this standard. For other lamps, falling under the scope of this standard, the relevant data are supplied by the lamp manufacturer or responsible vendor.

- *EN 60901: 'Single-capped fluorescent lamps – Performance specifications'*.

Scope:

This International Standard specifies the performance requirements for single-capped fluorescent lamps for general lighting service.
The requirements of this standard relate only to type testing. Conditions of compliance, including methods of statistical assessment, are under consideration.

The following lamp types and modes of operation with external ballasts are included:
a) lamps operated with an internal means of starting, having preheated cathodes, for operation on a.c. mains frequencies;
b) lamps operated with an external means of starting, having preheated cathodes, for operation on a.c. mains frequencies with the use of a starter, and additionally operating on high frequency;
c) lamps operated with an external means of starting, having preheated cathodes, for operation on a.c. mains frequencies without the use of a starter (starter less), and additionally operating on high frequency;
d) lamps operated with an external means of starting, having preheated cathodes, for operation on high frequency;
e) lamps operated with an external means of starting, having non-preheated cathodes, for operation on high frequency.

- *EN 50285: 'Energy efficiency of electric lamps for household use – Measurement methods'.*

Scope:

Specifies the test conditions and method of measurement of luminous flux, lamp wattage and lamp life as given on a label on the lamp packaging, together with a procedure for verification of the declared values. Only those parameters that are specific to Directive 92/75/EEC are included in this standard, all other parameters are defined in the relevant lamp performance standards.

- *EN 13032-1 (2004), Lighting applications — Measurement and presentation of photometric data of lamps and luminaires — Part 1: Measurement and file format*

Scope:

This European Standard establishes general principles for the measurement of basic photometric data for lighting application purposes. It establishes the measurement criteria needed for the standardisation of basic photometric data and details of the CEN file format for electronic data transfer. This is part 1 of a multi part standard. Part 1 deals with the basic photometric measurement and file format. Other parts deal with lamps and luminaires data depending on the applications.

Status:

Recently adopted; manufacturers do not yet have data available according to this format.

Identified gaps:

In practice the sector often uses a sector specific file format (EULUMDAT, IES, ..).
For a luminaire that can house different lamp types, it is dependent on the characteristics of the lamp, as well optical as thermal.
LOR measurement without Power (P) measurement of the luminaire (see section 1.1.3.3).

- *EN 13032-2(2004): Light and lighting. Measurement and presentation of photometric data of lamps and luminaires. Part 2: Presentation of data for indoor and outdoor work places*

Scope:

This document specifies the required data for lamps and luminaires for the verification of conformity to the requirements of EN 12464-1 and prEN 12464-2. It also specifies data that are commonly used for lighting of indoor and outdoor work places. When these data are provided, they should conform to this document

- *EN 60921: 'Ballasts for tubular fluorescent lamps – Performance requirements'.*

Scope:

This standard specifies performance requirements for ballasts, excluding resistance types, for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz, associated with tubular fluorescent lamps with pre-heated cathodes operated with or without a starter or starting device and having rated wattages, dimensions and characteristics as specified in IEC 60081 and 60901. It applies to complete ballasts and their component

parts such as resistors, transformers and capacitors.
(It only applies to ferromagnetic ballasts; electronic ballasts are covered under IEC60929.)

- *EN 60929 : 'AC-supplied electronic ballasts for tubular fluorescent lamps – Performance requirements*'.

Scope :

This International Standard specifies performance requirements for electronic ballasts for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with tubular fluorescent lamps as specified in IEC 60081 and IEC 60901 and other tubular fluorescent lamps for high frequency operation. (It only applies to electronic ballasts; ferromagnetic ballasts are covered under IEC60921.)

- *CIE 127 (2007) : 'Measurement of LED's' (2nd ed.)*

Scope :

There are significant differences between LEDs and other light sources which made it necessary for the CIE to introduce new quantities for their characterization with precisely defined measurement conditions. New quantities introduced here are "Averaged LED Intensity" and "Partial LED Flux".
The report describes in detail the measurement conditions for ALI (Averaged LED Intensity), Total and Partial LED Flux and Spectral Power Distribution. It is shown that measurements by substitution method using LED standards can be simpler; however it is important to compare similar coloured LEDs or use colour correction on the measurement results. The standard LEDs need to be calibrated by National Metrology Laboratories or a laboratory traceable to National Metrology Laboratories.

