European Commission

Preparatory Study on Light Sources
for Ecodesign and/or Energy Labelling Requirements
('Lot 8/9/19').

Final report, Task 1, Main

Scope, Standards, Legislation

Energy

Prepared by:

VITO, in cooperation with VHK
Date: 31 October 2015

Prepared for the European Commission, DG ENER.C.3
Contact person: Ruben KUBIAK
SPECIFIC CONTRACT No ENER/C3/2012-418 LOT1/07/SI2.668526
Implementing Framework Contract No ENER/C3/2012-418-Lot 1

Main contractor:
Consortium of VITO NV, VHK BV, Viegand & Maagøe ApS, Wuppertal Institute for Climate, Environment and Energy GmbH, ARMINES, represented by Dirk Fransaer, Managing Director VITO

Technical Team Leader: René KEMNA (VHK)
Contract Manager: Caroline LEMEIRE (VITO)

Other Participants:
Roy VAN DEN BOORN, Leo WIERDA (VHK)
Stuart JEFFCOTT (external collaboration)
Lieven VANHOOYDONCK, Paul VAN TICHELEN, Dominic ECTORS (VITO)
Wai Chung LAM (VITO, Quality Control)

Status: Final report

This report was ordered and paid for by the European Commission, Directorate-General for Energy.

Contents

ANNEXES (separate report)

EXECUTIVE SUMMARY

This is the Task 1 report of the "Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19')" for the European Commission DG ENER C3. The document is part of an Interim Report that also covers MEErP Task 0 and a major part of MEErP Task 2. MEErP Tasks 3 through 7 are not covered at this stage.

Task 1 deals with the product scope, test standards and legislation.

The initial scope of the study regards all light sources, lamps, ballasts and lamp control gears according to the definitions provided for these lighting products [1]. The definition for light sources limits their scope to "*surfaces or objects designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wavelength of 380-780 nm.*"

In addition, the study also includes control devices and luminaires, but only as regards their integration with the lamps or as regards their compatibility with separately marketed lamps or light sources.

This extensive initial scope can be restricted using the eligibility criteria for the application of ecodesign measures of article 15 of the Ecodesign Framework Directive 2009/125/EC. The scopes, exemptions, definitions and lighting functions of the current regulations have to be ignored for the purpose of establishing a scope for the current study, at least in this stage.

This report analyses the status of a variety of special purpose lamps in the current regulations and presents a first proposal for restriction of the scope. Exclusions from the scope of the study, at this stage, are proposed amongst others for backlighting for displays, non-electric lamps, lights for signal transmission, and most lamps used in and on means of transport. For the full proposal see Table 1 in par. 1.12. These MEErP Task 1 exclusions are based mainly on the chosen initial scope and on the existence of other Community legislation. Further exclusions are possible after gathering additional information in future MEErP tasks.

In many occasions, the analysis of special purpose lamps and of other lamps exempted from the current lighting regulations has highlighted a lack of accurate definitions; in particular a lack of technical parameter definitions that enables market surveillance to establish in a straightforward and affordable manner if the lamp is of the declared type. The priority at this moment is to establish these definitions, rather than to decide whether a certain type of non-well-defined lamp should be in or out the scope of the current study. Establishing these definitions is a task of the current study, that has been initiated with the information and analysis presented in this report, but should now proceed in cooperation with the stakeholders.

Hundreds of test standards for lighting products exist that are outlined in (the annexes to) this report. The main issues that may need to be addressed e.g. through mandates to the European standardisation organisations relate to (practical test procedures for) LED lumen maintenance and lifetime, colour rendering metrics across lamp types, dimmer compatibility, (costs of and alternatives for) goniophotometric testing of directional lamps and overall consolidation of test standards for photometric (and colourimetric) testing. Furthermore, it needs to be verified whether reliable and practical tests are available for special purpose lamps and other exemptions.

As regards legislation, international comparison of minimum efficacy and functionality requirements in this report shows that the current EU lighting legislation has the broadest product scope and overall

[1] For details see chapter 5 of the Task 0 report and par. 1.1, 1.2 and Annex B of this Task 1 report.

the most stringent requirements worldwide. This means that with further expansion of the scope, the EU will be 'breaking new ground', i.e. it cannot build on experience from elsewhere.

For mandatory energy labelling of lamps and ballasts, the EU currently covers significantly more lamp types than other countries. When the 'graphical' lamp label and the product information requirements of the EU legislation are taken into account, the EU labelling/information requirements are, in comparison to most countries, very comprehensive. An inspiration for possible improvement may be the US voluntary LED Lighting Facts label, which also presents graphical information about LED colour temperature, LED lumen maintenance and colour accuracy, the addition of which may assist EU consumers in selecting appropriate replacement products, particularly where multiple lamps are in the same fitting.

Note on revision 1:

Revision 0 of this document, as presented during the 1st stakeholder meeting of 5 February 2015, was commented by the stakeholders. These comments have been considered in revision 1. For convenience, the following table provides a survey of the paragraphs that have been changed in revision 1. Changes that are only editorial have not been included in this table.

paragraph	Description of change(s) in revision 1
1.2.2	Added IALD comment regarding definition for control gear
1.2.3	Added UBA opinion regarding LED terminology
1.4.1.6	Added DEA opinion regarding preferred definition for special purpose lamps
1.4.1.6	Added IALD comment regarding energy estimates for special purpose lamps
1.4.2.1	Added reference to UK NMO study on compliancy of special purpose lamps
1.4.2.1	Added IALD opinion regarding rough service lamps
1.4.2.13	Added UBA opinion regarding 200,000 sales limit in Ecodesign Directive
1.4.2.17	Added IALD comment on emergency lighting remaining always on.
1.12	Added ANEC&BEUC opinion regarding luminaires and appliance integrated lamps
1.12	Added IALD opinion regarding floodlighting, decorative, signage and light art.
3.1	Added reference to IEC webstore for IEC 62471 (section on UV-radiation)
4.1.1	Inserted reference to information on flicker in the Task 3 report
4.1.1	Added IALD comment regarding test methods for flicker and recommended limits.
4.1.4	Inserted comment from LightingEurope and DEA opinion regarding DLS flux definition
5.1.6	Inserted list of issues signalled by stakeholders for review of regulation 1194/2012
5.1.7	Inserted list of issues signalled by stakeholders for review of regulation 874/2012

1. PRODUCT SCOPE

1.1. Introduction

According to the MEErP the aim of Task1 is to:

- *Identify relevant*
  a- Prodcom category or categories (Eurostat);
  b- Categories according to EN- or ISO-standard(s);
  c- Labelling categories (EU Energy Label or Eco-label), if not defined by the above.
- *Define preliminary product scope, including preliminary product definitions, taking into account that categorisation shall preferably be linked to primary performance parameter (the 'functional unit') if needed sub-categorisation can take place on the basis of secondary performance parameters and for indirect ErPs the affected energy system(s).*

Considering the assignment described in the Task 0 report, the initial product scope of the current preparatory study is (very) wide.

The assignment refers to 'lighting products' which includes not only 'lamps' but also 'lighting controllers' (either as part of a luminaire or as an independent product) and 'luminaires' (either with or without built-in light sources such as LED modules).

As regards the lamps, practically all types for all uses have to be considered: directional and non-directional lamps, for indoor- and outdoor use, both for residential and non-residential application. In addition to the lamps already covered by the existing regulations, the study shall also consider those not yet regulated and give attention to 'special purpose' lighting products.

In chapter 5 of the Task 0 report the initial scope of the study has been formulated as:

> "The study regards all light sources, lamps, ballasts and lamp control gears according to the definitions provided above".

The indication "above" refers to the same chapter 5 of the Task 0 report that presents the definitions for light sources, lamps, ballasts and control gears (the same definitions can also be found in paragraph 1.2 below).

According to the same reference:

> The study also includes control devices and luminaires, but only as regards their integration with the lamps or as regards their compatibility with separately marketed lamps.

Restriction of the initial scope

As explained in chapter 5 of the Task 0 report, this extensive initial scope can be restricted using the criteria of article 15 of the Ecodesign Framework Directive 2009/125/EC, disregarding, at least in a first approach, the scopes and the exemptions of the current lighting regulations.

In the current MEErP Task 1, the possibilities for such a restriction are limited: formally only the existence of other Community legislation can be considered [2]. Other relevant information such as sales, energy consumption, variety in existing technologies, consumer impacts, industry impacts, health issues, etc. are handled in subsequent MEErP tasks. However, in an attempt to centralise information, to make the discussion on the various types of special purpose lamps as fruitful as possible, and to gather comments right from the start, some preliminary estimates for sales and energy consumption of special purpose lamps are anticipated here.

Although the scope and the exemptions of the existing regulations should be disregarded for the purposes of establishing a scope for the current study, a discussion on the status of the various types of lamps in the current regulations is anyway considered useful and included in paragraph 1.4. It clarifies the situation from which any new regulation will have to start, and highlights any problems with the current definitions, which is important considering that part of the assignment is to formulate new definitions. In addition, the exemptions in the existing regulations were there for a reason and it is important to track what this reason was and if it still valid.

The focus of this chapter is on the supply of information and on considerations: the decision on the scope of the study should be taken by the Commission and by the stakeholders [3]. For some types of lamps the study team suggest an inclusion in or exclusion from the study but for other types the conclusion is left open for the moment.

Functions of lighting

An ecodesign preparatory study is normally based on the comparison of products that perform the same function. In the current study the main function considered is the same as that in the existing regulations, i.e. the general lighting function 'to make objects and scenes visible'. The related main functional parameter is the luminous flux (in lumen, lm) or the maintained useful flux density (lm/m^2). In principle the study should consider all lighting products, even if their function is different from the main one mentioned above.

Lighting products have a large variety of functions. Some are close to the main function in that they still aim 'to make objects and scenes visible' but in a special way (food display, theatres, microscopes), or in a special environment (vibration resistant, ovens, explosion proof, marine applications). Others can be viewed to have the function to make themselves visible (traffic lights, exit signs, projector lamps). In addition there are lighting products that have a completely different function (grow lights, breeding lights, lamps for UV-treatments, IR lamps for heating, decorative/mood lighting). When maintained in the scope of the study each of these functions requires a separate preparatory study (sales, energy consumption, life, usage characteristics, base-case and BAT technology, availability of standards, scenario analysis, impact on consumers, impact on industry), and, if implemented in an ecodesign or labelling regulation, each of these functions may have its own minimum requirements and label classes.

Outline of this chapter

This chapter collects information that is relevant for the discussion on the scope and performs a first analysis of the various types of lighting products, with a focus on lamps / light sources:

- Paragraph 1.2 reviews the currently existing definitions regarding lighting products.
- Paragraph 1.3 discusses the parameters and functional units used in previous studies and in the existing regulations to characterise the lighting products.

[2] Directive 2009/125/EC, article 15.2(c)(i)

[3] This decision can have implications for the amount of work to be performed by the study team.

- Paragraph 1.4.1 reviews the scope and the exemptions of the current regulations on lighting products, mainly with the aim to identify all the lamp types for which inclusion in or exclusion from the scope of the current study has to be decided.
- Paragraph 1.4.2 provides a first analysis of the lamp types identified in 1.4.1 and discusses their inclusion in the scope of the current study. This paragraph can be considered as the 'heart' of the chapter.
- Paragraph 1.5 is dedicated to mains voltage directional filament lamps. These lamps are considered separately because the assignment requests a detailed market study for them, in the context of the review of Regulation 1194/2012. This work will mainly be performed as part of future MEErP tasks.
- Paragraph 1.6 briefly reviews some recent lighting technologies, mainly to verify if they should be included in the scope of the study.
- Paragraph 1.7 explains the most relevant coding systems that are being used for the classification of lamps.
- Paragraph 1.8 is closely related to 1.7 and introduces the lamp subdivisions that will be used for the presentation of sales data in the Task 2 report.
- Paragraphs 1.9, 1.10 and 1.11 briefly deal with respectively ballasts and control gears, control devices, and luminaires.
- Paragraph 1.12 provides a summary and a first proposal for the restriction of the initial scope.

1.2. Definitions related to lighting products

A list of definitions related to lighting products, including lighting-types, lamp-types and light-related parameters is included in Annex B. In most cases, these definitions have been taken from the existing regulations on lighting: 244/2009 (non-directional household lighting), 245/900 (tertiary lighting), 874/2012 (energy labelling) and 1194/2012 (directional lamps).

Where the definition for the same term is not identical for all regulations, usually the definition from the most recent Regulations 874/2012 and 1194/2012 has been preferred.

Some selected definitions are discussed below.

1.2.1. Discussion on the definitions for luminaires, lamps and light sources

As regards the distinction between 'Luminaires', 'Lamps' and 'Light sources' the following definitions taken from Regulations 874/2012 and 1194/2012 are used:

> '*Luminaire*' means an apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes all the parts necessary for supporting, fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply. [4]
>
> '*Lamp*' means a unit whose performance can be assessed independently and which consists of one or more light sources. It may include additional components necessary for starting, power supply or stable operation of the unit or for distributing, filtering or transforming the optical radiation, in cases where those components cannot be removed without permanently damaging the unit.

[4] *Regulation 245/2009 uses the same definition, but at the end of the definition additionally specifies: "but not the light sources themselves".* This has been removed in 1194/2012 to accommodate integrated LED luminaires.

'Light source' means a surface or object designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wavelength of 380-780 nm.

A first thing to note is that a 'luminaire' can accommodate one or more 'lamps' while a 'lamp' can consists of one or more 'light sources', so 'luminaire' is the largest object and 'light source' the smallest one.

In the case of a '**light source**' the focus is on what actually emits light. In the most limited meaning it is only the surface that actually emits light [5]. In the more extensive meaning of 'object designed to emit *light*' the term becomes quite flexible however, apparently covering everything from a classical light bulb to a completely integrated LED luminaire.

In the case of a '**lamp**' the focus is on the fact that it is a single integrated unit that cannot be disassembled without damaging it. When a 'lamp' consists of only one 'light source' and it does not include any additional components, it is practically identical to a 'light source'. Under the above definitions, a classical incandescent light bulb or a halogen capsule could be termed 'lamp' as well as 'light source'. Even a compact fluorescent lamp with integrated ballast, which has 'additional components', could be a 'lamp' as well as a 'light source'. For this reason in this report the two terms will often be treated as interchangeable.

Comparing the definitions, a 'lamp' can also come close to being a 'luminaire' [6] [7]. Note however that a 'lamp' always has to remain a single integrated unit that cannot normally be disassembled, while a 'luminaire' can also consist of several parts that can be separated.

In conclusion the definitions for 'luminaire', 'lamp' and 'light source' are partially overlapping and quite flexible, but this basically reflects the large variety of lighting products that exists on the market, especially when also considering recent LED lighting products. Although in literature from time to time there are discussions on whether 'lamp' or 'light source' should be used [8], the above definitions do not seem to create serious problems when formulating ecodesign or labelling requirements. Considering that it is preferable not to change existing definitions without a need, the existing definitions will be used in this report.

Review of the definitions or new definitions might be necessary in relation to new lighting products, e.g. integrated LED luminaires, OLED lighting panels, lamps with integrated lighting controls, etc.

See also par. 1.11 on how integrated LED luminaires are handled in Regulation 1194/2012.

1.2.2. Discussion on the definitions for ballasts, control gears and control devices

As regards the distinction between 'Ballasts', 'Control gears' and 'Control devices' the following definitions taken from Regulations 874/2012 and 1194/2012 are used:

[5] Compare the definition of LES = 'Light Emitting Surface' in the Zhaga Interface Specifications for LED lighting products, http://www.zhagastandard.org/specification , see also section H.21 in Annex H.

[6] This is also expressed by the ILV-definition for a lamp: "*source made in order to produce optical radiation, usually visible. NOTE This term is also sometimes used for certain types of luminaires*." (for ILV see section H.3 in Annex H). The ILV definitions for 'luminaire' and 'light source' are similar to the definitions above.

[7] This also reflects the common use in some languages where the term 'lamp' can indicate anything from the classical light bulb to the complete object ('luminaire') in which this light bulb is inserted for use.

[8] See for example: "Revision of European Ecolabel and Green Public Procurement Criteria for Lamps – Eco-lighting project – Background Report including Draft Criteria Proposal – Working document for 2nd AHWG meeting for the development of ecolabel criteria for lamps", January 2014, http://www.eco-lighting-project.eu/uploads/docs/docs1_Eco_lighting_Background_Repor_including_Draft_Criteria_Proposal_amended_version.pdf

'*Ballast*' means lamp control gear inserted between the supply and one or more discharge lamps, which, by means of inductance, capacitance or a combination of inductance and capacitance, serves mainly to limit the current of the lamp(s) to the required value.

'*Lamp control gear*' means a device located between the electrical supply and one or more lamps, which provides a functionality related to the operation of the lamp(s), such as transforming the supply voltage, limiting the current of the lamp(s) to the required value, providing starting voltage and preheating current, preventing cold starting, correcting the power factor or reducing radio interference. The device may be designed to connect to other lamp control gear to perform these functions. The term does not include:

- control devices
- power supplies within the scope of Commission Regulation (EC) No 278/2009.

'*Control device*' means an electronic or mechanical device controlling or monitoring the luminous flux of the lamp by other means than power conversion, such as timer switches, occupancy sensors, light sensors and daylight regulation devices. In addition, phase cut dimmers shall also be considered as control devices.

Considering these definitions the term 'ballast' indicates a subtype of 'control gear'. 'Ballast' is limited to use on discharge lamps (which excludes LED control gears) and its main function is to limit lamp current, while 'control gear' is more generic, not being limited to a certain lamp type and potentially having a more extensive range of functions.

In the International Lighting Vocabulary of 2011 [9] the term 'control gear' does not appear. The term 'ballast' is defined in almost the same way as above but it has a note that leaves additional functionality open.

In this report 'ballast' and 'control gear' will be used interchangeably, the only difference being that the former does not include 'LED control gear' (LED driver [10]) while the latter does.

The above definitions do not seem to create serious problems when formulating ecodesign or labelling requirements. Considering that it is preferable not to change existing definitions without a need, the existing definitions will be used in this report [11].

The need might arise to add a definition for 'LED control gear'. In that case, the following definition as used by Zhaga [12] could be considered:

The Electronic Control Gear (ECG, also named LED driver) is defined as:

"a unit that is located between the External Power and one or more LED Modules to provide the LED Module(s) with an appropriate voltage or current. It may consist of one or more separate

[9] CIE S 017/E:2011 'ILV: International lighting vocabulary, new' http://eilv.cie.co.at/ (online version, accessed May 2014).

[10] According to a LightingEurope comment on the draft report, the term 'driver' should be avoided. In IEC language the term 'control gear' is used.

[11] IALD comment: "We would like to stress that care is needed to ensure that there is no confusion between definitions. As it stands now, some definitions would require further refinement. It is important that this confusion does not cause unintentional effects - there is a potential risk of misalignment of definitions with the realities of the market.
A good example to show this potential confusion relates specifically to control gear: power supplies are potentially separate (this is becoming normal industry practice a DC power supply is used in conjunction with gear to regulate current or voltage and interface with lighting control systems). This type of device falls between the definition of lamp control gear and control device particularly where it functions with a directly connected contact close switch or potentiometer. This could potentially have negative consequences in application and enforcement of future regulation, as these devices would not be regulated or not allowed to be manufactured."