- *Draft EN 62612 (IEC/PAS 62612) : 'Self-ballasted LED-lamps for general lighting services >50V – Performance requirements*'.

Scope :

This draft International Standard, already in the stadium of a publicly available specification (PAS), specifies the performance requirements for self-ballasted LED lamps with a supply voltage up to 250V, together with the test methods and conditions, required to show compliance with this standard, intended for domestic and similar general lighting purposes, having:
– a rated wattage up to 60 W;
– a rated voltage of up to 250V AC or DC;
– a lamp cap according to IEC 62560 1)
The requirements of this standard relate to type testing.
This standard does not cover self-ballasted LED lamps that intentionally produce tinted or coloured light neither does it cover OLEDs.
Recommendations for whole product testing or batch testing are under consideration.
These performance requirements are additional to the requirements in the draft standard IEC 62560: safety standard for self-ballasted LED lamps.

Remark:

In this draft standard, the definition for the lifetime of a lamp is in accordance with the definition ”operational lifetime” as introduced in this study in part 1.1.3.1.

- *Australian and New Zealand standard proposal AS/NZS 4847.1:200X :* ‘Test method Energy performance *for Self-ballasted lamps for general lighting services*’.

Scope :

The objective of this part of the Interim Standard is to specify test methods for key performance attributes of self-ballasted compact fluorescent lamps (CFLs) that have integrated means for starting, controlling and stable operation. Part 2 of this Interim Standard is intended to cover Minimum Energy Performance Standards requirements with compliance values or limits.

This Interim Standard is structured to be suitable for reference in minimum performance Standards legislation.

- *Australian and New Zealand standard proposal AS/NZS 4934.1(Int):2008 :* ‘Test method Energy performance *for Incandescent lamps for general lighting service*.

Scope :

This Interim Standard specifies test methods for energy performance of tungsten filament and tungsten halogen lamps used in general lighting services.

This Interim Standard applies to both non-reflector and reflector lamps of all voltages. “Incandescent lamps” in this standard proposal include also halogen lamps.

Identified gaps:

The proposed measurement method for directional light sources in an Ulrich-sphere is not easy for taking into account the functional solid angle. If screens are used to measure the light output in these solid angles, a precise positioning of the optical centre of the lamp is needed.

1.2.2 Other test standards and guidelines not related to the functional unit

EN 12665 (2002): ‘Light and lighting - Basic terms and criteria for specifying lighting requirements’

Scope:

This standard defines basic terms for use in all lighting applications; specialist terms with limited applications are given in individual standards. This standard also sets out a framework for the specification of lighting requirements, giving details of aspects which shall be considered when setting those requirements.

- *EN 60968 : ‘Self-ballasted lamps for general lighting services - Safety requirements’*.

Scope:

This Standard specifies the safety and interchangeability requirements, together with the test methods and conditions, required to show compliance of tubular fluorescent and other gas-discharge lamps with integrated means for controlling starting and

stable operation (self-ballasted lamps), intended for domestic and similar general lighting purposes, having: -a rated wattage up to 60 W; -a rated voltage of 100 V to 250 V; -Edison screw or bayonet caps.

- *EN 60630 : 'Maximum lamp outlines for incandescent lamps'.*

Scope:

This Standard specifies the maximum outlines for GLS-lamps in different shapes, with different caps etc.

- *EN 60061 : 'Lamp caps and holders together with gauges for the control of interchangeability and safety'*

Scope:

This Standard specifies the dimensions of all kind of standardized lamp caps and holders together with the control gauges. for GLS-lamps in different shapes, with different caps etc.

Status:

Continuously enlarged because *'creativity'* of lamp designers seems to be unlimited.