[12] See http://www.zhagastandard.org/ (accessed May 2014).

components, and may include additional functionality, such as means for dimming, power factor correction, and radio interference suppression." [13] [14]

'Control gear' is distinguished from 'control device'. Given the availability of a certain supplied power, 'control gear' manages to make the lamp function correctly, while a 'control device' manages the availability of the power. A 'control device' decides when to switch on/off the power supply and which level of power to supply (dimming) [15].

'Ballasts' and 'control gears' are subjects of the present study, while 'control devices' will primarily be handled in the parallel Lot 37 study (see Task 0 report). However, dimming may be relevant for the current study as well, especially regarding the dimmability of certain lamp types.

1.2.3. Discussion on the definitions for LEDs

The following LED-related definitions have been used in Regulations 874/2012 and 1194/2012:

'*Light emitting diode (LED)*' means a light source, which consists of a solid-state device embodying a p-n junction *of inorganic material*. The junction emits optical radiation when excited by an electric current [16].

'*LED package*' means an assembly having one or more LED(s). The assembly may include an optical element and thermal, mechanical and electrical interfaces [17].

'*LED module*' means an assembly having no cap and incorporating one or more LED packages on a printed circuit board. The assembly may have electrical, optical, mechanical and thermal components, interfaces and control gear.

'*LED lamp*' means a lamp incorporating one or more LED modules. The lamp may be equipped with a cap [18].

As regards the definition of *'Light emitting diode (LED)',* a major issue is whether the specification '*of inorganic material*' should be present. In Regulation 1194/2012 this dictation IS present while in Regulation 874/2012 it is NOT. The absence or presence determines if OLEDs (organic LEDs) are considered to be LEDs or not. Considering that OLEDs and LEDs used for lighting purposes have significantly different characteristics it could be advantageous to leave the dictation '*of inorganic material*' in the LED definition, thus clearly separating inorganic LEDs from OLEDs. On the other hand,

[13] LightingEurope comments that the definition from IEC 62504 should be preferred: "3.6.1 control gear for LED module, LED control gear unit inserted between the electrical supply and one or more LED modules, which serves to supply the LED module(s) with its (their) rated voltage or rated current, and may consist of one or more separate components and may include means for dimming, correcting the power factor and suppressing radio interference, and further control functions…"

[14] IALD comment: "We would also like to mention that the references to ZHAGA documents would imply referencing a membership-based organization, whose documents are private and therefore not verifiable."

[15] A 'control device' may also have additional functions such as monitoring the quantity of light or the room occupancy, or emitting signals to change the colour of the lamps, etc.

[16] IEC 62504 defines LED: "solid state device embodying a p-n junction, emitting incoherent optical radiation when excited by an electric current". LightingEurope suggests to use this definition.

[17] IEC 62504 defines LED package: "…single electrical component encapsulating principally one or more LED dies, possibly including optical elements and thermal, mechanical, and electrical interfaces". LightingEurope suggests to use this definition.

[18] IEC 62504 defines a LED lamp: "LED light source provided with (a) cap(s) incorporating one or more LED module(s) and possibly including one or more of the following; electrical, optical, mechanical, and thermal components, interfaces and control gear". LightingEurope suggests to use this definition. The component "cap" is already part of the definition of "lamp".

the LED definition in the new standard IEC 62504 [19] seems to include both LEDs and OLEDs. This standard does not specifically mention OLEDs [20], and no distinction is made between organic and non-organic [21].

Another issue could be that the regulations currently define LED as a 'light source'. This does not seem to be common practice and is in contrast for example with IEC 62504 that sees only LED-modules and LED-lamps as 'light sources', not LEDs, intended as LED dies or LED packages. According to this standard, the term 'LED' should NOT be used for reporting product performance.

As regards '*LED package*', there is no comparable definition from Zhaga (Annex H.21) nor from the ILV (Annex H.3). The definition in IEC 62504 [19] is similar to the one above from the regulations, but it sees an LED package as a 'single electrical component' or a 'discrete component' rather than as an 'assembly'. Comparing the existing definition with the opinion of Lighting Europe (LE) on the classification codes for LEDs (see par. 1.7.3 and Annex G), the existing definition seems to be acceptable. For classification purposes LE underlines that an LED package should essentially be seen as a basic semiconductor device (HS code 85.41) and not as a product ready to be connected to the commercial power supply for lighting purposes (HS code 85.39) [22]. The same view is expressed in IEC 62504.

As regards '*LED module*', the Zhaga definition (Annex H.21) [23] explicitly excludes the presence of a control gear, while the definition from existing regulation allows it ("*may have … a control gear*"). IEC 62504 also allows the presence of a control gear and uses a definition similar to the one from the existing regulations. This standard further distinguishes the following types of LED modules: built-in, independent, integral, integrated, semi-integrated and non-integrated.

LightingEurope (LE) (see par. 1.7.3 and Annex G) considers LED modules/assemblies as LED light sources: "*comprising one or multiple LEDs on a joint mounting device (like a printed circuit board), typically together with further active or passive electronic components and other elements (like optical or thermal components)*."

Different from 'LED packages', that are treated as basic semi-conductor devices, **LE considers 'LED modules' on the same level as 'LED lamps', both being light sources** and intended to be installed in a luminaire or other general lighting system. According to the LE-document a range of LED assemblies

[19] IEC FDIS 62504, 'General Lighting – Light Emitting Diode (LED) products and related equipment – Terms and Definitions', IEC 2014 (final draft International Standard currently submitted for voting).

[20] LightingEurope comment: The reason for this is that the term "OLED" is given in the safety standard for OLED, IEC 62868 (in preparation), document 34A/1786/FDIS: "light emitting semiconductor consisting of an electroluminescent zone made of organic compounds, situated between two electrodes"

[21] In its comment on this report, the Federal Environment Agency of Germany (UBA) expresses the opinion that inorganic LEDs should be indicated as ILEDs and organic LEDs as OLEDs, while the term LED should be used only if all LEDs (organic and inorganic) are intended.

[22] Two citations from the LE-text in Annex G illustrate this:
"Light Emitting Diodes (LEDs) as the basic semiconductor devices, including the bare LED chips/dies as well as LED packages encapsulating one or multiple chips (and possibly additional protective elements). In general lighting applications, such LEDs are not intended to be directly connected to a (commercial) power supply."
"LightingEurope considers it essential that LED packages (LEDs) are being understood as basic semiconductor devices, regardless of the number of LED chips included in the package, regardless whether or not these LED chips are connected among each other, and regardless of the presence of any protective diodes (Zener diodes)."

[23] Zhaga definition for an LED-Module: "*a light source that is supplied as a single unit. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its optical, thermal, mechanical and electrical properties, but it* ***does not include the electronic control gear***".

with different complexities exists depending on whether there are only LEDs on the printed circuit board or also other components, whether the assembly contains only passive components or also active ones, whether the electronic control gear is included, and whether there is a (standardised) socket or not. As it is difficult to find a meaningful and convincing distinction of these LED Assemblies between 'simple' and 'complex', LE prefers a classification of all LED assemblies as LED light sources (HS code 85.39).

As regards '*LED lamps*', the definition from existing regulations states that they "*may be equipped with a cap*". This seems to be in contrast with the vision of LE where the presence of the cap is the main characteristic of an LED lamp [24] and which distinguishes it from an LED module. Both can be installed in a luminaire, but an LED lamp has a cap that enables easy installation of the lamp by an ordinary person while an LED module is more difficult to install. The new standard IEC 62504 also explicitly states that an LED lamp is provided with a cap and that it "*is designed so that it can be replaced by an ordinary person (as defined in IEC 60050-826, 826.18.03)*".

Zhaga does not use the term 'LED lamp' but uses 'LED light engine' instead, being simply defined as: *"a combination of one electronic control gear and one or more LED modules."* Regarding the term 'LED light engine', the standard IEC 62504 states that: "*The scope of this term is not clear enough to be part of this document at present. A universal definition is under consideration.*" [25]

The existing regulations do not have a definition for 'LED luminaire'.

Zhaga (Annex H.21) defines an LED luminaire as:

> *"a lighting fixture which provides an appropriate environment for one or more LED light engines (LLEs). A luminaire typically (but not necessarily) is comprised of a heat sink to carry away the heat generated in the LLEs, optical features to reshape the light beam of the LLEs, means to supply electrical power to the LLEs, and means to attach the luminaire to a wall, ceiling, stand, etcetera."*

LightingEurope (Annex E) distinguishes two types of luminaires "*designed for use with LEDs only*":

- Integrated LED luminaires incorporating LED light sources (LED lamps or LED assemblies) which are not intended to be replaced by an ordinary person. The LED light sources are typically installed by the luminaire maker as part of the manufacturing process before the luminaire is sold to the end user.

- Luminaires for (replaceable) LED lamps having a socket that are not used for conventional lamps. Such luminaires are equipped with lamp holders that can engage with corresponding LED lamp sockets, but would not engage with conventional lamp sockets.

In the standard IEC 62504 the following definitions can be found:

> *LED luminaire*
> *Luminaire designed to incorporate one or more LED light source(s.)*

[24] According to the LightingEurope document on classification of LED products (Annex G): "*LED lamps include LED replacement lamps having a socket which is also used for the conventional (non-LED) lamps that can be replaced. LED lamps may also come with new types of sockets that have not been used for conventional lamps. The main characteristic is the presence of a socket that allows the easy installation of the LED lamp into a corresponding luminaire by an ordinary person (regardless whether the socket is also used for conventional lamps or not).*"

[25] According to LightingEurope comments, Zhaga is revisiting the concept of LED Light Engine, and this term should not enter into any regulation.

Non-repairable, factory-sealed LED luminaire
Luminaire which cannot be dismantled without being permanently damaged, and incorporating LED light source(s) and any additional elements necessary for starting and stable operation of the light source.

See also par. 1.11 on how integrated LED luminaires are now handled in Regulation 1194/2012.

It is expected that LED lighting will play a central role in the current preparatory study, so definitions regarding LEDs will most likely be important. It might be necessary to:

- reflect on the definition for 'LED' (include or exclude OLED; is it a light source?)
- reflect on the definition for 'LED module' (with or without a control gear)
- reflect on the definition for 'LED lamp' (with or without a cap)
- add a definition for 'LED luminaire' (see examples above)

In addition, considering that the definition for 'LED' might explicitly exclude OLEDs, a definition for OLEDs might be required (see also par. 1.6.1).

If feasible, it is recommended to choose definitions in line with IEC 62504 [26].

1.3. Parameters and functional unit for the characterisation of lighting products

According to the MEErP, the categorisation of the products to be selected for the ecodesign preparatory study *"shall preferably be linked to the primary performance parameter (the 'functional unit') if needed sub-categorisation can take place on the basis of secondary performance parameters"* [27]. The main idea is to group products according to function and to avoid for example to group products according to technology.

"*The primary purpose of the functional unit is to provide a calculation reference to which environmental impacts (such as energy use, costs, …) can be related and to allow for comparison between functionally equal lighting products with and without options for improvement.*" [28]

This paragraph therefore gives a survey of the performance parameters for lighting products that have been distinguished in previous studies and regulations and then discusses the 'functional unit'.

1.3.1. Parameters for the characterisation of lighting products

The following parameters for the characterisation of lamps have been used in the existing regulations [29]:

- nominal lamp power / rated lamp power or wattage

[26] This is also recommended by LightingEurope, see their comments in Annex K.

[27] MEErP 2011, Methodology for Ecodesign of Energy-related Products, part 1: Methods and part 2: Environmental policies and data, René Kemna (VHK) November 28th 2011. For a general discussion on the use of the 'functional unit' in ecodesign, see chapter 1 of the MEErP.

[28] Slightly adapted from: Preparatory Studies for Eco-design requirements of EuPs, Final Report, Lot 8: Office lighting, Study for the European Commission DGTREN unit D3, contact Andras Toth, by VITO in cooperation with Laborelec and Kreios, April 2007, Contract TREN/D1/40-2005/LOT8/S07.56452, available through 'eup4light.net'.

[29] For definitions, see Annex B; for abbreviations see the list of acronyms at the end of the main text.

- nominal luminous flux / rated luminous flux
- maximum rated power (Pmax) for a given rated luminous flux (Φ)
- rated luminous efficacy (lm/W), initial 100h value, at 25˚C (or 35˚C), in function of wattage
- Energy Efficiency Index = Pcor / Pref (1194/2012, annex III) (874/2012, annex VII)
- weighted energy consumption (E_C) in kWh per 1 000 hours, calculated in accordance with Annex VII of 874/2012.
- equivalent incandescent lamp power
- nominal life time / rated life time of the lamp in hours
- lamp survival factor (at 2 000 h, 4 000 h, 6 000 h, 8 000 h, 12 000 h, 16 000 h and 20 000h)
- lumen maintenance factor at the end of the nominal life (or at 2 000 h, 4 000 h, 6 000 h, 8 000 h, 12 000 h, 16 000 h and 20 000h)
- number of switching cycles before failure
- premature failure rate
- starting time
- lamp warm-up time to 60 % Φ or 80 % Φ or 95 % Φ
- percentage of UVA + UVB radiation
- percentage of UVC radiation
- colour rendering index (Ra)
- (correlated) colour temperature
- chromaticity coordinates
- lamp dimensions
- lamp mercury content
- lamp dimmability
- ambient temperature at which the lamp was designed to maximise its luminous flux
- burning hours per year

Parameters mentioned for ballasts:

- lamp power factor/displacement factor [30] (for lamps with integrated control gear)
- ballast efficiency / lamp control gear efficiency, in function of wattage
- Energy Efficiency Index (for ballasts)
- dimmability / minimum level of dimming
- no-load power consumption of lamp control gear
- standby power consumption of lamp control gear

Parameters or other aspects mentioned for luminaires:

- power consumption when the lamps do not emit any light
- Upward Light Output Ratio (ULOR) values per road class for street lighting luminaires
- Utilisation Factor (UF) values for standard road conditions
- CEN flux code of the luminaire or the complete photometric file
- luminaire maintenance factor LMF
- compatibility with ballasts complying with certain requirements
- compatibility with lighting control systems
- types of lamps and/or ballast compatible with a certain luminaire
- maintenance / cleaning instructions
- disassembly instructions

[30] According to a comment of LightingEurope: "Displacement factor" instead of "power factor" is the correct terminology to be used. "Power factor" in this context is a confusing and meaningless term. There are initiatives within international standardization bodies to adapt terminology accordingly. The timeframe of this adaptation of terminology is expected to be concluded in due course. Consequently all new EU lighting regulation from its first draft document need to take into account the new terminology in order to avoid any confusion. However, see also this report in par. 3.1.

- installation instructions

From this list of parameters, it is clear that lighting is a very complex function, with many aspects, that is difficult to capture using a single main characterising parameter.

1.3.2. Functional units used in previous studies

This paragraph examines which 'functional units' have been used in previous lighting studies.

In the Lot 8 preparatory study on 'office lighting' [31] the functional unit is defined as:

> *"The maximum maintained useful luminous flux (lumen) from the luminaire according to the performance requirements for the office lighting task as set out in EN12464-1.*
>
> *'Maintained' means that performance depreciation parameters are taken into account (e.g. the luminaire maintenance factor LMF, lamp lumen maintenance factor LLMF, ballast maintenance factor BMF, ...) and 'useful' means that only the luminous flux received by the office task area and immediate surrounding area is taken into account. 'Maximum' means that it is the luminous flux in non-dimming conditions.'*

As also remarked in the reference, this is closely related to the concept of 'illuminance' [32]. For office lighting, this is a logical choice because lighting requirements are expressed as minimum illuminance values in lux (lumen per m^2 work area).

In the Lot 9 preparatory study on 'public street lighting' [33] the functional unit (FU) is defined in a similar way as:

> *"The maintained useful luminous flux (lumen) from the luminaire according to the performance requirements as set out in EN13201-2 for these respective classes.*
>
> *'Maintained' means that performance depreciation parameters are taken into account (e.g. the luminaire maintenance factor LMF and the lamp lumen maintenance factor LLMF, ...) and 'useful' means that only the useful flux received by the road surface is taken into account.*
>
> *FU [lumen] = UF x LMF x LLMF x Lamp Lumen Output"*

The requirements for street lighting are expressed, depending on the type of road, either in terms of 'illuminance' (lux=lm/m^2) or in terms of 'luminance' (cd/m^2), which can be directly related to the chosen functional unit.

In the Lot 19 preparatory study part 1 on 'non-directional domestic lighting' [34] the functional unit is defined as:

> *"1 lumen provided by a light source during 1 hour of operation"* or

[31] See note 28.

[32] Illuminance (lux) = luminous flux (lm) / surface (m^2)

[33] Preparatory Studies for Eco-design requirements of EuPs, Final Report, Lot 9: Public Street lighting, Study for the European Commission DGTREN unit D3, contact Andras Toth, by VITO in cooperation with Laborelec and Kreios, January 2007, Contract TREN/D1/40-2005/LOT9/S07.56457, available through 'eup4light.net'

[34] Preparatory Studies for Eco-design requirements of EuPs, Final Report, Lot 19: Domestic lighting, Study for the European Commission DGTREN unit D3, contact Andras Toth, by VITO in cooperation with Bio Intelligence Service, Energy Piano and Kreios, October 2009, Contract TREN/07/D3/390-2006/S07.72702, available through 'eup4light.net'.

"1 lumen provided by a light source during 1 hour of operation in any direction"

As explained in the reference, lumen*hour is used as the functional unit instead of the luminous flux in lumen, so that differences in burning hours between different lamp types will have a low impact on the calculations.

Different from 'office lighting' or 'street lighting' in the case of 'domestic lighting', there are no clearly defined lighting requirements, there is no clearly defined task area to be lit, and the lighting is generic 'ambient lighting' or 'decorative lighting', so there is no need/possibility to use illuminance. In addition the reflective properties of the variety of objects and walls found in a domestic environment are difficult to establish, so 'luminance' is not a suitable parameter.

In the Lot 19 preparatory study part 2 on 'directional lamps and household luminaires' [35] there are two definitions for the functional unit:

- For directional lamps (GLS-R, HL-MV-R, HL-LV-R, MHi-R, CFLi-R, halogen reflector retrofit LED lamps):

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

- For luminaires with integrated lamps e.g. LED downlighters, LED modules, CFLi-R not sold for retrofitting reflector lamps:

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

Summarizing (see Figure 1) [36]:

- for non-directional lamps the useful luminous flux is measured over all directions (360˚)
- for down-lighting luminaires the useful luminous flux is measured over 180˚
- for accent lighting reflector lamps the useful luminous flux is measured over 90˚

[35] See note 34.

[36] In the final Regulation (EU) No 1194/2012 on DLS-lamps, the useful luminous flux is defined slightly different:
- directional lamps with a beam angle ≥ 90° other than filament lamps and carrying a warning on their packaging that they are not suitable for 'accent lighting': rated luminous flux in a 120° cone;
- other directional lamps: rated luminous flux in a 90° cone.

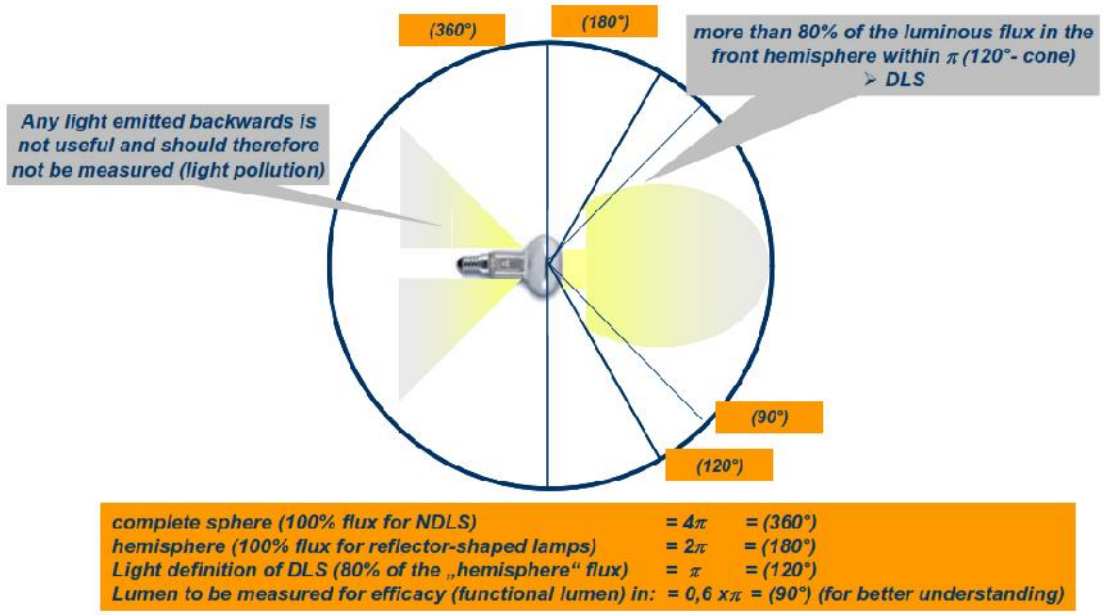

Figure 1 Definition of the functional lumen for DLS reflector lamps (source: Lot 19 preparatory study)

In the exploratory study for Lot 37 (lighting systems) [37] VITO identifies as relevant primary parameter (functional unit):

"Functional luminous flux (Φ [lm]) equal to the illumination (E [lx]) per square meter as calculated with secondary performance parameters as defined in standards".

The same reference further observes that:

"This functional unit is equivalent to the so-called 'Lighting Power Density' (LPD) [W/(m².lx)] (Pr EN 13201-5) or 'Lighting Energy Numerical Indicator' (LENI) (kWh/m² per year) (EN 15193).

For an area where luminance is used instead of illuminance, the following conversion formula is used: ***E = L/Q0*** *where,*

E is the average illuminance
L is the average luminance specified in cd/m²
Q0 is the average luminance coefficient (e.g. 0.07 for asphalt)

The formula to calculate the functional unit from the secondary lighting system performance parameters (see also Figure 2*) is:*

$$\textbf{Functional unit} = 1/(U * LOR * LMF * \eta_{lamp} * LLMF * \eta_{gear} * BGF)$$ [38] [39]."

[37] "Exploratory study on lighting systems, including lighting schemes, luminaires and lighting controls for intelligent systems, for Ecodesign, Energy Labelling, and/or Energy Performance of Building requirements ('Lot 37') Final Report", VITO reference 2014/ETE/R/036, march 2014, prepared for the European Commission DG-ENER-C3, SPECIFIC CONTRACT No ENER/C3/2012-418 LOT1/05/SI2.660099 Implementing Framework Contract No ENER/C3/2012-418-Lot 1. Restricted Distribution.

[38] The lamp efficacy η_{lamp} is in [lm/W] so the functional unit according to this formula is in [W/lm] which corresponds to the units for the Lighting Power Density ([W/(m².lx)]=[W/lm]), but not to the units for the 'functional luminous flux' [lm]. So in reality there are two different functional units defined, even if closely related to each other.

[39] In the ongoing Lot 37 study (follow-up to the exploratory study) the intention is to replace the Ballast Gain Factor (BGF) by the terminology used in EN 15193, e.g. daylight factor, occupancy factor and continuous lumen control factor. In

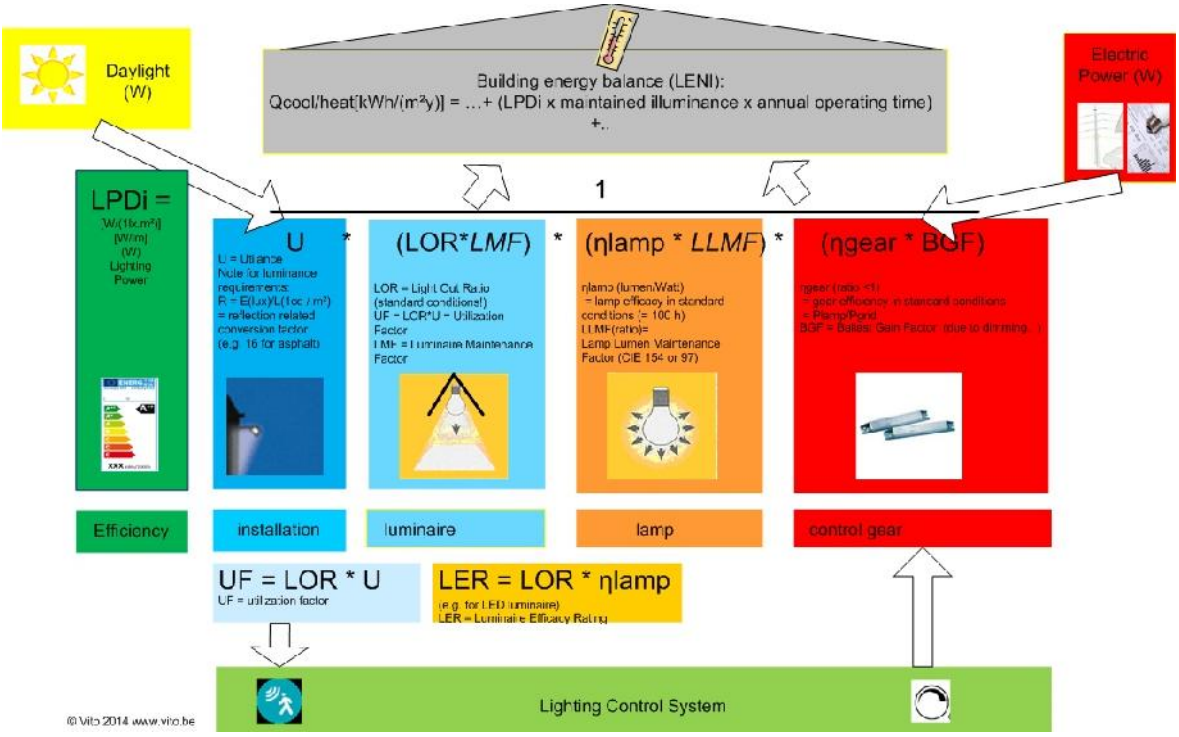

Figure 2 Components of a lighting system and the most relevant performance parameters related to energy efficiency (source: VITO 2014, Lot 37 exploratory study)

1.3.3. Discussion and conclusion regarding functional units

Discussion [40]:

The Lot 19 study also summarizes the functional units used in other studies, and states that Lot 8 and Lot 9 used 'illuminance in one hour' (lumen/(hour*m^2)) as the functional unit [41]. This is different from the definitions in the Lot 8 and Lot 9 studies themselves, as reported above, but the final intention is the same and logical, i.e. to compare lamps and luminaires for office lighting and street lighting in function of the useful light that actually arrives in the area to be lit (per m^2 of target area). The functional unit based on illuminance as used in Lot 8 and Lot 9 and proposed for Lot 37 allows addressing system level improvement options that are not directly related to the lumen output of the luminaire, e.g. light recovered from reflection on the ceiling in a particular room geometry. Such an approach based on illuminance is not required in this study, because these improvement options are often related to the installation and they will be addressed in the lighting system study (Lot 37).

The use of '*1 lumen during 1 hour of operation*' [lm/h] instead of just '*lumen*' [lm] was selected after various discussions with stakeholders who stressed that the product lifetime is an important parameter too. In this approach for example, a replacement of a 1000 lumen lamp with 1000 hours lifetime can be done with two lamps of 1000 lumen and 500 hours lifetime for the same total amount of functional units. However, this could still lead to confusion: a lamp of 1000 lumen with 1000 hours

addition the Luminaire Maintenance Factor (LMF) and Lamp Lumen Maintenance Factor (LLMF) may be integrated in the general Maintenance Factor (MF) as used in EN 15193.

[40] For additional information, see also paragraph 1.1.5 in part 2 of the Lot 19 study.

[41] See table 1-5 in part 2 of the Lot 19 study.

of lifetime cannot be replaced by a 2000 lumen lamp with a lifetime of 2000 hours despite the same functional unit.

In Regulations 244/2009, 874/2012 and 1194/2012 the requirements regarding lamp efficacy and the definition of energy efficiency classes are expressed by comparing the actual (corrected) lamp power to a reference lamp power. The latter is computed using the useful luminous flux of the lamp, which is thus confirmed as a primary performance parameter.

In Regulation 245/2009 on tertiary lighting (office, streets) the efficacy requirements are formulated in a different way by specifying directly a minimum efficacy in terms of lm/W in function of the lamp wattage. This regulation distinguishes a large number of very specific lamp types. The luminous flux used to determine the efficacy is the entire emitted flux in all directions. The concepts 'useful luminous flux', 'illuminance' (lm/m^2) and 'luminance' (cd/ m^2) are not used in this regulation.

Conclusion:

Considering that the current preparatory study will focus on light sources and less on luminaires and lighting systems, the '***useful luminous flux in lumen***' is chosen as the main functional unit.

The addition of '***useful***' primarily refers to the light emission in certain directions, i.e. inside a 90˚ or 120˚ cone for directional lamps or in all directions for non-directional lamps. This is in line with the existing regulations. Secondarily, if this turns out to be necessary, it might also refer to the light that is actually arriving in a specified task area, i.e. to 'illuminance' in lm/m^2 or to 'luminance' in cd/m^2.

This preliminary choice for the functional unit may be changed or refined as the study proceeds.

The 'useful luminous flux' cannot be the only performance parameter to distinguish between lamp types. Considering the parameters listed in the previous paragraph there will be many secondary performance parameters to be taken into account.

1.4. Lamp types distinguished in previous studies and regulations

The current preparatory study does NOT regard a new product group for ecodesign: previous studies and regulations exist for lighting products. Consequently, this paragraph examines how lamps have been classified in the past.

In the existing regulations regarding lighting [42], a large variety of characteristics has been used to distinguish between different lamp types, to define the lamps to which certain requirements apply, and to determine the lamps that are outside of the scope of the regulation.

First of all, lamps have been distinguished by their function, i.e. by 'what' they have to illuminate:

- Household Lighting (Regulation 244/2009)
- Office Lighting (Regulation 245/2009)
- Public Street Lighting (Regulation 245/2009)
- Accent Lighting (Regulation 1194/2012, directional lamps)
- Special Purpose Lighting (see par. 1.4.1.6, 1.4.2)
- Lamps intended for outdoor or industrial applications

The next most important characteristic is the technology used for the generation of light. The following technologies have been distinguished [43]:

[42] Regulations: 244/2009 (non-directional household lighting), 245/900 (tertiary lighting), 874/2012 (energy labelling) and 1194/2012 (directional lamps), see Task 0 report.

[43] For definitions, see Annex B; for abbreviations see the list of acronyms at the end of the main text.

- Incandescent (filament) lamps, (GLS) [44]
- (Tungsten-filament) Halogen Lamps (HL)
- Fluorescent Lamps (FL)
- High-Intensity Discharge Lamps (HID)
  - High-Pressure Mercury lamps (HPM)
  - High-Pressure Sodium Lamps (HPS)
  - Metal Halide Lamps (MH)
- Light-Emitting Diode Lamps (LED)

Lamps have often been distinguished by their shape:

- Linear Fluorescent Lamps (LFL):
  - tubes of diameter 7 mm (T2) or less
  - tubes of diameter 16 mm (T5)
  - tubes of diameter 26 mm (T8)
  - tubes of diameter 38 mm (T12)
- Compact Fluorescent Lamps (CFL):
  - Small single parallel tube
  - Double parallel tubes
  - Triple parallel tubes
  - Four parallel tubes
  - Long single parallel tube
  - Four legs in one plane
  - Single flat plane tube
  - T9 (tube 29 mm) circular
  - T5 (tube 16 mm) circular
- ELV lamps with reflector type: MR11 GU4, MR16 GU 5.3, AR111
- Blown glass reflector type: R50/NR50, R63/NR63, R80/NR80, R95/NR95, R125
- Pressed glass reflector type: PAR16, PAR20, PAR25, PAR30S, PAR36, PAR38

In addition lamps have often been distinguished by their cap- or socket-type [45]:

- double capped fluorescent lamps
- single capped fluorescent lamps
- incandescent lamps with E14/E27/B22/B15 caps
- incandescent lamps with S14, S15 or S19 caps
- T12 fluorescent lamps with cap G-13 Medium BiPin base
- T5 fluorescent lamps with cap 2G11 4 pin base
- high intensity discharge lamps not having lamp cap E27, E40, PGZ12
- clear lamps with G9 or R7s cap
- discharge lamp with cap GX53
- fluorescent lamps with caps G23 (2 pin) or 2G7 (4 pin), G24d (2 pin) or G24q (4 pin), GX24d (2 pin) or GX24q (4 pin), 2G11 (4 pin), 2G10 (4 pin), GR8 (2 pin), GR10q (4 pin) or GRY10q3 (4 pin), 2G8, G10q, 2GX13

Lamps have also been distinguished by the nature of the light that they emit:

- directional (DLS) or non-directional (NDLS) Lamps [46]

[44] Intended as the classical light bulbs, non-halogen, often indicated as GLS = General Lighting Service.

[45] For a description of the caps/sockets referred to in this section, see Annex C.

[46] 'Directional lamp' means a lamp having at least 80 % light output within a solid angle of π sr (corresponding to a cone with angle of 120°).

- directional lamps with a beam angle ≥ 90°
- clear (C) or non-clear (F-frosted) Lamps
- colour of the emitted light in terms of chromaticity coordinates [47]
- colour of the emitted light in terms of colour temperature [48]
- lamps with a specified colour rendering index (Ra)
- lamps that are not white light sources as defined in Annex II of 245/2009
- fluorescent lamps having a +/– 5 m (+magenta, –green) colour compensating filter value limit (cc)
- UV-content of the emitted light spectrum [49]
- high intensity discharge lamps having a specific effective UV output > 2 mW/klm
- infra-red lamps or lamps used for heating

Distinctions based on main functional parameters [50]:

- lamps having a luminous flux below 60 lumens or above 12 000 lumens
- clear lamps in lumen-ranges 60 – 950, 60-725, 60-450 lm
- lamps and LED modules with a luminous flux of less than 30 lumens
- directional lamps with useful luminous flux over or under 1300 lumens
- mains voltage (MV) filament lamps / other filament lamps
- extra low voltage (ELV) lamps
- incandescent lamps with a voltage equal to or below 60 volts
- fluorescent lamps having power P ≤ 13 W or P > 80 W
- non-clear lamps with power $P \leq 0{,}5 * (0{,}88\sqrt{\Phi}+0{,}049\Phi)$
- lamps with rated lamp lifetime higher than 2 000 h

Distinctions made regarding ballasts or control gears or similar:

- fluorescent lamps without integrated ballast
- incandescent lamps without integrated transformer
- T12 lamps equipped with an external ignition strip
- lamps requiring external power supply
- lamps (of different technologies) operating on external control gear
- fluorescent lamps operating on non-HF ballasts / on HF ballasts with warm-start
- fluorescent lamps working on electromagnetic ballast / on electronic ballast
- retrofit lamps designed to operate on high pressure mercury vapour lamp control gear

Miscellaneous characteristics used for distinction of lamps in the regulations:

- lamps with a second envelope
- lamps with anti-glare shield
- lamps containing mercury in amalgam form
- LED modules marketed as part of luminaires that are placed on the market in less than 200 units per year.

[47] For example Regulation 244/2009 does not apply to lamps having the chromaticity coordinates: [$x < 0.200$ or $x > 0.600$] and [$y < -2.3172 x^2 + 2.3653 x - 0.2800$ or $y > -2.3172 x^2 + 2.3653 x - 0.1000$].

[48] For example, Regulation 245/2009 excludes "*high intensity discharge lamps with Tc > 7 000 K*".

[49] For example, Regulation 244/2009 does not apply to lamps having:
- 6 % or more of total radiation of the range 250-780 nm in the range of 250-400 nm,
- the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB).

[50] In addition, many of the requirements in the regulations are defined in function of the power of the lamp or in function of its luminous flux.

- lamps and LED modules marketed as part of a luminaire and not intended to be removed by the end-user, except when they are offered for sale, hire or hire purchase or displayed separately to the end user, for example as spare parts.
- lamps and LED modules marketed as part of a product whose primary purpose is not lighting, except if they are offered for sale, hire or hire purchase or displayed separately, for example as spare parts.
- lamps and LED modules that do not comply with requirements becoming applicable in 2013 and 2014 according to regulations implementing Directive 2009/125/EC.

In many occasions, two or more of the above distinctive characteristics have been combined to indicate a very specific lamp-type for regulation purposes, e.g.:

- incandescent lamps with E14/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer.
- single capped fluorescent lamps having a diameter of 16 mm (T5) 2G11 4 pin base, Tc = 3200 K with chromaticity coordinates x=0,415 y=0,377 and Tc = 5500 K with chromaticity coordinates x=0,330 y=0,335.

Considering the above, the existing 'classification' is rather complex and sometimes very detailed. Even if this reflects the real world, which actually shows a large variety of lighting products for a large variety of applications, it would be preferable to simplify the subdivision in lamp types, in particular when all existing regulations have to be integrated into one.

1.4.1. Lamp types not yet regulated (identification)

The current study shall also analyse lighting products that are not covered yet by the existing regulations and identify those to be included in the current study (see Assignment in Task 0 report). As an example, the assignment mentions lamps having a luminous flux above 12,000 lm.

This paragraph aims at identifying the lamp types not covered by the existing regulations. Subparagraphs 1.4.1.1 through 1.4.1.4 take a look at the scope of each of the four existing regulations, while 1.4.1.6 is dedicated to 'special purpose lamps'. Subparagraph 1.4.1.7 provides information from the draft Ecodesign Working Plan 2015-2017. The non-regulated lamp-types identified in this paragraph are briefly discussed in paragraph 1.4.2.

1.4.1.1. Lamps to which Regulation 244/2009 is (NOT) applicable

Commission Regulation (EC) No 244/2009 applies to (article 1):

> *"non-directional household lamps [51], including when they are marketed for non-household use or when they are integrated into other products."*

The same article 1 also specifies the household and special purpose lamps to which the regulation does NOT apply. Among these are:

[51] According to 244/2009 article 2:
'non-directional lamp' means a lamp that is not a directional lamp;
'directional lamp' means a lamp having at least 80 % light output within a solid angle of π sr (corresponding to a cone with angle of 120°);
'household lamp' means a lamp intended for household room illumination; it does not include special purpose lamps;
'household room illumination' means the full or partial illumination of a household room, by replacing or complementing natural light with artificial light, in order to enhance visibility within that space.