- *EN 60669-2-1 : 'Electronic switches for households and similar use'.*

Scope :

Applies to electronic switches and to associated electronic extension units for household and similar fixed electrial installations either indoors or outdoors.

- *EN 61047 : 'D.C. or A.C. supplied electronic step-down converters for filament lamps. Performance requirements'.*

Scope :

Specifies performance requirements for electronic step-down convertors for use on d.c. supplies up to 250 V and a.c. supplies up to 1000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with tungsten halogen lamps as specified in IEC 60357 and other filament lamps.

- *EN 50294 : 'Measurement Method of Total Input Power of Ballast-Lamp Circuits'.*

Scope:

This Standard gives the measurement method of the total input power for ballast-lamp circuits when operating with their associated fluorescent lamp(s). This standard applies to electrical ballast-lamp circuits comprised solely of the ballast and of the lamp(s). NOTE: Requirements for testing individual ballasts during production are not included. It specifies the measurement method for the total input power for all ballasts sold for domestic and normal commercial purposes operating with the following fluorescent lamps: linear lamps with power equal to or greater than 15 W; single ended (compact) lamps with power equal to or greater than 18 W; other general purpose lamps. This standard does not apply to: ballasts which form an integral part

of the lamp; ballast-lamp circuits with capacitors connected in series; controllable wire-wound magnetic ballasts; luminaires which rely on additional optical performance aspects.

The standard mandates that a ballast lumen factor be declared by the manufacturer - this has to be in the range 0.925 to 1.0 for magnetic ballasts and between 0.925 and 1.075 for electronic ballasts.

The test method for ferromagnetic and electronic ballasts is quite different and each is described below:
For magnetic ballasts, the test ballast is operated with a reference lamp. In addition the reference lamp is operated with a reference ballast. The total input power and the lamp power are measured for each circuit in parallel. Finally, the total input power for the test ballast/lamp circuit is corrected for the ballast lumen factor (BLF), this correction is done by measurement of the lamp power compared to the reference lamp. Please note that for the reference ballast a normalized ballast lumen factor of 0.95 has been chosen (this suggests that manufacturers tend to under-run lamps on average on magnetic ballasts). A similar method exists for electronic ballasts, in this case a reference ballast lumen factor of 1 is chosen. The total input power for the test ballast/lamp circuit is corrected for the ballast lumen factor (BLF), this correction is done by measurement of the lamp luminous flux compared to the reference lamp. Please note that for T5 fluorescent lamps no magnetic reference ballast exists, therefore an electronic reference ballast with known BLF needs to be obtained (Klinger (2006)), e.g. from a lamp manufacturer.
It is important to realize that in this approach the losses of the lamp filament preheating are accounted as ballast losses, because magnetic ballasts have switch-off lamp filament preheating enforced by the principle and also the most advanced T5 ballasts that are used as reference ballast do so.

- *EN 60927: 'Specification for auxiliaries for lamps. Starting devices (other than glow starters). Performance requirements'.*

Scope:

Specifies performance requirements for starting devices (starters and igniters) for tubular fluorescent and other discharge lamps for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz which produce starting pulses not greater than 5 kV. Should be read in conjunction with IEC 60926.

- *EN 61048 : 'Auxiliaries for Lamps - Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp Circuits - General and Safety Requirements'.*

Scope :

This International Standard states the requirements for both self-healing and non-self-healing continuously rated a.c. capacitors of up to and including 2,5 kVAr, and not less than 0,1 µF, having a rated voltage not exceeding 1 000 V, which are intended for use in discharge lamp circuits operating at 50 Hz or 60 Hz and at altitudes up to 3000m.

- *EN 61049 : 'Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp Circuits Performance Requirements'.*

Scope :

Specifies the requirements for both self-healing and non-self-healing continuously rated a.c. capacitors of up to and including 2,5 kVAr, and not less than 0,1 F, having a rated voltage not exceeding 1 000 V, which are intended for use in discharge lamp circuits operating at 50 Hz or 60 Hz and at altitudes up to 3 000 m. Does not cover radio-interference suppressor capacitors, the requirements for which are given in IEC 60384-14. This publication supersedes IEC 60566.