- "*directional lamps*" (covered by 1194/2012)
- "*fluorescent lamps without integrated ballast*" (covered by 245/2009)
- "*high-intensity discharge lamps*" (covered by 245/2009)
- "*incandescent lamps with E14/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer (…)* " (these lamps are exempted in stages 1-5 but NOT from stage 6 so they can be considered as covered by 244/2009)[52]
- "*incandescent lamps with S14, S15 or S19 caps (…)*" (these lamps are exempted in stages 1-4 but NOT from stages 5 and 6 so they can be considered as covered by 244/2009)[53]

This leaves the following lamps that are <u>not covered by any regulation</u>:

(a) (non-directional household) lamps having the following chromaticity coordinates x and y:
- $x < 0.200$ or $x > 0.600$
- $y < -2.3172\ x^2 + 2.3653\ x - 0.2800$ or $y > -2.3172\ x^2 + 2.3653\ x - 0.1000$; [54]

(b) (non-directional household) lamps having a luminous flux below 60 lumens or above 12 000 lumens [55];

(c) (non-directional household) lamps having:
- 6 % or more of total radiation of the range 250-780 nm in the range of 250-400 nm [56],
- the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB) [57].

In Annex II table 2 of 244/2009 other exceptions from the main efficacy requirements are mentioned, but these exceptions anyway have their own specific requirements, so they are effectively covered by 244/2009.

What is a 'household lamp'?

For many lamp types, the exemption from Regulation 244/2009 depends on whether or not they can be considered to be 'non-directional household lamps'. The distinction between directional and non-directional is clearly defined [58]. The definition of '**household lamp**' leaves room for interpretation:

> " *'household room illumination' means the full or partial illumination of a household room, by replacing or complementing natural light with artificial light, in order to enhance visibility within that space*;
>
> *'lamp' means a source made in order to produce an optical radiation, usually visible (…);*
>
> *'household lamp' means a lamp intended for household room illumination; it does not include special purpose lamps;*
>
> *'special purpose lamp' means a lamp not intended for household room illumination because of its technical parameters or because the related product information indicates that it is unsuitable for household room illumination.*"

[52] Background unclear: The typical lamps with these characteristics are (traffic) signalling lamps, but on the other hand, there are also signalling lamps that operate at mains voltage (230 V) and they would then not be addressed.

[53] See annex D.4 for an example.

[54] Coloured lamps, i.e. non-white lamps, see also remarks in Annex D.1.1.

[55] Lamps with a light output less than 60 lumen are mainly decorative lamps (low-wattage incandescent, e.g. 11 W). Lamps with a light output over 12,000 lumen are mainly professional projection or spot (arc-) lamps.

[56] Ultra-Violet lamps, see also par. 1.4.2.3

[57] LightingEurope comments that some FL and HID lamps can be within this definition.

[58] According to 244/2009 article 2: 'non-directional lamp' means a lamp that is not a directional lamp; 'directional lamp' means a lamp having at least 80 % light output within a solid angle of π sr (corresponding to a cone with angle of 120°).

In addition Recital (5) of the regulation states:

> "*Products subject to this Regulation are designed essentially for the full or partial illumination of a household room, by replacing or complementing natural light with artificial light, in order to enhance visibility within that space. Special purpose lamps designed essentially for other types of applications (such as traffic signals, terrarium lighting, or household appliances) and clearly indicated as such on accompanying product information should not be subject to the ecodesign requirements set out in this Regulation*."

A LightingEurope interpretation of this Recital (5) [59] includes most of the lamp types that are considered as special purpose lamps in par. 1.4.1 and 1.4.2 of the current document.

1.4.1.2. Lamps to which Regulation 245/2009 is (NOT) applicable

Commission Regulation (EC) No 245/2009 applies to (article 1):

> *"fluorescent lamps without integrated ballast, high intensity discharge lamps, and ballasts and luminaires able to operate such lamps (…) , even when they are integrated into other energy-using products."*

Annex I of Regulation 245/2009, as amended by Regulation 347/2010, specifies the lighting products to which the regulation does NOT apply [60]. Considering that '*directional lamps*' are covered by Regulation 1194/2012, this leaves the following lamps that are <u>not covered by any regulation</u>:

(a) (non-directional)(FLni and HID) lamps having the following chromaticity coordinates x and y:
- $x < 0.270$ or $x > 0.530$
- $y < -2.3172\,x^2 + 2.3653\,x - 0.2199$ or $y > -2.3172\,x^2 + 2.3653\,x - 0.1595$;

This exemption does NOT apply to high pressure sodium lamps [61] [62].

(b) (non-directional) blended high intensity discharge lamps having [63]:
- 6 % or more of total radiation of the range 250-780 nm in the range of 250-400 nm, and
- 11 % or more of total radiation of the range 250-780 nm in the range of 630-780 nm, and
- 5 % or more of total radiation of the range 250-780 nm in the range of 640-700 nm.

(c) (non-directional) blended high intensity discharge lamps having [64]:
- the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB).

(d) (non-directional) double capped fluorescent lamps (without integrated ballast) having:
- a diameter of 7 mm (T2) and less,
- a diameter of 16 mm (T5) and lamp power $P \leq 13$ W or $P > 80$ W,

[59] As reported in the Omnibus study, see details there.

[60] According to the amendments of Regulation 347/2010 "(…) the technical documentation file drawn up for the purposes of conformity assessment pursuant to Article 8 of Directive 2009/125/EC *shall state* which of the technical parameters *is the basis* for their exemption (…)"

[61] The original formulation excludes "*lamps that are not white light sources as defined in Annex II*". In that Annex '*white light sources*' are defined as those with chromaticity coordinates that satisfy the following requirements:
- $0.270 < x < 0.530$
- $2.3172\,x^2 + 2.3653\,x - 0.2199 < y < -2.3172\,x^2 + 2.3653\,x - 0.1595$.

[62] Coloured lamps, i.e. non-white lamps, see also remarks in Annex D.1.1.

[63] This formulation is from amendment 347/2010. A '*blended lamp*' is defined as "*a lamp containing a mercury vapour lamp and an incandescent lamp filament connected in series in the same bulb*".

[64] As note 63.

- a diameter of 38 mm (T12), lamp cap G-13 Medium BiPin base, +/– 5 m (+magenta, –green) colour compensating filter value limit (cc). CIE coordinates x=0.330 y=0.335 and x=0.415 y=0.377,
- a diameter of 38 mm (T12) and equipped with an external ignition strip.

(e) (non-directional) single capped fluorescent lamps (without integrated ballast) having a diameter of 16 mm (T5) 2G11 4 pin base, Tc = 3 200 K with chromaticity coordinates x=0.415 y=0.377 and Tc = 5 500 K with chromaticity coordinates x=0.330 y=0.335.

(f) (non-directional) high intensity discharge lamps with Tc > 7 000 K.

(g) (non-directional) high intensity discharge lamps having a specific effective UV output > 2 mW/klm.

(h) (non-directional) high intensity discharge lamps not having lamp cap E27, E40, PGZ12.

Question:
Exactly what types of lamps are intended in points (b) (630-780 nm, 640-700 nm), (d), (e), (f), (g), (h)? What was the reason for their exemption and is that reason still valid?

In addition, Annex I of Regulation 245/2009, as amended by Regulation 347/2010, excludes:

(i) (non-directional)(FLni and HID) products intended for use in applications other than general lighting and products which do not provide a general lighting function [65];

(j) (non-directional)(FLni and HID) lamps covered by the requirements of Directive 94/9/EC or Directive 1999/92/EC [66];

(k) (non-directional)(FLni and HID) emergency lighting **luminaires** and emergency sign luminaires within the meaning of Directive 2006/95/EC (Low Voltage Directive) [67];

(l) **ballasts** intended for use in luminaires defined in the previous point and designed to operate lamps in emergency conditions [68];

(m) **luminaires** covered by the requirements of Directives 94/9/EC (use in explosive atmospheres), Directive 1999/92/EC (use in explosive atmospheres), Directive 2006/42/EC (machinery), Council Directive 93/42/EEC (medical devices), Council Directive 88/378/EEC (safety of toys) and luminaires integrated into equipment covered by these requirements.

For many lamp types, the exemption from Regulation 245/2009 depends on whether or not they can be considered to be "*products intended for use in **applications other than general lighting** and products which do not provide a general lighting function*". A problem here is that the definition for 'general lighting' is rather vague:

[65] '*General lighting*' means substantially uniform lighting of an area without provision for special local requirements.
[66] Application of lamps in potentially explosive atmospheres. This formulation is from amendment 347/2010/EC.
[67] This directive does not seem to mention emergency lighting, so the reference is a bit confusing.
[68] This has been added in amendment 347/2010.

" 'General lighting' means substantially uniform lighting of an area without provision for special local requirements."

1.4.1.3. Lamps to which Regulation 1194/2012 is (NOT) applicable

Commission Regulation (EU) No 1194/2012 applies to (article 1):

- *directional lamps* [69]
- *light-emitting diode (LED) lamps* [70]
- *equipment designed for installation between the mains and the lamps, including lamp control gear, control devices and luminaires (other than ballasts and luminaires for fluorescent and high-intensity discharge lamps).*

Article 1 of the Regulation specifies as an exemption not covered by any regulation:

(a) LED modules if they are marketed as part of luminaires that are placed on the market in less than 200 units per year [71].

In addition article 3 clarifies that ecodesign requirements are NOT applicable to ***'Special purpose products'***, which article 2.4 of Regulation 1194/2012 defines as:

> *"a product that uses the technologies covered by this Regulation [72] but is intended for use in special applications because of its technical parameters as described in the technical documentation. Special applications are those that require technical parameters not necessary for the purposes of lighting average scenes or objects in average circumstances."*

From the list of '**Special applications**' that follows this definition, lamp types can be identified that are not covered by any regulation:

(b) (directional or LED) lamps for applications where the primary purpose of the light is not lighting, such as:
  (i) emission of light as an agent in chemical or biological processes (such as polymerization, ultra-violet light used for curing/drying/hardening, photodynamic therapy, horticulture, pet-care, anti-insect products);
  (ii) image capture and image projection (such as camera flashlights, photocopiers, video projectors);
  (iii) heating (such as infrared lamps);
  (iv) signalling (such as traffic control or airfield lamps);

(c) (directional or LED) lamps for applications where:
  (i) the spectral distribution of the light is intended to change the appearance of the scene or object lit, in addition to making it visible (such as food display lighting or coloured

[69] Including directional LED lamps.

[70] Both directional and non-directional.

[71] Explanation from LightingEurope: "Industry should have the freedom for small special application/expensive luminaire-series making LED-modules which might be not conform to the given parameters, thus the limitation on 200 luminaires per year, which was seen as a reasonable quantity during the preparation of the Regulation. It was to prevent the situation where a short run product or custom product required a full test regime that could in principle require the production of more test samples than products actually sold to customers."

[72] This reference to 'technology' seems superfluous because the Regulation applies to all directional lamps, independent from the technology that they use.

lamps as defined in point 1 of Annex I [73]), with the exception of variations in correlated colour temperature;

(ii) the spectral distribution of the light is adjusted to the specific needs of particular technical equipment, in addition to making the scene or object visible for humans (such as studio lighting, show effect lighting, theatre lighting);

(iii) the scene or object lit requires special protection from the negative effects of the light source (such as lighting with dedicated filtering for photosensitive patients or photosensitive museum exhibits);

(iv) lighting is required only for emergency situations (such as emergency lighting luminaires or control gears for emergency lighting);

(v) the lighting products have to withstand extreme physical conditions (such as vibrations or temperatures below – 20 °C or above 50 °C);

(d) (directional or LED) products incorporating lighting products, where the primary purpose is not lighting and the product is dependent on energy input in fulfilling its primary purpose during use (such as refrigerators, sewing machines, endoscopes, blood analysers).

For many lamp types, the exemption from Regulation 1194/2012 depends on whether or not they can be considered to be "*lamps for applications where the **primary purpose of the light is not lighting***". The following definitions are relevant in this context:

> " *'lighting' means the application of light to a scene, objects or their surroundings so that they may be seen by humans;*
>
> *'light source' means a surface or object designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wavelength of 380-780 nm;*
>
> *'lamp' means a unit whose performance can be assessed independently and which consists of one or more light sources (…)*
>
> *(…) Special applications are those that require technical parameters not necessary for the purposes of lighting average scenes or objects in average circumstances."*

1.4.1.4. Lamps to which Delegated Regulation 874/2012 is (NOT) applicable

Commission Delegated Regulation (EU) No 874/2012 applies to (article 1):

> *"(…) electrical lamps such as filament lamps, fluorescent lamps, high-intensity discharge lamps, LED lamps and LED modules."*

Point 2 of the same article specifies the lighting products to which the regulation does NOT apply:

- *lamps and LED modules with a luminous flux of less than 30 lumens* (but these lamps are not exempted as such in Regulation 1194/2012)
- *lamps and LED modules marketed for operation with batteries* (but these lamps are not exempted as such in Regulation 1194/2012)
- *lamps and LED modules marketed for applications where their primary purpose is not lighting* [74] (this is the same exception as in Regulation 1194/2012)
- *lamps and LED modules marketed as part of a luminaire and not intended to be removed by the end-user, except when they are offered for sale, hire or hire purchase or displayed*

[73] The same definition as in 245/2009 is used to distinguish between 'white' and 'coloured' light, see note 61.

[74] The same examples are listed here as in Regulation 1194/2012, see point 1.4.1.3(b).

separately to the end user, for example as spare parts (but these lamps are not exempted as such in Regulation 1194/2012)

- *lamps and LED modules marketed as part of a product whose primary purpose is not lighting. However, if they are offered for sale, hire or hire purchase or displayed separately, for example as spare parts, they shall be included within the scope of this Regulation* (this is more or less the same exception as in Regulation 1194/2012)
- *lamps and LED modules that do not comply with requirements becoming applicable in 2013 and 2014 according to regulations implementing Directive 2009/125/EC of the European Parliament and of the Council*

The exemptions "***where the primary purpose is not lighting***" are more or less the same as in Regulation 1194/2012 (see 1.4.1.3(b) and 1.4.1.3(d)), but surprisingly in 874/2012 the specific example of "*ultra-violet light used for curing/drying/hardening*" is missing.

It is also noteworthy that the explicit 1194/2012 exemptions listed in point 1.4.1.3(c) are not present in 874/2012.

For many lamp types, the exemption from Regulation 874/2012 depends on the **non-compliance *"with requirements becoming applicable in 2013 and 2014*** *according to Regulations implementing Directive 2009/125/EC".* For lamps that are covered by Regulations 244/2009, 245/2009 or 1194/2012 this is quite clear: if they do not fulfil the requirements from these regulations becoming applicable in 2013 or 2014 they are exempted from the labelling requirements. This makes sense because in practice these lamps would be phased out and consequently labelling would be useless.

A question that can be raised is what this means for lamp types that are exempted from Regulations 244/2009, 245/2009 or 1194/2012. For exempted lamps, the question if they comply or not is a bit confusing. The most logical interpretation would be that these exempted lamps do not comply with the regulations and consequently are also exempted from the labelling requirements.

1.4.1.5. Proposed amendments to Regulations 244/2009 and 1194/2012

As part of the review process for Regulation 244/2009, in April 2014 a draft regulation has been proposed [75], containing amendments on Regulations 244/2009 and 1194/2012.

As regards Regulation 1194/2012, the definition of special purpose products in article 2(4) remains essentially unchanged (see 1.4.1.3(b), 1.4.1.3(c), 1.4.1.3(d)) except that the contents of the last point (1.4.1.3(d), lighting products integrated in other products) is moved to the definition of luminaires in article 2(28).

There are some new requirements however:

Article 3(2) is replaced by the following:

> *"2.* ***Special purpose products shall always be of the highest energy efficiency class possible*** *according to Commission Delegated Regulation (EU) No 874/2012, for the intended special application, if they are within the scope of the aforementioned Regulation.*
>
> *Special purpose products shall comply with the information requirements set out in Annex I."*

[75] Working Document on amending Commission Regulation (EC) No 244/2009 with regard to ecodesign requirements for non-directional household lamps and Commission Regulation (EU) No 1194/2012 with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment http://www.eup-network.de/fileadmin/user_upload/Working_document_on_draftreegulation_amndt_244_2009_-_to_CF.pdf?PHPSESSID=a99e47f748aa05ed88829181fc43bfd0

and Annex I.2 is changed to include:

"The technical documentation file drawn up for the purposes of conformity assessment in accordance with Article 8 of Directive 2009/125/EC shall list the technical parameters that:

– make the product design specific for the stated intended purpose; and

*– **justify that no other product in a higher energy efficiency class according to Commission Delegated Regulation (EU) No 874/2012 could be used in this special application** if the product is within the scope of the aforementioned Regulation."*

As regards regulation 244/2009, the definition of the scope in article 1 remains unchanged (par. 1.4.1.1) but the definition of special purpose products of article 2(4) is replaced by the same (amended) text as in 1194/2012 (par. 1.4.1.3 and above). In addition the same texts presented above for 1194/2012 article 3(2) and Annex I.2 are also introduced in 244/2009.

Note that the special purpose lamps listed in 1.4.1.3(b) (UV, IR, imaging, signalling) and 1.4.1.3(d) (integrated in other products) are NOT in the scope of 874/2012 and consequently would NOT be subject to the requirements of article 3(2) and Annex I.2 as presented above.

The special purpose lamps listed in 1.4.1.3(c) (food display, coloured, theatre, dedicated filtering, emergency, extreme physical conditions) are not explicitly excluded from the scope of Regulation 874/2012. However, considering that they are (or with the foreseen amendments would be) excluded from 244/2009 and 1194/2012, they could be considered as being non-compliant with these latter regulations and in that case they would anyway be out of the scope of 874/2012. Consequently the applicability to these lamps of article 3(2) and Annex I.2 as presented above would be doubtful.

1.4.1.6. Special purpose lamps

The current study shall review the definitions of special purpose products and propose updates "*with a view to minimise the possible misuse while keeping otherwise regulated products for use in special applications exempt from ecodesign and/or labelling requirements*" (see Assignment in the Task 0 report).

In addition, as also recalled before, the current study shall "*analyse lighting products that are not covered yet by the existing regulations and identify those to be included in the current study*" (see Task 0 report). Special purpose lamps (SPLs) are among the lighting products not covered yet and consequently the assignment calls for an analysis to identify those that could be included in the present study, if any.

A comprehensive and detailed discussion of the definitions of 'special purpose products' used in the existing regulations can be found in the Omnibus study [76] (see also Task 0 report).

According to that study the definitions for SPLs are different for Regulations 244/2009, 245/2009 and 1194/2012, the most detailed and mature definition being given by Regulation 1194/2012 (see par. 1.4.1.3(b), 1.4.1.3(c), 1.4.1.3(d) in the current report) [77].

[76] "Omnibus Review Study on Cold Appliances, Washing Machines, Dishwashers, Washer-Driers, Lighting, Set-top Boxes and Pumps Final Report", VHK (NL) / VITO (B) / Viegand Maagøe A/S (DK) / Wuppertal Institut für Klima, Umwelt, Energie GmbH (D), Brussels/Delft 01.04.2014, Chapter 8 and Annex E on special purpose lamps.

[77] In their comments to the report, the Danish Energy Agency state their opinion that the definition of special purpose lamps from 1194/2012 should also apply to NDLS.

In many discussions SPLs are synonym for (incandescent) '*shockproof lamps*', '*shatter-resistant lamps*', '*vibration resistant lamps*', '*rough service lamps*' or similar [78].

Although 'lamps for use in extreme physical environments' are an important group (see par. 1.4.2.1), there are many other types of SPLs. Most of the non-regulated lamp types identified in the previous paragraphs can be considered as SPLs. The following main categories of SPLs have been identified so far:

- Signalling and signage lamps
- Appliance-integrated (non-primary lamps)
- Decorative and architectural lamps
- Rough service lamps and similar
- Projection, microscopy, light guide lamps
- Movie/TV or photo studio/theatre/event lamps
- Grow lights
- Food display lights
- Scientific lamps
- UV lamps
- IR and collagen lamps
- Backlighting for electronic displays
- Lights in vehicles, transport lights
- Other mobile lights
- Data communication and (other) laser applications
- Emergency lighting
- Battery-operated lighting

A more detailed description of these lamp types is provided in **Annex D**, which also clarifies the question why special purpose lamps are being distinguished and highlights the large variety of special lamp types that exists on the market.

The same annex also presents a preliminary rough estimate of the yearly energy consumption in the EU due to special purpose lamps. The total (electric) energy consumption for all listed lamp types is estimated around 138 TWh/year, but this also includes light sources integrated into other products that have already been considered in other ecodesign studies (e.g. backlighting for electronic displays). Excluding these light sources, the estimated energy consumption of special purpose lamps remains 70-80 TWh/year, which is a significant amount in the context of ecodesign. Note for example that the estimated (electric) energy consumption for the entire lighting sector in the EU is around 400 TWh/year, while all household cleaning appliances together (washing machines, dish washers, laundry driers, vacuum cleaners) are estimated to consume around 100 TWh/year [79] [80] [81].

Question:
Do Stakeholders agree with the energy estimate for SPL? Any additional information available?

[78] Also the Omnibus study is dedicated for a large part to '*shockproof*' lamps.

[79] Figures extracted from: Ecodesign Impacts 2010-2050, Annex A, draft June 2014, VHK for European Commission.

[80] LightingEurope answer to question: "This figure appears to be arbitrary and is by no means supported by empiric evidence. LightingEurope does not agree and does not recognize the figures in this chapter."

[81] IALD comment: "The shown energy estimates for special purpose lamps are not entirely based on demonstrable calculations, and therefore we would advise not to take them into account."

1.4.1.7. Ecodesign Working Plan 2015-2017 (draft)

In June 2014 a preparatory study for the Ecodesign Working Plan 2015-2017 was published [82]. This report contains a list of product categories already covered by preparatory studies or regulations (annex I), a 'reminder' list (annex II) and a 'remaining products list' (annex III). From the latter two listings it can be derived that the following lighting products are NOT being considered covered by the existing regulations:

- Traffic lights
- Other safety and signalling lighting equipment (emergency/safety lighting, traffic signs and road signalisation products)
- Commercial lighting equipment (retail lighting, illuminated displays, illuminated advertising, signs, electronic labels, decorative/festivity lighting (city beautification, Christmas lighting etc.), non-task area lighting in office buildings (corridors, toilets, reception areas etc.) [83]
- Other Lighting Applications not covered by existing lots (industrial lighting, tunnel lighting, private outdoor lighting, other colour lamps, daylight systems) [84]

In addition the report signals that 'very small HID lamps' are not yet covered by Regulation 245/2009 [85].

1.4.2. Lamp types not yet regulated (first analysis)

This paragraph provides a first, preliminary, analysis of the lamp types that have been identified in the preceding paragraph as not being covered by the existing regulations. The aim of this analysis is to present the available information, to identify missing information, to identify potential problems with the current definitions, and to further restrict the initial scope of the study (par.1.1), if possible considering the available information.

1.4.2.1. Lamps for use in extreme physical environments [86]

In many discussions, '*special purpose lamps*' are synonym for (incandescent) '*shockproof lamps*', '*shatter resistant lamps*', '*vibration resistant lamps*', '*rough service lamps*' or similar [87].

The reason for this is that around 16 million units/year [88] of these lamps are abusively sold in the EU for general lighting services, thus undermining Regulation 244/2009 [89]. According to industry association LightingEurope (LE) this costs the European lighting industry millions of Euro each year. In their opinion there are suitable alternatives for incandescent 'extreme physical environment' lamps

[82] Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC, Draft Task 2 Report, 6 June 2014, BIO by Deloitte (BIO), Oeko-Institut and ERA Technology for the European Commission – DG ENTR http://www.ecodesign-wp3.eu/sites/default/files/Ecodesign%20WP3_Task_2_06062014.pdf

[83] Comment from reference: "General retail lighting should be covered by 245/2009. Directional lighting is sometimes used in commercial applications which would be in scope of 1194/2012 (this includes LEDs and luminaires)."

[84] According to comments in the reference, some of these lighting applications might be covered by 245/2009.

[85] Par. 1.2 of the reference.

[86] For more detailed information see Omnibus study chapter 8; the Task 0 report and Annex D.5.

[87] Also the Omnibus study is dedicated for a large part to '*shockproof*' lamps.

[88] Figure estimated in the Omnibus study.

[89] As signalled by ANEC&BEUC in their comments, UK's National Measurement Office (NMO) investigated in December 2014 whether special purpose lamps comply with the legislation requirements. They found that this is generally the case and that sales of special purpose lamps seem to be decreasing in favour of LEDs. The press release does not enter in details however, see https://www.gov.uk/government/news/nmo-investigation-into-special-purpose-lamps

and consequently these should be explicitly banned as soon as possible [90] [91]. The existence of suitable replacements for incandescent shockproof lamps is also confirmed in the Omnibus study which proposes, as one of the possible legislative options, to explicitly lift the exemption for rough service lamps.

However, strictly speaking, only Regulation 1194/2012 point 2.4(b)(v) explicitly mentions "*lighting products that have to withstand extreme physical conditions (such as **vibrations** or temperatures below –20 °C or above 50 °C)*". A similar expression is not mentioned in Regulations 244/2009 or 245/2009.

As regards Regulation 244/2009, that is giving the major problems, the exemption of 'extreme physical environment' lamps is based on:

- Article 1, that applies the ecodesign requirements to '*household lamps*';
- Article 2.3, that defines a 'household lamp' as "*a lamp intended for household room illumination; it does not include special purpose lamps*";
- Article 2.1, that defines 'household room illumination' as "*the full or partial illumination of a household room, by replacing or complementing natural light with artificial light, in order to enhance visibility within that space*";
- Article 2.4, that defines 'special purpose lamp' as a "*lamp not intended for household room illumination because of its technical parameters **or** because the related product information indicates that it is unsuitable for household room illumination*" [92] [93];
- Recital (5), stating that: "*Products subject to this Regulation are designed essentially for the full or partial illumination of a household room, by replacing or complementing natural light with artificial light, in order to enhance visibility within that space. Special purpose lamps designed essentially for other types of applications (such as traffic signals, terrarium lighting, or household appliances) and clearly indicated as such on accompanying product information should not be subject to the ecodesign requirements set out in this Regulation*."

In a LightingEurope interpretation of Recital (5) of Regulation 244/2009 this includes '*Temperature- and shockproof lamps*' [94].

In Regulation 245/2009 'extreme physical environment' lamps are not explicitly excluded. They could be implicitly exempted if they are considered as "*products intended for use in applications other than general lighting*" but this is not clear. In addition they would be exempted if "*covered by the requirements of Directive 94/9/EC or Directive 1999/92/EC* [95] ".

In CDR (EU) No 874/2012 'extreme physical environment' lamps are excluded only if they are considered as non-compliant with the ecodesign regulations (see remarks in par. 1.4.1.4 and 1.4.1.5).

The draft regulation of April 2014 (par. 1.4.1.5) intended to amend 244/2009 and 1194/2012, still includes as example of exempted special purpose products "*lighting applications where the lighting*

[90] This opinion was expressed in a meeting between LightingEurope and the study team in June 2014. It is a change with respect to the earlier opinion as reported in a note in par. 8.4 of the Omnibus study: "*LightingEurope remarks that 'shockproof' incandescent lamps are much more shockproof than halogens. LE further states that 'CFLi, LEDi and Halogen Eco types are not generally resistant to vibration. LED emitters themselves are OK, but the construction of LED retrofit lamps is generally NOK for vibration service*."

[91] However, IALD in its comments states the opposite: "With regard to Rough Service lamps there are still no alternative products in the market that are suitable to replace these in specific applications."

[92] LightingEurope comment: "The 'or' in this paragraph is misleading terminology impacting negatively on the unmistakeable reading of the regulation."

[93] Amendments have now been proposed for this article, see par. 1.4.1.5.

[94] As reported in the Omnibus study.

[95] Application of equipment in potentially explosive atmospheres.

products have to withstand extreme physical conditions (such as vibrations or temperatures below -20°C or above 50°C)", but under the amendment manufacturers of such lamps would have to justify that the lamps are of the highest possible energy efficiency class [96]. It is noteworthy however that the 'extreme physical environment' lamps have not been removed: they remain exempted lamps.

According to the preliminary estimates reported in Annex D.15, the annual sales are around 5 million units for shockproof lamps used in car-repair shops, inspection, mining, etc. and additional over 4 million for temperature-resistant, vibration-resistant and shatter-resistant lamps [97]. This is far above the 200,000 units indicated as eligibility criterion for ecodesign measures in Directive 2009/125/EC, article 15.2a. A large part of these lamp sales are incandescent lamps with low energy efficiency.

The same Annex provides an estimate for the total EU-28 energy consumption for these lamps of around 1 TWh/year, which can be considered significant in terms of environmental impact. This only includes lamps actually used for the intended 'extreme physical environment' application, not those abused for general lighting services [98].

Considering the Omnibus study, the opinion expressed by LightingEurope, and a quick research on the Internet, there are suitable energy-efficient replacements for incandescent 'shockproof', 'vibration-resistant' and 'shatter-resistant' lamps so that the criterion of Directive 2009/125/EC article 15.2(c)(ii) seems to be satisfied.

Additional considerations and additional study would be required for 'temperature-resistant' lamps, in particular as regards lamps for use in environments above 50˚C. LED lamps might have problems in such environments, suffering a decrease in efficiency and in lifetime.

Additional study would also be required to evaluate the other criteria of Directive 2009/125/EC article 15, and to formulate clear definitions or test standards that enable market surveillance to establish quickly and efficiently if a marketed lamp really belongs to one of these categories. Such definitions would be of particular importance if these lamps are exempted from a future regulation, but they will probably be necessary as well if these lamps are covered by new ecodesign measures: the prescribed minimum requirements for energy efficiency and for other lighting parameters for 'extreme physical environment' lamps might be different from those for lamps used in general lighting service.

Considering the above it is proposed, at least for the moment, to maintain 'lamps for use in extreme physical environments' in the scope of the study.

1.4.2.2. Non-white lamps and lamps with colour-changing ability

Exemption status in existing regulations:

- 244/2009 (NDLS) : explicitly excluded using chromaticity coordinates as a criterion
- 245/2009 (LFL,CFLni,HID): explicitly excluded using chromaticity coordinates as a criterion (but high-pressure sodium lamps are not excluded [99])
- 1194/2012 (DLS, LED): explicitly excluded using chromaticity coordinates as a criterion
- 874/2012 (labelling): not explicitly excluded, see comments below

[96] However, see the discussion in par. 1.4.1.5

[97] In principle, this does NOT include lamps used in or on means of transport that are often also tested on vibration resistance.

[98] LightingEurope comment: "Altogether, including these abused lamps, the consumption amounts to 11 TWh".

[99] From the point of view of ecodesign-philosophy the exception in Regulation 245/2009 for high-pressure sodium (HPS) lamps is doubtful. If a non-HPS lamp would be developed with the same non-white colour as a HPS lamp, the non-HPS lamp would be exempted from Regulation 245/2009 while the HPS lamp would not be exempted.

might be excluded because non-compliant with other regulations

Coloured lamps in CDR 874/2012

In CDR 874/2012, there is no explicit reference to the colour of the lamps. Coloured lamps would be excluded if their primary purpose is not considered to be lighting (article 1.2(c)) but taking into account the examples provided and the definition of 'lighting' (article 2(2)), exclusion on these grounds is rather doubtful. Coloured lamps could also be excluded because they do not comply with the requirements of other ecodesign regulations (article 1.2(f)), but considering that they are exempted from those regulations it is difficult to state that they do or do not comply. This topic seems to need clarification.

Different definitions for 'white light'

The definition of 'white light', by means of chromaticity coordinates, is not the same in Regulation 244/2009 on the one hand and Regulations 245/2009 and 1194/2012 on the other hand, see Annex D.1.1 for details [100]. In Regulation 244/2009, a wider range of colours is still considered as 'white'. For future regulations, it would be preferable to align the definitions [101].

Question:
Was there a rationale for having different definitions?

Colour-changing LED lamps

There are already LED lamps on the market that can change colour. By means of a dedicated remote control, by means of an app on a smart phone or tablet, or by means of a dedicated wall-mounted control, these lamps can be switched on or off, be dimmed, or change colour from white (with different colour temperatures) to almost any colour of the rainbow, on user command.

Although these lamps have not been studied in detail yet and at this stage sales data are still lacking, the mere existence of such colour-changing lamps is a challenge for any future regulation. The lamps can neither be considered as 'white' nor as 'non-white', energy efficiency will most likely be variable, depending on the colour selected, and parameters like colour temperature, colour consistency and colour rendering become difficult to regulate. Lamp lifetimes may also depend on the colour that is predominantly being used. In some occasions it may be difficult to characterise these lamps without considering the interaction with their controls.

Consequently, including lamps with colour-changing ability in the scope (of this study and/or of a new regulation) introduces considerable problems. On the other hand, excluding them from the scope would clearly open a loophole because these lamps can be used in place of 'normal' white lamps that would be in the scope. The possibility could be explored to characterise and regulate these lamps with colour-changing ability for a specified white light only.

Other remarks

'Non-white' lamps (as now defined in the regulations) do not form a homogeneous product group with a well-defined function as necessary for ecodesign. They have a variety of functions (mood/ambient light, decorative, various UV-treatments, IR heating, etc.). Due to the variety of

[100] The draft proposal for amendment of 244/2009 of April 2014 (see par. 1.4.1.5) further complicates this situation: the existing definition for non-white of 244/2009 article 1 is maintained for definition of the scope, while the different non-white definition from 1194/2012 is introduced in article 3(2) of 244/2009 in relation to the information requirements for special purpose lamps. As a consequence of the amendments, 244/2009 would include 2 different definitions for non-white in the same regulation.

[101] LightingEurope comment: "Preference is with definition in Reg. 245/2009 and Reg. 1194/2012"

functions, 'non-white' lamps are not suitable as a product group for ecodesign measures: the individual functions should be considered separately (see also remarks in par. 1.1).

Lamps that are now excluded because they are considered 'non-white' may be excluded from the current regulations also for other reasons. For example, UV- or IR-lamps can have chromaticity coordinates that make them 'non-white'. Many 'non-white' lamps will probably also NOT have lighting as the primary purpose or they will fall into (other) categories of special purpose lamps as defined in Regulation 1194/2012, regardless of their colour. So even when dropping the 'non-white' exemption, many of these lamps would be exempted from the current regulations for other reasons.

The chromaticity coordinates can be determined by market surveillance authorities using established test methods and procedures. Excluding the lamps by their type of application, e.g. decorative lighting, food display lighting, show effect lighting, would be difficult to verify during inspections. So when dropping the 'non-white' exemption, the availability of other verifiable criteria for exemption should be considered.

Annex D.15 contains a first estimate of the sales and the energy consumption of special purpose lamps. Among these are 'non-white' lamps, but they are spread over several items and not always easily identified. Excluding lamps for signalling and signage, UV-lamps and IR-lamps, the major energy consumption of other 'non-white' lamps is estimated for Christmas light strings (item 44) and lamps for fairs and amusement parks (item 46) with a total energy consumption in the EU-28 around 2 TWh/year. However, the major part of the sales for these lamps is already estimated to be non-incandescent, i.e. LED.

It is proposed, at least for the moment, to maintain 'lamps with colour-changing ability that can also produce white light' in the scope of the study. Other 'non-white' lamps with a fixed colour, or with variable colours not including white, do not have a unique function and can therefore not be considered as a product group for ecodesign studies [102].

1.4.2.3. Ultraviolet lamps

Exemption status for UV lamps in existing regulations:

- 244/2009 (CFLi,HL,GLS) : explicitly excluded are lamps having:
  - 6 % or more of total radiation of the range 250-780 nm in the range of 250-400 nm,
  - the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB);

  explicitly excluded if 'non-white' (chromaticity coordinates)
  implicitly excluded because UV lamps are not 'household lamps'

- 245/2009 (LFL,CFLni,HID): explicitly excluded are:
  - blended HID-lamps having 6 % or more of total radiation of the range 250-780 nm in the range of 250-400 nm,
  - blended HID-lamps having the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB),
  - HID lamps having a specific effective UV output > 2 mW/klm

[102] This does NOT mean that it is the intention to exclude them from the study, but only that these lamps have to be considered by their function, e.g. decorative, UV treatments, IR heating, food display, grow light, etc.

	explicitly excluded if 'non-white' (chromaticity coordinates) implicitly excluded if UV-lamps are not for 'general lighting'
- 1194/2012 (DLS, LED):	explicitly excluded if 'non-white' (chromaticity coordinates) implicitly excluded because primary purpose is not lighting
- 874/2012 (labelling):	implicitly excluded because primary purpose is not lighting Implicitly excluded because 'non-compliant'

Discussion of the criteria for exclusion

Most UV lamps would be expected to have (non-white) chromaticity coordinates that exempt them from Regulations 244/2009, 245/2009 and 1194/2012.

The explicitly formulated exclusions based on the characteristics of the emitted light spectrum are clear and verifiable. Their correctness / adequacy to cover only the intended lamps should be checked.

In Regulation 244/2009 the explicit exemptions apply to all lamp-types. In addition, regarding the implicit exclusion, the definition of 'household lamp' is such that UV lamps can reasonably be considered excluded from the scope of the regulation also for this reason. This is not 100% clear however and it is not verifiable, in the sense that there is no test that determines if a lamp is a 'household lamp'.

In Regulation 245/2009 the explicit exemptions apply only to HID-lamps, or very specifically only to blended HID-lamps [103]. This is a consequence of the amendments introduced by Regulation 347/2010. Prior to those amendments the first two explicit criteria, which are identical to those in Regulation 244/2009, applied to all regulated lamps (LFL, CFLni, HID). Regulation 347/2010 generally explains that this change was applied "*to avoid unintended impacts on the availability and performance of the products covered*" by 245/2009, but no details are provided [104]. As a consequence, for example UV LFL lamps as used in tanning installations (annex D.9) are not exempted by the explicit UV criteria. These lamps would be excluded only if they have non-white chromaticity coordinates.

The implicit exclusion of UV lamps in Regulation 245/2009 (as amended by 347/2010) is not clear because the definition for 'general lighting' [105] only refers to the distribution of the light, not to its spectrum, nor to visibility aspects. In Regulation 245/2009 there is no definition for 'lighting', 'lamp' or 'light source' that covers these aspects.

In Regulations 1194/2012 and 874/2012 there are no explicitly formulated criteria for the exemption of UV lights. In Regulation 1194/2012, they are excluded if they have non-white chromaticity coordinates. UV lamps are implicitly excluded from these regulations (as special purpose lamps) if the primary purpose of their light is NOT considered to be lighting. The definitions for 'lighting', 'lamp' and 'light source' do not really clarify if UV lamps are excluded [106], but Regulation 1194/2012 provides examples that include (most) UV lamps:

[103] A '*blended lamp*' is defined as "*a lamp containing a mercury vapour lamp and an incandescent lamp filament connected in series in the same bulb*".