- *EN 60598-1 : 'Luminaires Part 1 : General requirements and tests'.*

Scope:

This Part 1 specifies general requirements for luminaires, incorporating electric light sources for operation from supply voltages up to 1000 V. The requirements and related tests of this standard cover: classification, marking, mechanical construction and electrical construction.

Important remark:

This standard demands a.o. that on every luminaire, the number, the type and the maximum wattage of all the suitable lamps must be indicated. For safety reasons, no other lamps or no higher wattages may be installed.

- *EN 60598-2: 'Luminaires - Part 2: Particular requirements - Chapter 1: Fixed general purpose luminaires'.*

Scope:

This chapter of Part 2 of IEC Publication 598 specifies requirements for fixed general purpose luminaires for use with tungsten filament, tubular fluorescent and other discharge lamps on supply voltages not exceeding 1000 V. It is to be read in conjunction with those chapters of Part 1 to which reference is made.

- *EN 60598-2: 'Luminaires - Part 2: Particular requirements - Chapter 2: Recessed luminaires'.*

Scope:

Specifies requirements for recessed luminaires for use with tungsten filament, tubular fluorescent and other discharge lamps on supply voltages not exceeding 1000 V. This chapter does not cover air-handling luminaires.

- *EN 60598-2: 'Luminaires - Part 2: Particular requirements – Chapter 6: Luminaires with built-in transformers for tungsten filament lamps'.*

Scope:

Specifies requirements for luminaires with built-in transformers for use with all tungsten filament lamps, halogen lamps included.

- *CIE 089 (1989) : 'Measurement of luminous flux' (technical report)*

Scope :

This technical report defines the terminology required for luminous flux measurements. It then deals with the principles of luminous flux measurements and describes methods for the evaluation of the illuminance distribution, the measurement of luminous flux by means of an integrating sphere photometer and the determination of luminous flux via luminance, luminous intensity and luminance measurements.

- *EN 60013-2 (CIE 13.3) : 'Method of Measuring and Specifying Colour Rendering Properties of Light Sources'*

Scope :

This standard establishes the recommended method of measuring and specifying colour rendering properties of light sources based on resultant colour shifts of test objects, referred to as the "Test-colour Method". It is the fundamental method for appraisal of colour rendering properties of light sources, and is recommended for type testing as well as for testing individual lamps.

This specification applies to most general purpose illuminants (e.g. tungsten filament lamps, tubular fluorescent lamps, and all other kinds of gaseous discharge electrical lamps except sources of predominantly monochromatic radiation such as low pressure sodium, etc.). This method may also be applied to modified daylight.

The rating consists of a General Colour Rendering Index which may be supplemented by a set of Special Colour Rendering Indices. The derivation of the Special Colour Rendering Indices is based on a general comparison of the length of colour difference vectors in the CIE 1964 Uniform Space.

To apply the recommended Test-Colour Method the resultant colour shifts for suitably chosen test-colour samples must be calculated. A set of eight test-colour samples is specified by their spectral radiance factors for calculating the General Colour Rendering Index. These samples cover the hue circle, are moderate in saturation, and are approximately the same in lightness. Data for six additional test-colour samples representing a strong red, yellow, green and blue as well as complexion and foliage colours are also supplied. From the colour shifts, Colour Rendering Indices may be found.

- *CIE 177 (2007) : 'Colour Rendering of White LED Light Sources')*

Scope :

The Committee recommends the development of a new colour rendering index (or a set of new colour rendering indices) by a Division 1 Technical Committee. This index (or these indices) shall not replace the current CIE colour rendering index

immediately. The usage of the new index or indices should provide information supplementary to the current CIE CRI, and replacement of CRI will be considered after successful integration of the new index. The new supplementary colour rendering index (or set of supplementary colour rendering indices) should be applicable to all types of light sources and not only to white LED light sources. Possibilities for an improved description of colour rendering are summarized in the Appendix of this Technical Report. (This work is still under consideration!)

- *IEC/TS 61231 : 'International lamp coding system (ILCOS)'.*

Scope :

This technical specification gives the rules for the international lamp coding system and covers all lamp categories, excluding vehicle lamps. Coding for the main lamp types is specified and, for the others, will follow by amendments to this technical specification as appropriate.

The object of the international lamp coding system is:

- to improve communication about the different types of lamps;
- to help in discussions concerning interchangeability and compatibility of products;
- to create a closer relationship between international standards and manufacturers' literature (for example the code could be given in future in the relevant parts of a standard);
- to enable correct replacements of lamps;
- to be used as a complementary marking on the luminaire;
- to replace national and regional coding systems.

- *EN 62471 (2008) : 'Photobiological safety of lamps and lamp systems'.*

Scope :

This international Standard gives guidance for evaluating the photobiological safety of lamps and lamp systems including luminaires. Specifically it specifies the exposure limits, reference measurement technique and classification scheme for the evaluation and control of photobiological hazards from all electrically powered incoherent broadband sources of optical radiation, including LED's but excluding lasers, in the wavelength range from 200 nm through 3000 nm.

1.3 Existing legislation

1.3.1 Legislation and Agreements at European Community level

1.3.1.1 Regulations

- *Commission Regulation (EC) No 244/2009* of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps.
- *Commission Regulation (EC) No 245/2009* of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council.

1.3.1.2 Environmental Directives (RoHS, WEEE)

- *Directive 2002/95/EC on Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)*

Scope:

The RoHS Directive stands for "the restriction of the use of certain hazardous substances in electrical and electronic equipment". This Directive bans the placing on the EU market, from 1 July 2006, of new electrical and electronic equipment containing lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants.

Exemptions:

In annex, the exemptions from this requirements (a.o. for lamps) are listed:

- mercury in compact fluorescent lamps not exceeding 5mg per lamp
- mercury in straight fluorescent lamps for general purposes not exceeding

halophosphate	10mg
triphosphate with normal lifetime	5mg
triphosphate with long lifetime	8mg

- mercury in straight fluorescent lamps for special purposes
- mercury in other lamps not specifically mentioned in this annex
- lead in glass of fluorescent tubes.

There are no exemptions for luminaires and ballasts.

- *Directive 2002/96/EC on waste electrical and electronic equipment (WEEE)*

Scope:

The WEEE Directive aims to:

- reduce waste arising from electrical and electronic equipment (EEE);

- make producers of EEE responsible for the environmental impact of their products, especially when they become waste.
- encourage separate collection and subsequent treatment, reuse, recovery, recycling and sound environmental disposal of EEE .
- improve the environmental performance of all those involved during the lifecycle of EEE.

Exemptions:

In annex I A, all general categories of electric and electronic equipment concerned are mentioned; in annex I B, the subcategories with the exemptions are listed. In the subcategory of luminaires for fluorescent lamps, an exception is made for luminaires in households. Also filament bulbs (incandescent and halogen lamps) are exempted from this directive.

1.3.1.3 Efficiency Directives

- *Directive 2000/55/EC on energy efficiency requirements for ballasts for fluorescent lighting*

Scope:

The purpose of this Directive is to improve the efficiency of the systems by limiting the ballast losses. For this purpose, CELMA developed a classification system that takes both parts of the system into account, the lamp and the ballast and that is compliant with the directive. It constitutes an implementing measure within the meaning of article 15 of Directive 2005/32/EC.

- *Directive 98/11/EC of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps*

Scope:

This Directive, which was published on 10th March 1998, applies the energy labelling requirements for household electric lamps supplied directly from the mains (filament and integral compact fluorescent lamps) and to household fluorescent lamps (including linear and non-integral compact fluorescent lamps), even when marketed for non-household use.

In Annex I of the Directive, the design and content of the label is setted out, as well as the colours that may be used.
The label must include the following information:
• the energy efficiency class of the lamp;
• the luminous flux of the lamp in lumens;
• the input power (wattage) of the lamp;
• the average rated life of the lamp in hours.
The label shall be chosen from the following illustrations in Figure 1.8. Where the label is not printed on the packaging but a separate label is placed on or attached to the packaging, the colour version shall be used. If the ‘black on white’version of the label is used, the printing and background may be in any colours that preserve the legibility of the label.