[104] LightingEurope comment:" It was to avoid the unintentional phase out of Mercury Blended UV lamps that are needed for pet care application."

[105] '*General lighting*' means substantially uniform lighting of an area without provision for special local requirements.

[106] In particular consider the definition: " *'light source' means a surface or object designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wave-length of 380-780 nm*". The wording 'mainly visible' and the interval 380-780 nm do not per definition exclude UV lamps.

"emission of light as an agent in chemical or biological processes (such as polymerisation, ultraviolet light used for curing/drying/hardening, photodynamic therapy, horticulture, pet-care, anti-insect products)."

Surprisingly, in 874/2012, which uses a very similar formulation, UV lamps are no longer explicitly mentioned among the examples:

"emission of light as an agent in chemical or biological processes (such as polymerisation, photodynamic therapy, horticulture, pet-care, anti-insect products)"

As for all lamp types, if UV lamps are excluded from the ecodesign regulations, they can be considered excluded from the labelling regulation as well if they are interpreted as being 'non-compliant' with the ecodesign regulations.

Question:
Was there a reason for no longer having the explicit UV-exemptions in 1194/2012 and 874/2012?

Remarks regarding the scope for the current study

In general, the following types of UV light are distinguished:

- UVA (near UV-Black Light) 315-400 nm
- UVB (middle UV-Erythemal) 280-315 nm
- UVC (far UV-Germicidal) 100-280 nm

The definition for the initial scope of the current study refers to "mainly visible optical radiation in a wavelength of 380-780 nm". In principle this means that UV lamps would be excluded, but this has to be more precisely defined for market surveillance purposes. It could be verified if the following definition (taken from Regulation 244/2009) effectively excludes all UV lamps that are intended to be excluded, that it does not exclude any lamps that are intended to remain in the scope of the current study, and that it does not open possibilities for the creation of loopholes:

lamps having:

- *6 % or more of total radiation of the range 250-780 nm in the range of 250-400 nm,*
- *the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB).*

In this definition it is stated that 6% of the emitted spectrum should be in the UV range. Given that, without fluorescent coating, the original spectrum of CFLs, LFLs and white (actually UV/blue) LEDs is in the UV range, it should not pose any technical (or efficacy) problems to make a 'white light' source that has 6% of its spectrum in the UV range. In other words, the above definition makes them again prone to misuse. For mainly commercial reasons, they are often given a purple/black or blue coating to stress the UV-character of the lamp and they emit mainly bluish light and it might well be necessary to make these features mandatory in the definition to avoid misuse.

An ecodesign preparatory study should compare products that have the same function. In the current study the intended function is 'to make objects or scenes visible' and the main lighting parameter considered (in addition to other secondary parameters) is the luminous flux (lm) or the flux density (lm/m^2). UV lamps typically have different functions (see Annex D.15, items 100-130) and would require different main functional parameters with different minimum requirements. See also remarks in par. 1.1 regarding functions.

According to the (rough) estimates in Annex D.15, the total electric energy consumption for UV lamps in EU-28 is 2.5 TWh/year. This total consumption is the sum of many relatively small consumptions for a variety of applications, the most important being tanning lamps (9.4 million units per year; 0.6

TWh/year), UVC waste water treatment lamps (0.6 million units per year; 0.5 TWh/year), and UV lamps for industrial use (0.5 million units per year; 1.0 TWh/year).

For more information on UV lamps see Annex D.9.

UV lamps have specific associated safety and exposure problems, see for example Directive 2006/25/EC [107] on Artificial Optical Radiation (exposure of workers to UV light) and some of the standards listed in Annex H. This aspect requires further study if UV lights remain in the scope of the study.

Considering the above, a good definition for ultraviolet lamps must be found before they can be excluded from the scope.

1.4.2.4. Infrared and collagen lamps

Exemption status for IR lamps in existing regulations:

- 244/2009 (CFLi,HL,GLS) : explicitly excluded if 'non-white' (chromaticity coordinates)
  implicitly excluded because they are not household lamps
- 245/2009 (LFL,CFLni,HID): explicitly excluded if 'non-white' (chromaticity coordinates)
  explicitly excluded are:
  - blended HID-lamps having 11 % or more of total radiation of the range 250-780 nm in the range of 630-780 nm,
  - blended HID-lamps having 5 % or more of total radiation of the range 250-780 nm in the range of 640-700 nm,

  implicitly excluded if the lamps are not for 'general lighting'
- 1194/2012 (DLS, LED): explicitly excluded if 'non-white' (chromaticity coordinates)
  implicitly excluded because primary purpose is not lighting (heating applications such as infra-red lamps mentioned as example)
- 874/2012 (labelling): implicitly excluded because primary purpose is not lighting (heating applications such as infra-red lamps mentioned as example)
  implicitly excluded because 'non-compliant'

The main function of IR lamps is always heating, and not lighting [108]. For this reason, they are excluded from the current regulations. Regulation 1194/2012 is the most explicit in exempting lamps used for heating. Collagen lamps emit visible red light for therapeutic purposes.

Most IR lamps and collagen lamps (see annex D.10 for examples) will be exempted from the current ecodesign regulations on the basis of their non-white chromaticity coordinates.

[107] DIRECTIVE 2006/25/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL 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) (19th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0038:0059:EN:PDF

[108] Depending on the context or on the standard, (near) infrared light has wavelengths above 700, 750 or 780 nm. Light is usually considered visible up to 780 nm, so most IR light is not visible for humans and consequently not fit for lighting.

In 244/2009 they would be implicitly exempted because they are not 'household lamps'. In 245/2009 they would be implicitly exempted if considered 'not for general lighting'.

IR lamps for heating applications are explicitly mentioned as exempted lamp types in Regulations 1194/2012 and 874/2012.

The exceptions in 245/2009 for blended HID-lamps for 630-780 and 640-700 nm are very specific and need clarification.

Remarks regarding the scope for the current study

Directive 2006/25/EC [109] distinguishes the following types of infrared light:

- IRA 780-1400 nm
- IRB 1400-3000 nm
- IRC 3000 nm – 1 mm

The definition for the initial scope of the current study refers to "mainly visible optical radiation in a wavelength of 380-780 nm". In principle this means that IR lamps would be excluded, but this has to be more precisely defined for market surveillance purposes. Collagen lamps might fall inside the definition for the initial scope.

A proposal for the definition of IR-lamps, similar to the one for UV, cannot be provided in this moment: further study would be required.

An ecodesign preparatory study should compare products that have the same function. In the current study the intended function is 'to make objects or scenes visible' and the main lighting parameter considered (in addition to other secondary parameters) is the luminous flux (lm) or the flux density (lm/m^2). IR lamps typically have different functions (mainly heating, see Annex D.15, items 134-145) and would require different main functional parameters with different minimum requirements. Other sources than light could be used for the same heating function. These should be considered when performing an ecodesign study for IR lighting products. See also remarks in par. 1.1 regarding functions.

Some infrared lighting products are already covered by other Community legislation. This regards IR lamps used in copiers and printers (imaging equipment, office equipment [110] [111]) and in electric hobs [112].

According to the (rough) estimates in Annex D.15, the total electric energy consumption for IR lamps in EU-28 is 33.2 TWh/year. Subtracting the contribution of lamps used in office equipment and electric hobs, 24-25 TWh/year remains. The main energy consumption is for 'counter-top heaters in restaurants (service counters)' (10.8 TWh) and various industrial applications (10.8 TWh). The energy consumption estimate for collagen lamps is negligible.

[109] See reference in section on UV-lights

[110] REGULATION (EU) No 174/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 February 2013 amending Regulation (EC) No 106/2008 on a Community energy-efficiency labelling programme for office equipment, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0174&from=EN

[111] COMMISSION DECISION 2014/202/EU of 20 March 2014 determining the European Union position for a decision of the Management entities under the Agreement between the Government of the United States of America and the European Union on the coordination of energy-efficiency labelling programmes for office equipment on adding specifications for computer servers and uninterruptible power supplies to Annex C to the Agreement and on the revision of specifications for displays and imaging equipment included in Annex C to the Agreement, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2014:114:FULL&from=EN

[112] COMMISSION REGULATION (EU) No 66/2014 of 14 January 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for domestic ovens, hobs and range hoods, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0066&from=EN

The problem with infrared heat lamps is that, if it were not for the 'intended use' on the packaging and the red or gold colour of the glass or coating, they would be indistinguishable from 'normal' incandescent or halogen lamps. Except for ('ceramic') heat lamps that do not emit visible light at all, the original spectrum (SPD, Spectral Power Distribution) of the heat lamp is practically identical to that of normal halogen and incandescent lamps that also emit 94% of their energy in the infrared spectrum. Without a good definition and/or marking (e.g. like an obligation of a reddish light colour, i.e. outside the 'white' chromaticity area) they are thus prone to misuse.

Collagen lamps, a relatively recent development, claim to emit mainly light in the visible red spectrum to create a certain health benefit. But there is no definition as to what portion of the spectrum should be in the visible red range. So for surveillance purposes the 'collagen lamps' can only be distinguished from non-collagen lamps through their 'intended use' and the pink colour of the glass, but there is no precise technical definition, which would be needed to exclude these lamps from the scope without a risk of misuse.

Considering the above a good definition for infrared heat lamps and collagen lamps must be found before they can be excluded from the scope.

1.4.2.5. Signalling and signage lamps

As presented in annex D.2 this includes signalling lamps for roads, railways, airfields and marine applications, neon and billboards, and exit signs.

Status in current regulations

In Regulation 244/2009, they are excluded if 'non-white' [113] or more in general because they are not 'household lamps' (traffic lights are explicitly mentioned as an example). According to the Omnibus study the exempted "*incandescent lamps with E14/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer (…)*" are typically used as (traffic) signalling lamps, but these lamps are exempted only in stages 1-5 , not in stage 6 of 244/2009. In addition, this exception would not cover mains voltage lamps.

In Regulation 245/2009 they are excluded if 'non-white' or more in general because they are 'not for general lighting'. This regulation also exempts 'emergency sign luminaires' but this applies to the luminaires, not to the lamps used inside them.

In Regulation 1194/2012 signalling and signage lamps are excluded if 'non-white' or more in general because their primary purpose is not lighting. In 874/2012 they are also excluded because their primary purpose is not lighting or because they are considered 'not compliant' with the ecodesign regulations. Both regulations explicitly mention "*signalling (such as traffic control or airfield lamps)*" as an exemption example.

'Traffic lights' and 'other safety and signalling lighting equipment' are also mentioned in the draft Ecodesign Workplan 2015-2017 (see par. 1.4.1.7).

Remarks regarding the scope for the current study

The function of the lamps in this group is relatively close to the main function considered in this study (par. 1.1). In this case, the objects to be illuminated could be interpreted to be the luminaires themselves, or the (coloured) shields in front of the lamps. Most likely the luminous flux or its density will be an important parameter also for signalling and signage applications.

[113] This refers to the lamp itself, not to filters in the luminaire that might make the final light coloured.

For some applications in this category, the lamps used inside them could also be used in general lighting functions. Excluding these lamps could thus provide a loophole.

The (roughly) estimated energy consumption for signalling and signage lamps in EU-28 is 6.4 TWh/year (Annex D.15) of which almost two-thirds (4.1 TWh/year) are due to exit signs in commercial and industrial buildings. Other relevant contributions come from traffic signalling lights (1 TWh/year, majority of sales incandescent) and from neon and billboards (0.9 TWh/year, relatively low sales, but high power, most LFL and MH).

An **exit sign** is a battery backed-up device (on mains voltage). Depending on the design, LED exit signs may save 50% or more with respect to CFL-equipped exit signs (and much more with respect to legacy incandescent-lit exit signs). Exit signs are plentiful and required to be lit 24h per day and thus the energy consumption is significant. Alternatives may be photo-luminescent and tritium exit signs, which consume no power at all, but there are some possible drawbacks (see remarks in Annex D.2.3).

Considering their energy consumption and sales volumes it would be relevant to include exit signs in the scope of the current study. Note that exit signs have safety aspects, with related regulations and standards that would have to be taken into account in the study.

Traffic lights are also considered in the legislation regarding Green Public Procurement (see par. 5.1.10). There are many standards and regulations regarding traffic lights that would have to be considered. Note that traffic lights were excluded from the Lot 8 preparatory study on street lighting (see Task 0 report, par.2.2) because of their different function and requirements.

Considering the above it is proposed, at least for the moment, to include lamps for signalling and signage in the scope of the study, in particular as regards exit signs and possibly traffic lights.

1.4.2.6. Appliance-integrated (non-primary) lamps

As clarified in Annex D.3, these are light sources that are integrated in products where the primary function does not depend on the light source, but lighting is a secondary function typically as a task light. Examples are lamps in refrigerators, ovens, sewing machines, etc. The grouping used in Annex D is quite wide, including also aquarium lighting and swimming pools.

Status in current regulations

In Regulation 244/2009 these lamps are primarily exempted because they are not 'household lamps' (lamps designed for terraria and for household appliances are explicitly mentioned as an example). Some appliance-integrated lamps may also be exempted because they have less than 60 lumen.

In Regulation 245/2009 appliance-integrated lamps will normally be exempted because they are considered as "*products intended for use in applications other than general lighting*". Some lamps could be exempted if they belong to the very specific categories (e.g. double capped LFL T2 or LFL T5 with P<13 W). For lamps in swimming pools, the exemption from 245/2009 is less clear.

In Regulations 1194/2012 appliance-integrated lamps are exempted as "*products incorporating lighting products, where the primary purpose is not lighting and the product is dependent on energy input in fulfilling its primary purpose during use (such as refrigerators, sewing machines, endoscopes, blood analysers)*". Regulation 874/2012 has a similar exemption. Note that this does NOT seem to exempt aquarium lighting and swimming pool lighting. Aquarium lighting can anyway be considered exempted in both regulations because 'pet-care' is explicitly mentioned as an example and because aquarium lighting will often have an UV rich spectrum against growth of algae. For lamps in swimming pools, the exemption from 1194/2012 and 874/2012 is less clear, unless this lighting has other special

characteristics (apart from the application in swimming pools) that cause exemption [114], e.g. "*the spectral distribution of the light is intended to change the appearance of the scene or object lit, in addition to making it visible*".

Remarks regarding the scope of the current study

For range hoods that illuminate the cooking plane [115] lighting is already considered in the ecodesign regulation for the appliance. For other appliances this does not seem to be the case.

According to the (rough) estimates in Annex D.15, the total electric energy consumption for these lamps in EU-28 is 9.7 TWh/year (excluding lighting in range hoods). The largest consumers are 'aquarium lamps' (3.5 TWh/year), 'lamps for swimming pools' (2.2 TWh/year) and 'lamps used in vending machines' (2.5 TWh/year).

The function for lamps in this group is essentially the same as the main function considered in this study, i.e. 'to make objects and scenes visible', although each application has its specific requirements.

Considering the above it is proposed, at least for the moment, to include 'appliance-integrated lamps' in the scope of the study, except when these lamps are already being considered in ecodesign regulations for these appliances.

1.4.2.7. Decorative and architectural lamps

For examples of lamps in this group see Annex D.4. The lamps are often low power, with low lumen output and several lamps in this group are 'non-white'. This group (as presented in Annex D) does NOT include flood lights for outdoor illumination of buildings or for 'city beautification' because these lamps are not considered as special purpose lamps: they are normally in the scope of the study if they are not excluded for other reasons.

Status in current regulations

In Regulation 244/2009 these lamps are NOT exempted [116]. Coloured decorative lamps can be exempted because they have non-white chromaticity coordinates. Some lamps may also be exempted because they emit less than 60 lumen. '*Incandescent lamps with S14, S15 or S19 caps*' (exempted in stages 1-4 of 244/2009) also fall into this group, see annex D.4.

In Regulation 245/2009 these lamps would be exempted if they are not considered to be for 'general lighting', which is doubtful. Coloured decorative lamps can be exempted because they have non-white chromaticity coordinates. Double-capped LFL are exempted if they are T2 or T5 with power less than 13 W.

In Regulations 1194/2012 and 874/2012 these lamps are NOT exempted [117]. In Regulation 1194/2012 they can be excluded if "*the spectral distribution of the light is intended to change the appearance of the scene or object lit, in addition to making it visible*". This explicitly refers to coloured lamps and their non-white chromaticity coordinates.

[114] A distinction should be made between lamps intended as luminaires, that have to be water-tight and safe, and lamps intended as light sources inside these luminaires that might be 'non-special' lamps.

[115] COMMISSION REGULATION (EU) No 66/2014 of 14 January 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for domestic ovens, hobs and range hoods, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0066&from=EN

[116] According to the Commission's DG ENER, in a comment on the draft version of this report. This implies that they are considered to be 'household lamps'

[117] According to the Commission's DG ENER, in a comment on the draft version of this report. This implies that they are considered to be for 'general lighting'

Under Regulation 874/2012 decorative lamps can be excluded if they emit less than 30 lumen, if they are marketed for operation on batteries, or if they are integral part of a luminaire. As for all lamp types, if decorative lamps are excluded from the ecodesign regulations, they can be considered excluded from the labelling regulation as well if they are interpreted as being 'non-compliant' with the ecodesign regulations.

Remarks regarding the scope of the current study

According to the (rough) estimates in Annex D.15, the total electric energy consumption for these lamps in EU-28 is 2.6 TWh/year. The largest consumers are 'Christmas light strings (mini bulb 50x0.5W=25W, LED 100 x 0.06=6W)' (1.1 TWh/year) and 'coloured and mirror bulbs <11W & LED, for fairs and amusement parks' (0.9 TWh/year). However, the major part of the sales for these lamps is already estimated to be non-incandescent, i.e. LED.

It is difficult to define when a lamp is decorative and there is anecdotal information that there are people trying to sell their lighting products as 'pieces of art' in an attempt to escape the requirements of the regulations. So excluding decorative lamps would be a potential loophole.

It is also difficult to grasp the special function of decorative lamps: for many of these lamps the luminous flux will not be an important output parameter.

Considering the above it is proposed to neither specifically include decorative lighting in the study, nor to specifically exclude it from the study. An attempt should be made to include/exclude these lamps based on other grounds than their being 'decorative'.

'Architectural lamps' would need a better definition before their inclusion/exclusion can be discussed.

1.4.2.8. Projection, microscopy, light guide lamps

This group covers a large variety of lamps, see Annex D.6 for examples.

Status in current regulations

In Regulation 244/2009 these lamps are exempted because they are not 'household lamps'. Some lamps may be excluded because they emit more than 12,000 lumen.

In Regulation 245/2009 these lamps are exempted because they are '*intended for use in applications other than general lighting*'.

In Regulations 1194/2012 and 874/2012 at least some of these lamps are exempted because the '*primary purpose of the light is not lighting*'. Image projection is explicitly mentioned as an example.

Remarks regarding the scope of the current study

According to the (rough) estimates in Annex D.15, the total electric energy consumption for these lamps in EU-28 is 2.4 TWh/year. The largest consumers are 'copier and scanner exposure lamps (CCFL, HL, Xe)' (0.9 TWh/year) that are mostly covered by the voluntary ecodesign measures on 'imaging equipment' [118]. The next highest energy consumption estimate is for projectors used in offices and

[118] COMMISSION STAFF WORKING DOCUMENT 'Impact Assessment' accompanying the document 'REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the voluntary ecodesign scheme for imaging equipment', Brussels 29.01.2013, SWD(2013) 15, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2013:0015:FIN:EN:PDF

schools (items 59, 60, 61 in Annex D.15) that together account for 0.8 TWh/year. For other lamp types in this group the estimated energy consumption is small.