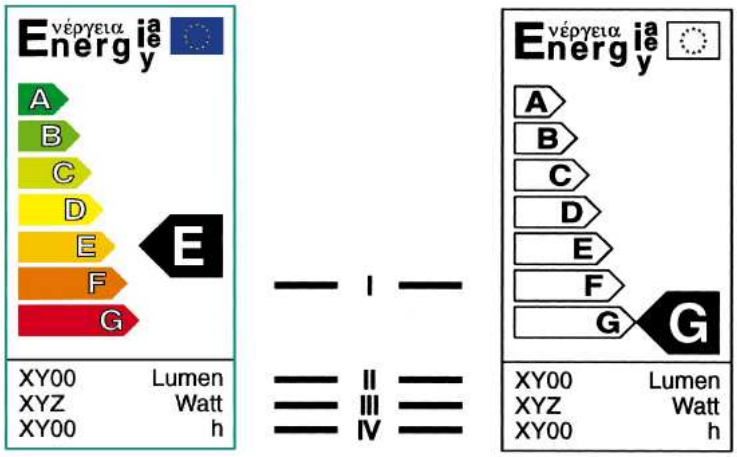

Figure 1.8: Energy efficiency label

The following notes define the information to be included:

I. The energy efficiency class of the lamp, determined in accordance with Annex IV. This indicator letter shall be placed at the same level as the relevant arrow.
II. The luminous flux of the lamp in lumens, measured in accordance with the test procedures of the harmonised standards referred to in Article 1(4).
III. The input power (wattage) of the lamp, measured in accordance with the test procedures of the harmonised standards.
IV. The average rated life of the lamp in hours, measured in accordance with the test procedures of the harmonised standards. Where no other information on the life of the lamp is included on the packaging, this may be omitted.

Where the information specified in II, III and, where applicable, IV is included elsewhereon the packaging of the lamp, it may omitted from from the label, as may the box that contains it.

Annex IV of the Directive specifies the calculation to determine the energy efficiency class of a lamp.

Identified gaps:

- The mention of the average rated life of the lamp is not strictly imposed.
- The origin of the formulas in Annex IV is not clear.
- Some much used lamps are excluded from the labelling e.g. reflector lamps (DLS) and lamps with an inut power of less than 4W (e.g. LED's).
- Also all lamps that are not directly supplied from the mains, e.g. the widespread low voltage halogen lamps (HL-LV) are not included in this Directive.

- *Commission Decision of 9 September 2002 establishing revised ecological criteria for the award of the Community eco-label to light bulbs and amending Decision 1999/568/EC*

Scope:

This Decision amends the Decision 1999/568/EC for the award of the Community eco-label. It sets specific criteria for light bulbs that aim in particular at promoting:

- the reduction of environmental damage or risks related to the use of energy (global warming, acidification, depletion of non-renewable resources) by reducing energy consumption,
- the reduction of environmental damage or risks related to the use of resources in both the manufacture and treatment/disposal of a light bulb by increasing its average lifetime,
- the reduction of environmental damage or risks related to the use of mercury by reducing the total emissions of mercury during the lifetime of a light bulb. to become this Community eco-label.

In annex also the test method is described to measure the mercury content.

1.3.1.4 Other product related directives

- *Directive 2006/25/EC of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation.*

Scope:

The Council Directive 2006/25/EC of 5 April 2006 introduces measures to protect workers from the risks associated with optical radiation, owing to its effects on the health and safety of workers, in particular damage to the eyes and to the skin.

- *Electromagnetic Compatibility (EMC) Directive 2004/108/EEC*

Scope:

The Council Directive *2004/108/EEC* of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive) governs on the one hand the electromagnetic emissions of this equipment in order to ensure that, in its intended use, such equipment does not disturb radio and telecommunication as well as other equipment. In the other the Directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions normally present used as intended.