For some applications in this group there are strong 'lock-in' effects, i.e. existing sockets and available spaces require specific lamps.

A technical definition of this group could include 'radiance', i.e. quantities of optical radiation that describe the amount of light that is emitted from a defined unit area and encompassed within a solid angle in a specific orientation. The quantity is expressed in watts per square centimeter per steradian ($W/cm^2/sr$). Furthermore, there could be requirements for spectrum (e.g. in microscopes) and/or colour rendering (for projectors).

It is proposed to exclude from the scope of the study those lamps that are already covered by other ecodesign measures. All lamp types in this group require a robust definition.

1.4.2.9. TV/movie/photo/theatre/event/stadium lighting

This group mainly contains spotlights for professional use with (very) high luminous flux, see Annex D.7 for examples.

Status in current regulations

In Regulation 244/2009 these lamps are exempted because they are not 'household lamps'. A considerable number of lamps may be excluded because they emit more than 12,000 lumen.

In Regulation 245/2009 these lamps are exempted because they are "*intended for use in applications other than general lighting*". This specifically refers to "*substantially uniform lighting of an area without provision for special local requirements*" which is in contrast with the aim of many lamps in this group.

In Regulations 1194/2012 most of the lamps in this group would be 'special applications' that "*require technical parameters not necessary for the purposes of lighting average scenes or objects in average circumstances".* In addition, the following two exemptions could apply:

- *spectral distribution of the light that is intended to change the appearance of the scene or object lit,*
- *spectral distribution of the light that is adjusted to the specific needs of particular technical equipment, in addition to making the scene or object visible for humans (such as studio lighting, show effect lighting, theatre lighting).*

In Regulation 874/2012, there is no clear exemption for lamps in this category. As for all lamp types, if the lamps are excluded from the ecodesign regulations, they can be considered excluded from the labelling regulation as well if they are interpreted as being 'non-compliant' with the ecodesign regulations.

Remarks regarding the scope of the current study

According to the (rough) estimates in Annex D.15, the total electric energy consumption for these lamps in EU-28 is 2.5 TWh/year. The largest consumers are 'TV/video/film studio lamps' (1.4 TWh/year) followed by outdoor stadium lighting (0.6 TWh/year).

As the assignment explicitly asks for an analysis of lamps with more than 12,000 lumen, further work on lamps in this category is planned in this preparatory study.

1.4.2.10. Backlighting

This mainly includes cold cathode fluorescent lamps (CCFL) and LEDs (OLEDs) for application in televisions, desktop monitors, tablets, smart phones, GPS devices and hand-held games.

As regards Regulation 244/2009, these lamps are not 'household lamps'. In addition the types of lamps considered in 244/2009 (CFLi, HL, GLS) are not typical for backlighting applications.

As regards Regulation 245/2009, these lamps might be exempted if not considered for 'general lighting', but this is doubtful. In addition 245/2009 explicitly excludes double-capped fluorescent lamps with diameter 7 mm (T2) or less.

The lamps in this group would be exempted from Regulations 1194/2012 and 874/2012 because they are "*applications where the primary purpose of the light is not lighting*" (image projection is explicitly mentioned as an example). In addition, the exemption applies for "*products incorporating lighting products, where the primary purpose is not lighting and the product is dependent on energy input in fulfilling its primary purpose*". They are also exempted from Regulation 874/2012 if marketed for operation on batteries.

According to the (rough) estimates in Annex D.15, the total electric energy consumption for these lamps in EU-28 is 58.5 TWh/year. The largest consumers are 'CCFL TV lamps' (34.8 TWh/year) and 'CCFL desktop monitor lamps' (6.2 TWh/year). The majority of these lamps has been considered during the ecodesign studies on 'televisions' [119] and on 'computers' [120].

Backlighting is included in Ecodesign and energy labelling measures for televisions and Energy Star measures for computer monitors (both under review) and is thus adequately regulated.

A good definition is required, but chances of loopholes are small: LEDs and CCFLs for backlighting are usually traded as complete backlighting units. Individual CCFLs are used for general lighting in only very specific cases (e.g. in Artemide design lamp).

These lamps will be excluded from the current preparatory study.

1.4.2.11. Grow lights

The function of grow lights is to make plants grow, not to make a scene or objects visible to humans. Grow lights will usually have a spectrum that is different from lamps used in general lighting applications.

Sodium lamps are very efficient as grow lights in certain stages of plant growth because the green colour is largely missing from the spectrum (plants are relatively insensitive to green light). On the other hand, at some stages of growth also the blue light is helpful and –using the right phosphors— the lamp manufacturer will try to enhance the blue side of the spectrum in a grow light.

Status in current regulations

[119] COMMISSION REGULATION (EC) No 642/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for televisions, OJ L 191/42 23.07.2009, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009R0642

[120] COMMISSION REGULATION (EU) No 617/2013 of 26 June 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for computers and computer servers, OJ L 175/13 27.06.2013, http://eur-lex.europa.eu/legal-content/EN/ALL/;jsessionid=jW79TYNJNFQn90nSTj0KT1cFKS4qJXD2pM4VkTJvLjY1PNh5fdjB!770729252?uri=CELEX:32013R0617

In Regulation 244/2009 these lamps are exempted because they are not 'household lamps'. In addition, lamps might be excluded because of the 'non-white' criterion, depending on their chromaticity coordinates.

In Regulation 245/2009, these lamps could be exempted if considered not for 'general lighting', but this is somewhat doubtful. In addition, lamps might be excluded because of the 'non-white' criterion, depending on their chromaticity coordinates, but for Regulation 245/2009 this criterion does NOT apply to high pressure sodium lamps. The exemption of grow lights in Regulation 245/2009 is therefore uncertain.

Regulations 1194/2012 and 874/2012 explicitly exclude lamps for horticulture (example for the case where the primary purpose of the light is not lighting).

Remarks regarding the scope of the current study

According to the (rough) estimates in Annex D.15, the total electric energy consumption for grow lights in glass greenhouses in EU-28 is 5.2 TWh/year with annual sales close to 7 million units per year. This meets the eligibility criterion of Directive 2009/125/EC article 15.2.

Further study is required to verify the other criteria of this directive (see chapter 5 of the Task 0 report) and a more precise definition shall be elaborated as to what exactly is intended by 'Grow lights'.

A technical definition could refer to the spectrum, i.e. reduced power in the green range of the spectrum. But there could be other criteria, i.e. plant growth depends on.

In the professional greenhouses the reaction of the plants to light depends on the spectrum, intensity (in number of photons PPF in µmol m-2 s-1 or Lux, with 1 Lux=54 PPF), the position of lighting, the light sum (mol/m2) and the timing.

It is proposed, at least for the moment, to include grow lights in the scope of the study. A precise definition shall be formulated.

1.4.2.12. Food display lights

In general, 'food display lamps' are 'normal' lamps that claim to have an excellent and balanced colour rendering over the complete range of colours, especially for saturated colours. For this, it is not enough to have a high colour rendering index (CRI), which is always relative to a certain reference source with the same correlated colour temperature (CCT), but to have a complete and balanced spectrum over the visible range. For instance, halogen or metal halide lamps (also) containing Xenon (Xe) emit such a balanced spectrum and are popular in the food display sector. The metric that is used could be e.g. the relative gamut Qa in the colour quality scale (CQS) method or the so-called full-spectrum index (FSI). Lamps with a high FSI emit light that is supposedly closest to daylight, a capacity for which also certain health benefits are claimed. Reportedly, a complete and balanced spectrum costs lamp efficacy compared to other lamp types and thus these lamps can either be exempted, based on a suitable metric, or --more likely-- a suitable metric can be included as a parameter into the formula for generic minimum efficacy requirements.

A subgroup of food display is the one referred to as 'meat display lamps'. In principle, these are 'normal' lamps, with low UV emission (causes discoloration and colour fading), low IR heat emission (heat the product) and a colour rendering that is optimal in the visible red range. Usually warm (CCT of 2800 - 3500 K) fluorescent lamps (e.g. T5) are used and there would be no specific reason why they (or a possible LED alternative) should be exempted.

The qualification 'food display lamp' may be used for so-called shatterproof lamps, to avoid pieces of glass from a broken lamp ending up in food. In the US, the FDA Food Code Chapter 6, Section 202.11

is cited, where these shatterproof lamps are one of the options: *"…light bulbs shall be shielded, coated, or otherwise shatter-resistant in areas where there is exposed food; clean equipment, utensils, and linens; or unwrapped single-service and single-use articles."* No pan-European regulation on the subject could be identified. At Member State level, there may be rules to prevent lamp breakage in the food sector, but no cases that would necessitate shatterproof lamps were found.

Status in current regulations

In Regulation 244/2009 these lamps are exempted because they are not 'household lamps'. In addition, lamps might be excluded because of the 'non-white' criterion, depending on their chromaticity coordinates.

In Regulation 245/2009 these lamps can reasonably be considered exempted because they are not for 'general lighting'. In addition, lamps might be excluded because of the 'non-white' criterion, depending on their chromaticity coordinates. Note that Regulation 245/2009 also exempts double-capped fluorescent lamps with diameter 7 mm (T2) or less and diameter 16 mm (T5) with power less than 13 W. This could well apply to some of the food display lamps.

Regulation 1194/2012 explicitly exempts applications where "*the spectral distribution of the light is intended to change the appearance of the scene or object lit, in addition to making it visible (such as food display lighting)*".

In Regulation 874/2012, there is no clear exemption for lamps in this category. As for all lamp types, if the lamps are excluded from the ecodesign regulations, they can be considered excluded from the labelling regulation as well if they are interpreted as being 'non-compliant' with the ecodesign regulations.

Remarks regarding the scope of the current study

According to the (rough) estimates in Annex D.15, the total electric energy consumption for food display lights in EU-28 is 1.1 TWh/year with annual sales close to 27 million units per year. This meets the eligibility criterion of Directive 2009/125/EC article 15.2.

Further study is required to verify the other criteria of this directive (see chapter 5 of the Task 0 report) and a more precise definition shall be elaborated as to what exactly is intended by 'Food display lights' [121].

It is proposed, at least for the moment, to include Food Display lights in the scope of the study. A more precise definition shall be formulated.

1.4.2.13. Scientific lights

See Annex D.13 and D.15 for some examples.

Status in current regulations

In Regulation 244/2009, these lamps are exempted because they are not 'household lamps'.

In Regulation 245/2009 these lamps can reasonably be considered exempted because not for 'general lighting'.

[121] LightingEurope comment: "Until now we do not perceive any abusing of food-display lights for general lighting purposes. Lighting design possibilities require the exemption."

In Regulation 11194/2012 these lamps are most likely exempted as '*special applications' "that require technical parameters not necessary for the purposes of lighting average scenes or objects in average circumstances".*

In Regulation 874/2012 there is no clear exemption for lamps in this category. As for all lamp types, if the lamps are excluded from the ecodesign regulations, they can be considered excluded from the labelling regulation as well if they are interpreted as being 'non-compliant' with the ecodesign regulations.

Remarks regarding the scope of the current study

According to the (rough) estimates in Annex D.15, the total electric energy consumption for lamps with a scientific purpose in EU-28 is negligible and sales volume are below the 200,000 criterion of 2009/125/EC article 15 [122].

It is proposed to exclude these lamps from the current study because sales volumes do not meet the eligibility criterion. Additional attention is required to correctly define scientific lamps.

1.4.2.14. Transport lighting

It is recalled from chapter 5 of the Task 0 report that:

> *In article 1 sub 3 the Ecodesign Directive explicitly excludes 'means of transport for persons or goods'. However, this exclusion regards only the means themselves and not the products used inside or on those means.*

This paragraph examines if lights in or on means of transport should be excluded for other reasons, mainly by considering existing regulations in the transport sector.

Lighting in/on cars, trucks and busses

An overview of directives and regulations on motor vehicles, their trailers, systems and components can be found in the reference [123].

One of the directives listed there is 2007/46/EC [124]. This is a framework directive that deals with the approval of motor vehicles of categories M, N, O[125], including passenger cars, trucks, vans, busses and their trailers. For the technical requirements, and for the tests to be performed to obtain the type approval, the directive refers to the regulatory acts listed in part 1 of its Annex IV.

As regards lighting, reference is made to the following regulatory acts:

[122] In its comment on this report, the Federal Environment Agency of Germany (UBA) expresses the opinion that the 200,000 unit criterion is not intended to be applied to each subgroup but to product groups as a whole, and no precedence should be established here to change this rule. It still makes sense to exempt these very specific lamps from the study. However a precise definition based on technical properties is needed for such an exemption.

[123] http://ec.europa.eu/enterprise/sectors/automotive/documents/directives/motor-vehicles/index_en.htm

[124] DIRECTIVE 2007/46/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (OJ L 263, 9.10.2007, p.1), http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02007L0046-20140101, including amendments up to Council Directive 2013/15/EU of 13 May 2013 (OJ L 158, 10.6.2013, p.172), excluding amendments from Commission Regulations 133/2014, 136/2014, 214/2014 and 540/2014, but these do not regard aspects relevant here .

[125] As defined in Directive 2007/46/EC annex I part A. M: transport of persons; M1: maximum 8 seats plus driver; M2: more than 8 seats plus driver but maximum mass 5 ton; M3: mass over 5 ton; N: transport of goods; N1: maximum mass 3.5 ton; N2: mass between 3.5 and 12 ton; N3: mass over 12 ton; O: trailers.

- Regulation (EC) No 661/2009 [126]: general framework directive on safety of motor vehicles

- UNECE Regulation [127] [128] No 4: Illumination of rear-registration plates of power-driven vehicles and their trailers
- UNECE Regulation No 6 : Direction indicators for power-driven vehicles and their trailers
- UNECE Regulation No 7 : Front and rear position lamps, stop-lamps and end-outline marker lamps for motor vehicles and their trailers
- UNECE Regulation No 19 : Power-driven vehicle front fog lamps
- UNECE Regulation No 23 : Reversing lights for power-driven vehicles and their trailers
- UNECE Regulation No 31 : Power-driven vehicle's sealed-beam headlamps (SB) emitting an European asymmetrical passing beam or a driving beam or both
- UNECE Regulation No 37 : Filament lamps for use in approved lamp units of power-driven vehicles and their trailers
- UNECE Regulation No 38 : Rear fog lamps for power-driven vehicles and their trailers
- UNECE Regulation No 48: installation of lighting and light signalling devices
- UNECE Regulation No 77 : Parking lamps for power-driven vehicles
- UNECE Regulation No 87 : Daytime running lamps for power-driven vehicles
- UNECE Regulation No 91 : Side-marker lamps for motor vehicles and their trailers
- UNECE Regulation No 98 : Motor vehicle headlamps equipped with gas-discharge light sources
- UNECE Regulation No 99 : Gas-discharge light sources for use in approved gas-discharge lamp units of power-driven vehicles
- UNECE Regulation No 112 : Motor vehicle headlamps emitting an asymmetrical passing beam or a driving beam or both and equipped with filament lamps and/or LED modules
- UNECE Regulation No 123 : Adaptive front-lighting systems (AFS) for motor vehicles

As regards emissions and fuel consumption, reference is made to:

- Regulation (EC) No 715/2007 [129] for light duty vehicles, categories M1, M2, N1, N2
- Regulation (EC) No 595/2009 [130] for heavy duty vehicles, categories M3, N3

[126] REGULATION (EC) No 661/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2009R0661:20110501:EN:PDF , including amendments up to Commission Regulation (EU) No 407/2011 of 27 April 2011 OJ L 108 28.4.2011 p.13, but excluding amendments from Commission Regulation (EU) No 523/2012 of 20 May 2012 OJ L 160 21.6.2012 p.8

[127] UNECE is the United Nations Economic Commission for Europe. The main objective of the activities of the Committee on Economic Cooperation and Integration is to promote a policy, financial and regulatory environment conducive to economic growth, knowledge-based development and higher competitiveness of countries and businesses in the UNECE region. See: http://www.unece.org/. Many of the UNECE regulations are used directly in the EU-regulations. As regards lighting in vehicles, the UNECE has an Inland Transport Committee (ITC) under which resides the World Forum for Harmonisation of Vehicle Regulations (WP29) which on its turn has a Working Party on Lighting and Light Signalling (GRE).

[128] The UNECE regulations can be found on http://www.unece.org/trans/main/wp29/wp29regs41-60.html or associated web pages. They are part of the "Agreement Concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be fitted and/or be used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions." (Revision 2, including the amendments that entered into force on 16 October 1995)

[129] REGULATION (EC) No 715/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information (OJ L 171, 29.6.2007, p.1), consolidated version up to 459/2012. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02007R0715-20121231

[130] REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and

Some of the regulations listed above are briefly described below.

Regulation (EC) No 661/2009 is an implementation of framework Directive 2007/46/EC as regards safety aspects. It explicitly applies also to vehicle lighting. The regulation repeals, with effectiveness from 1 November 2014, a large number of directives related to vehicle lighting (article 19) and essentially replaces them by compulsory UNECE regulations [131]. Annex I of the regulation clarifies which lighting types are applicable to which vehicle categories. Annex IV provides a list of the applicable versions of the UNECE regulations.

At this stage only some of the UNECE regulations have been examined, in particular with the aim to verify if they contain requirements similar to those that would be included in ecodesign measures, i.e. energy efficiency requirements and functionality requirements for lamps or light sources. If so, the vehicle lamps would not be eligible for ecodesign measures considering Directive 2009/125/EC article 15.2(c)(i).

UNECE Regulation No 48 [132] is particular in that it does not regard a specific type of lamp or a specific lighting function, but deals in general with the installation on the vehicle of all lamps. It contains definitions for the various types of lamps, and for the fields on the x-y chromaticity diagram that are considered as white, red, amber, or selective yellow. In general, Regulation 48 specifies which types of lamps [133] are mandatory, which types are optionally allowed, and where, how, and how many of these lamps can be installed on a vehicle. The orientation of the light, the visibility in various directions, and the electrical connections are also addressed. For some lamps minimum and maximum light intensities are specified. For the individual lighting and light-signalling [134] functions (headlamps, stop lamps, indicator lamps, fog lamps, etc.) this regulation refers to other function-specific UNECE regulations, most of which have been listed above. One of these is Regulation 87, which is discussed below as an example. Regulation 48 does not contain requirements relevant for ecodesign, e.g. energy efficiency, lifetime, lumen maintenance etc.

UNECE Regulation No 87 [135] regards Daytime Running Lights (DRL) [136]. These lamps are of special importance because they have to be switched on during emission and fuel consumption tests (see later). The DRL shall be filament lamps according to UNECE Regulation 37 or LED light sources according to UNECE Regulation 128 (art. 3.2.2 and 6.5.1). The luminous intensity of the lamp shall not be less than 400 cd in the axis of reference and not more than 1200 cd in any direction (art. 7). The

on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC (OJ L 188 18.7.2009 p.1) http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0595

[131] Part 1 of Annex IV of Directive 2007/46/EC lists both the EC-regulations to be repealed from November 2014 and the newly applicable UNECE regulations.