- *Low Voltage Directive (LVD) 73/23/EEC*

Scope:

The Low Voltage Directive (LVD) 73/23/EEC seeks to ensure that electrical equipment within certain voltage limits both provides a high level of protection for European citizens and enjoys a Single Market in the European Union. The Directive covers electrical equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current. It should be noted that these voltage ratings refer to the voltage of the electrical input or output, not to voltages that may appear inside the equipment. For most electrical equipment, the health aspects of emissions of Electromagnetic Fields are also under the domain of the Low Voltage Directive.

1.3.1.5 Quality charters and voluntary agreements from industry on EU-level

- *There is a ' European Compact Fluorescent Lamps QUALITY CHARTER' see ' http://re.jrc.cec.eu.int/energyefficiency/CFL/ '*

Scope:

This charter, that is in revision at this moment, is an initiative promoted by the European Commission in co-operation with the following organisations: EURELECTRIC, ELC, ADEME (France), NOVEM (The Netherlands), THE DANISH ELECTRICITY SAVING TRUST (Denmark) and THE UK ENERGY SAVING TRUST (UK).

The aim of the European CFL Quality Charter is to offer a high quality standard to be used by utilities and other bodies in their promotion and procurement campaigns. The ultimate goal of the European Quality Charter for CFL is to increase consumer confidence in this environmentally friendly technology, which save money and the environment. To achieve this, the charter promotes the manufacturing, marketing and sales of high quality CFLs in the European Union in order to offer residential customers a satisfying product from an energy, comfort and economic point of view.

The requirements that are imposed by this charter are related to safety, performance, information, guarantee and information:

- Safety: standards EN 60968, EN 61199 and EN 60598 and comply with CE-marking legislation;
- Performance: luminous efficacy following energy label A (with a derating factor for lamps with an external casing 'bulb form') see Figure 1.9, lumen maintenance, running up time, number of ignitions (> lifetime in hr) and colour rendering (Ra≥80), with a written conformity certificate from an approved 'Notified Body[9]';

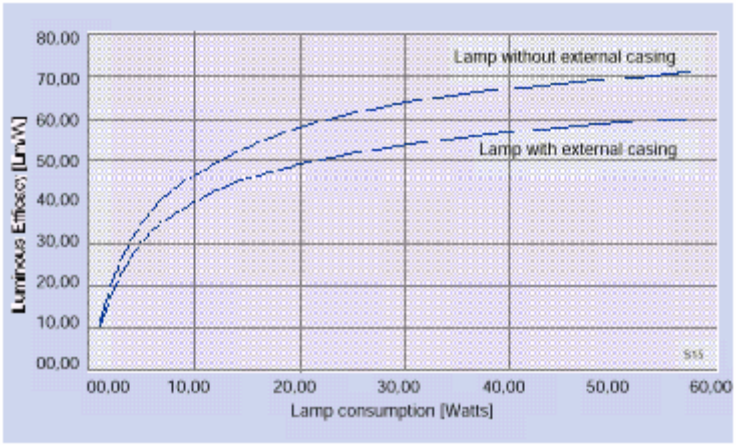

Figure 1.9: Luminous Efficacy limits for Integral Compact Fluorescent lamps

- Lifetime (LSF=0.5): minimum 6000hr and for 'Long Life' lamps minimum 12000hr;

[9] Notified bodies as defined in the Annex to 93/465/EEC: Council Decision of 22 July 1993 concerning the modules for the various phases of the conformity assessment procedures and the rules for the affixing and use of the CE conformity marking, which are intended to be used in the technical harmonization directives.

- Information: lifetime and energy label A must be shown on the individual package of each lamp, mentioned equivalence with GLS filament lamp must comply with defined lumen output;
- Guarantee: 2 years on lamp failure;
- Quality of production: manufactured under a Quality Assurance System EN ISO 9002 or equivalent.

It is important to note that the charter is a voluntary set of criteria established by the European Commission in collaboration with the organisations mentioned above.

- *The European Lamp Companies federation (ELC) has elaborated eco-design levels for certain lamp types the so-called ELC Eco-Profiles.*

  The following ecoprofiles can be found on their website http://www.elcfed.org/2_resource_publications.html :

  - *Eco-Profile for Self-ballasted Fluorescent Lamps*
  - *Eco-Profile for Fluorescent Lamps*
  - *Eco-Profile for Compact Fluorescent Lamps non-integrated*
  - *Eco-Profile for HID Lamps.*

1.3.2 Legislation and Agreements at Member State level

There are member states (a.o. in the UK by the Energy Saving Trust, in Sweden by the Swedish Energy Agency) that are preparing minimum performance specifications for (domestic) lamps. The specifications aim to enhance energy efficiency but also envisage colour rendering, colour temperature, lifetime, lumen maintenance, starting time, warm-up time, number of ignitions and guarantee period.

1.3.3 Third Country Legislation and Agreements

This section again deals with the subjects as above, but now for legislation and measures in Third Countries (extra-EU); some of them were indicated by stakeholders (NGO's, industry, consumers) as being relevant for the product group.

There are various minimum standards and labelling programs applied worldwide for compact fluorescent lamps (CFL) but only 4 countries have MEPS programmes that prohibit the sale of low efficiency CFL's[10]:

- China
- Mexico
- South Korea
- Japan.

[10] Source : Report No :2005/12 from the (Australian) National Appliance and Equipment Energy Efficiency Program : Minimum Energy Performance Standards - Compact Fluorescent Lamps.

Efficient Lighting Initiative (ELI) is an international program that develops voluntary technical specifications to identify lighting products that save energy and meet consumer expectations for quality and performance; see www.efficientlighting.net .

There is also the US governmental 'Energy Star' sensitization campaign for saving energy a.o. on lighting (see http://www.energystar.gov/index.cfm?c=lighting.pr_lighting).
For light bulbs (see http://www.energystar.gov/index.cfm?c=cfls.pr_cfls) people can consult a buyers guide and learn how to handle the mercury problem.
Also for luminaires (see http://www.energystar.gov/index.cfm?c=fixtures.pr_fixtures) comparisons between different fixtures can be found a.o. on LED-lighting in domestic sectors (see http://www.energystar.gov/index.cfm?c=ssl.pr_residential) and in commercial sectors (see http://www.energystar.gov/index.cfm?c=ssl.pr_commercial).
The 'Energy Star' programm is only a voluntary initiative. Manufacturers that fulfil those voluntary requirements can become partners and can obtain an 'Energy Star Label' for their products. The US have only legislation with MEPS for Fluorescent Lamps (not for CFL's), for Incandescent Reflector Lamps and for Under-Cabinet Luminaires[11].

Australia and New Zealand are preparing standards for MEPS and testing methods for compact fluorescent lamps and also for halogen (reflector) lamps [12].

Japan has a 'Top Runner Programme' for the efficiency of Energy using Products. For lighting, this programme imposes burdens for fluorescent lighting (see: http://www.eccj.or.jp/top_runner/).

On the website www.apec-esis.org existing MEPS and labelling programmes worldwide at the moment of this study can be found. Due to accelerated efforts of several governments, the accuracy of this source can not be guaranteed.

In Annex 11.3, some current MEPS and quality parameters for CFLi's worldwide can be found.

[11] Source : Appliance – Efficiency Regulations, December 2006, CEC-400-2006-002-REV2, California
[12] http://www.energyrating.gov.au/library/details200718-phaseout-incandescent-lamps.html.

2 ECONOMIC AND MARKET ANALYSIS

3 CONSUMER BEHAVIOUR AND LOCAL INFRASTRUCTURE

4 TECHNICAL ANALYSIS EXISTING PRODUCTS

5 DEFINITION OF THE BASE-CASE

6 TECHNICAL ANALYSIS BAT AND BNAT

7 IMPROVEMENT POTENTIAL

8 SCENARIO- POLICY- IMPACT- AND SENSITIVITY ANALYSIS

For more info see website www.eup4light.net.