[132] UNECE Regulation No 48, Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signalling devices, revision 12, 16 October 2014, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/updates/R048r12e.pdf

[133] In the sense of front lights, rear lights, indicator lights, license-plate lights, etc., NOT in the sense of the lamp technology that has to be used (filament, discharge, LED, ..).

[134] Lighting = Illumination of the road so that it can be seen by the driver. Light-signalling = Illumination or light reflection so that the vehicle can be seen by other road users. (this is no official definition)

[135] UNECE Regulation No 87, Uniform provisions concerning the approval of daytime running lamps for power-driven vehicles, revision 3, 20 August 2013, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2013/R087r3e.pdf (see also amendment 1)

[136] "'Daytime running lamp' means a lamp or an interdependent lamp system facing in a forward direction used to make the vehicle more easily visible when driving during daytime;" (Regulation 87, rev.3, amendment 1, article 2.1)

regulation prescribes how to measure the luminous intensity (voltage to be applied), after 1 minute and after 30 minutes, in the various directions (art. 10, Annex 3). In addition, a heat-resistance test of one hour is prescribed (art. 11). There are no requirements relevant for ecodesign, e.g. energy efficiency, lifetime, lumen maintenance etc. Note that Regulation 87 is a function-specific regulation and that it refers to other regulations (e.g. 37, 128) for lamp-technology-specific aspects. The same mechanism is also used in other function-specific regulations.

UNECE Regulation No 37 [137] regards the approval of Filament lamps for use in vehicle lighting. Approval for such lamps is requested with reference to a category of lamps. Annex I of the regulation contains a large number of datasheets for these categories. In addition to dimensional aspects, cap-types, and voltage levels (6, 12, 24 V), these datasheets also contain objective values for maximum power and luminous flux, which have to be met by the candidate lamps. Essentially this is equivalent to specifying a minimum energy efficiency in terms of lm/W. There are no requirements as regards lifetime or lumen maintenance.

UNECE Regulation No 128 [138] regards the approval of LED light sources for use in vehicle lighting. The principle is the same as for the Filament lamps above. Until now there are only two LED-categories defined, one for red light (objective values corresponding to 13-33 lm/W) and one for white light (objective values corresponding to 50-60 lm/W). There are no requirements as regards lifetime or lumen maintenance.

UNECE Regulation No 99 [139] regards the approval of gas-discharge light sources for use in vehicle lighting. The principle is the same as for the filament lamps above, i.e. Annex I contains datasheets for categories of discharge-lamps and candidate lamps have to meet the objective values for wattage and luminous flux specified there. Typical derived values are 70-90 lm/W depending on the category. This regulation also specifies start-up times and defines a tolerance field for the colour. There are no requirements as regards lifetime or lumen maintenance.

So the lamp-technology-specific UNECE regulations (37, 99, 128) contain prescriptions regarding energy efficiency. Approved lamps have a specific marking as defined in detail in the regulations.

Regulation (EC) No 715/2007 contains emission limits (euro 5 & 6) for light duty vehicles, but no test procedures on how to determine the emissions.

Regulation (EC) No 692/2008 [140] has to be consulted for the test procedures. Annex I, figure I.2.4 of this regulation specifies the tests that the manufacturer has to use to demonstrate compliance with the requirements, among which "CO_2 emissions, fuel consumption, electric energy consumption and electric range", mandatory for vehicles with any engine/fuel type. The corresponding test procedure

[137] UNECE Regulation No 37, Uniform provisions concerning the approval of filament lamps for use in approved lamp units of power-driven vehicles and of their trailers, revision 7, 3 July 2013, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/R037r7e.pdf (see also amendments 1-5)

[138] UNECE Regulation No 128, Uniform provisions concerning the approval of light emitting diode (LED) light sources for use in approved lamp units on power-driven vehicles and their trailers, 17 November 2012, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/updates/R128e.pdf (see also amendments 1-2)

[139] UNECE Regulation No 99, Uniform provisions concerning the approval of gas-discharge light sources for use in approved gas-discharge lamp units of power-driven vehicles, rev.3, 26 June 2014, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/updates/R099r3e.pdf

[140] COMMISSION REGULATION (EC) No 692/2008 of 18 July 2008 implementing and amending Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance (OJ L 199, 28.7.2008, p. 1), consolidated version including amendments up to 136/2014 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02008R0692-20140305

is provided in Annex XII of Regulation 692/2008, which however refers to UNECE Regulation No 101 for most general and technical test requirements.

UNECE Regulation No 101 [141] in article 5.2.1 specifies that

> "*The emissions of CO_2 and fuel consumption shall be measured according to the test procedure described in Annex 6 to this Regulation*".

In amendment 2 of 20 June 2014 on this regulation it is worthwhile to note the introduction of a new article 5.1.2:

> "*The daytime running lamps of the vehicle as defined in paragraph 2.7.25. of Regulation No. 48 shall be switched on during the test cycle if the vehicle is required to be equipped with daytime running lamps as indicated in paragraph 5.22. of Regulation No. 48. The vehicle tested shall be equipped with the daytime running lamp system that has the highest electrical energy consumption among the daytime running lamp systems, which are fitted by the manufacturer to vehicles in the group represented by the type approved vehicle. The manufacturer shall supply appropriate technical documentation to the Type Approval Authorities in this respect.*"

This includes the energy consumption of some of the vehicle lights in the evaluation of the emissions and of the fuel consumption of the vehicles. However, as clarified in UNECE Regulation 48 art. 6.19, daytime running lights are not allowed in all countries.

To complete the discussion, Annex 6 of Regulation 101 in art. 1.1 and 1.2 states:

> *Emissions of carbon dioxide (CO_2) and fuel consumption of vehicles powered by an internal combustion engine only shall be determined according to the procedure for the Type I test as defined in Annex 4a to Regulation No. 83 in force at the time of the approval of the vehicle.*
>
> *Emissions of carbon dioxide (CO_2) and fuel consumption shall be determined separately for the Part One (urban driving) and the Part Two (extra-urban driving) of the specified driving cycle.*

UNECE Regulation No 83 [142] in Annex 4a defines the urban cycle and the extra-urban cycle and provides all the details of the tests to determine gaseous and particle emissions. The fuel consumption is calculated on the basis of the emissions, see Annex 4a article 1.4.2 and 1.4.3 (text of amendment 2 should be considered!).

As regards emissions and fuel consumption of heavy duty vehicles (categories M3, N3), the regulative mechanism is similar to the one described above. Regulation (EC) No 595/2009 contains the emission limits, but the test procedures are defined in Regulation (EC) No 582/2011 which in Annex VIII refers to UNECE Regulation 49, Annex 12. This has not been explored in detail.

[141] UNECE Regulation No. 101, "Uniform provisions concerning the approval of passenger cars powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range, and of categories M1 and N1 vehicles powered by an electric power train only with regard to the measurement of electric energy consumption and electric range", rev.3, 12 April 2013, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/updates/R101r3e.pdf (see also amendments 1 and 2)

[142] UNECE Regulation No. 83, "Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements", rev.4, 26 April 2011, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/r083r4e.pdf (see also amendments 1-3 and corrigenda 1 and 2)

In summary, safety aspects of lamps in cars and trucks are regulated extensively through EU regulation and to add extra Ecodesign requirements for these products has a considerable risk of a significant negative impact on safety and functionality. Furthermore, the energy consumption of some vehicle lamps –i.e. the Daylight Running Lamps—has been recently, per 20 June 2014, included in the test cycle for the vehicles and thus has an influence on the overall efficiency and CO_2 emissions of the vehicles, which in turn are subject to several EU measures (labelling, emission standards, agreements with industry). Finally there are several regulations that set a maximum power and a minimum luminous flux on specific lamp types, demonstrating that the EU is dealing with the issue of energy efficiency in the transport sector.

The definition of vehicle lamps could involve lamp types referenced/defined in the appropriate (UNECE and EU) regulation.

Considering the above, the study team proposes to exclude lighting for motor vehicles (M, N, O category vehicles) from the scope of the current study, because other relevant Community regulation exists, and because market forces seem to be able to address the issue properly (Directive 2009/125/EC article 15.2(c)(i)). A definition still has to be agreed.

Lighting in/on mopeds, motorbikes and similar

An overview of directives and regulations on two- and three-wheel vehicles and quadricycles (category L vehicles) can be found in the reference [143].

Similar to the situation for cars, trucks and busses discussed above, there is a regulation regarding the general type-approval for L-category vehicles that contains requirements for lighting, but for the technical requirements it essentially refers to UNECE regulations.

The European regulation is in a phase of transition. The existing regulations contained in Directive 2009/67/EC [144] and 2002/24/EC [145] have been repealed, with effectiveness from 2016, by Regulation 168/2013 [146], which has recently been supplemented by other regulations of which in particular Regulation 3/2014 [147] is relevant. Annex I of the latter regulation provides a list of UNECE regulations which apply on a compulsory basis, many of which regard lighting. Annex IX gives requirements applying to the installation of lighting and light signalling devices, including automatic switching of lighting. The precise definition of the vehicles to which these regulations apply can be found in 168/2013, article 2, article 4 and annex I.

As regards the installation of lighting the regulations refer to:

[143] http://ec.europa.eu/enterprise/sectors/automotive/documents/directives/motorbikes/index_en.htm

[144] DIRECTIVE 2009/67/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 July 2009 on the installation of lighting and light-signalling devices on two or three-wheel motor vehicles (OJ L 222, 25.8.2009, p. 1), http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0067-20131211&from=EN, including amendment of Commission Directive 2013/60/EU of 27 November 2013

[145] DIRECTIVE 2002/24/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 March 2002 relating to the type-approval of two or three-wheel motor vehicles and repealing Council Directive 92/61/EEC, (OJ L 124, 9.5.2002, p. 1) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2002L0024:20081211:EN:PDF, inclusive amendments up to Regulation 1137/2008.

[146] REGULATION (EU) No 168/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles, (OJ L60/52 2.3.2013), http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0168&from=EN

[147] COMMISSION DELEGATED REGULATION (EU) No 3/2014 of 24 October 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of two- or three-wheel vehicles and quadricycles (OJ L7/1 10.1.2014), http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0003&from=EN (see also Regulations 44/2014, 134/2014 and 901/2014).

- UNECE Regulation No 53 (category L3 vehicles) [148]
- UNECE Regulation No 74 (category L1 vehicles) [149]

For the UNECE regulations regarding specific lamp types, see Regulation 3/2014 annex I. For additional remarks regarding the UNECE regulations, see the previous section on cars, trucks and busses.

Considering the above, the study team proposes to exclude lighting for motorbikes and similar (L-category vehicles) from the scope of the current study, because other relevant Community regulation exists.

Lighting in/on aeroplanes

The rough preliminary estimate presented in Annex D.15 shows an EU-28 yearly energy consumption for aeroplane-related lighting of 0.02 TWh and associated lamp sales of 300,000 per year. Consequently aeroplane-related lighting does not seem to be a relevant topic for inclusion in an ecodesign study on lighting products.

Nevertheless a short study of regulations and standards regarding aircraft lighting was performed, but the selected results presented below are far from exhaustive. If it is decided to include aircraft lighting in the scope of the study, a more detailed investigation is required.

The top-level European regulations regarding aircrafts can be found on the EASA website [150]. As regards lighting, the most relevant information is found in the Certification Specifications (CS) for the various types of aircraft [151]. As an example, some articles from EASA CS-25 for large aeroplanes [152] are indicated below:

- CS 25.812 Emergency lighting, including Illuminated emergency exit marking and locating signs, sources of general cabin illumination, interior lighting in emergency exit areas, floor proximity escape path marking, and exterior emergency lighting. Prescribes the brightness of the signs in cd/m^2 or the illuminance in lux (lm/m^2).
- CS 25.1381 Instrument lights, only generic requirements.
- CS 25.1383 Landing lights, only generic requirements.
- CS 25.1385 Position light system installation, includes forward position lights (red and green on the front wings), rear position light (white on the tail or wing tip). Must be approved. Detailed specification of light intensity (cd) and colour.
- CS 25.1401 Anti-collision light system, one or more flashing white or red lights. Must be approved. Detailed specification of light intensity (cd).
- CS 25.1403 Wing icing detection lights, only generic requirements.

EASA CS-25 does not seem to include requirements for the general cockpit and cabin lighting.

Note that the main focus is on emergency lighting, position lights, and anti-collision lights, which seem to be the mandatory lights. The CS does not prescribe details on the light sources, lamps or luminaires

[148] UNECE Regulation No 53 rev3 Uniform provisions concerning the approval of category L3 Vehicles with regard to the installation of lighting and light-signalling devices, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2013/r053r3e.pdf

[149] UNECE Regulation No 74 rev2 UNIFORM PROVISIONS CONCERNING THE APPROVAL OF CATEGORY L1 VEHICLES WITH REGARD TO THE INSTALLATION OF LIGHTING AND LIGHT-SIGNALLING DEVICES http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/r074r2e.pdf

[150] https://www.easa.europa.eu/regulations

[151] A complete list of Certification Specifications can be found in: http://easa.europa.eu/document-library/certification-specifications?search=&date_filter[min]=&date_filter[max]=&

[152] EASA CS-25 Large Aeroplanes, amendment 15, Annex to ED Decision 2014/026/R
http://easa.europa.eu/system/files/dfu/00%20Annex%20to%20ED%20Decision%202014-026-R.pdf

to be used, but all lights (and in general all components, parts or appliances in or on an aeroplane) have to be approved. Such an approval can be obtained (amongst others) by satisfying the requirements of a European Technical Standard Order (ETSO), for example:

- ETSO-C30c Aircraft Position Lights
- ETSO-C85a Survivor Locator Lights
- ETSO-C96a Anti-collision Light Systems
- ETSO-C141 Aircraft Fluorescent Lighting Ballast/Fixture Equipment

A quick look to the EN-standards Aero-series [153] revealed a long list of standards on aircraft lamps but they all seem to regard incandescent lamps. Nevertheless a large variety of LED-lamps for aircraft applications is available on the market.

Considering the above, the study team proposes to exclude lighting for aircraft from the current study. A more precise definition may be required.

Lighting in/on ships

The rough preliminary estimate presented in Annex D.15 shows a negligible EU-28 annual energy consumption for ships-related lighting and associated lamp sales of 76,000 units per year. Specific lighting products for ship-lighting are therefore not eligible for ecodesign measures according to Directive 2009/125/EC article 15.2.

At this stage no research has been conducted on the existence of regulations or standards on ship-related lighting.

Lighting for ships, in particular exterior lighting, will have special waterproof requirements and, as regards marine applications, corrosion-resistance requirements (salted sea water). Most likely such requirements have been resolved at the level of the luminaires: lamps and light sources used inside these luminaires might be the same as those for the main function examined in this study.

Most lighting for means of transport on water will be low voltage, battery-operated.

Considering the above, the study team proposes to exclude specific lighting for application on ships or other water-transport means from the scope of the current study, because such lighting does not meet the eligibility criteria from Directive 2009/125/EC article 15.2. However, see “other remarks on transport lighting” below.

Lighting in/on trains, trams and metro’s

The rough preliminary estimate presented in Annex D.15 shows an EU-28 annual energy consumption for train-related lighting of 0.15 TWh and associated lamp sales of 3.3 million units per year. The main contribution comes from the interior lighting for trains; the impact of head- and tail-lights is negligible.

At this stage no research has been conducted on the existence of regulations or standards on train-related lighting.

Most lighting for means of transport on rails is expected to be low voltage, battery-operated. Special requirements for the interior lighting may include vibration resistance and specific safety requirements, but lamps and light sources might be the same as those for the main function examined in this study.

[153] http://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID:6378&cs=13730F1CE30E0E27290D22896E49FE289

Considering the above, the study team proposes to exclude specific lighting for application on trains or other rail-transport means from the scope of the current study, because the expected environmental impact of such lights is small. However, see "other remarks on transport lighting" below.

Lighting on bicycles

Lighting on bicycles is either battery-operated or at zero-energy impact, i.e. the required energy for lighting is derived from the rotation of the wheels by means of a dynamo. All lamps and light sources will be low voltage.

At this stage no research has been conducted on the existence of regulations or standards on bicycle lighting and no energy estimates or sales estimates are available.

Considering the above, the study team proposes to not specifically include or exclude bicycle lighting from the scope of the current study, but to consider them as part of the battery-operated lamps.

Other remarks on transport lighting

A general exclusion from the regulations of lighting products designed for use in or on means of transport would probably be too vague and could potentially lead to loopholes, except where high acquisition costs for speciality lamps avoid this.

It might be necessary to make a distinction between specific lighting applications for transport such as head- and tail lamps, indicator lamps, anti-fog lamps, aircraft anti-collision lights etc. and more generic lights used in or on means of transport. In particular lamps for lighting the interior of means of transport such as ships, trains and busses might not be very different from those for the main lighting function examined in this study. Some lamps used for exterior lighting on ships might also be 'abused' for outdoor lighting in other places.

1.4.2.15. Other mobile lighting

Under the heading 'other mobile lighting' Annex D.15 mentions gas lamps (camping, non-electric, see par. 1.4.2.19) and torchlights (battery-operated, see par. 1.4.2.18).

As such, the terminology 'other mobile lighting' is not very adequate: floor standing lamps, desk lamps, any luminaire with a long wire used to light spaces far away from a grid connection, and any luminaire not fixed, directly or indirectly, by means other than a power supply cable, to a building or to the ground, could be seen as 'mobile'. Some of the examples of shockproof lamps for use in car repair shops, in building restructuration, do-it-yourself situations etc. could also be seen as 'mobile lighting', see par. 1.4.2.1.

Status in current regulations

In Regulation 244/2009, there is no reference to mobile or fixed lighting. A mobile light could well be used for 'household room illumination' and thus is in the scope, if not exempted for other reasons.

In Regulation 245/2009, the definitions for 'office lighting' and 'street lighting' both explicitly refer to a 'fixed' lighting installation. However, these definitions are used only to present benchmark data. They are not used for formulation of the requirements. A mobile light could be exempted if considered to be for 'applications other than general lighting' as it will typically provide 'local' lighting, but this is not clear.

In Regulations 1194/2012 and 874/2012, there is no distinction between mobile and fixed lamps, so mobile lamps, if not exempted for other reasons, are in the scope of these regulations.

Remarks regarding the scope of the current study

'Other mobile lighting' is not an adequate definition and can therefore neither be included nor excluded from the scope of the current study. Except for transport lighting (see par. 1.4.2.14) it is proposed not to make any distinction between fixed and mobile lighting.

1.4.2.16. Lighting for data communication and lasers

Annex D mentions some examples that include infrared LED lights for remote controls and various laser-applications.

Status in current regulations

As regards Regulation 244/2009, they are clearly outside the scope because they are not 'household lamps'.

In Regulation 245/2009, they are clearly outside the scope because they are not fluorescent lamps or HID-lamps, and anyway they are not used for 'general lighting' (there is no area being lighted while there are local requirements).

As regards Regulation 1194/2012, the light for data communication and lasers is clearly directional and it could come from LED lamps. Considering the definition for 'lighting' it is clear however that the 'primary purpose of the light is not lighting' and consequently this group of 'lamps' is exempted. For the same reason lamps for data communication and laser generated light are exempted from Regulation 874/2012.

Many of the 'lamps' in this group may also be exempted from current regulations because their light is 'non-white'.

Remarks regarding the scope of the current study

The energy estimate and sales data presented in Annex D.15 for lighting products in this category are not complete and do not allow to draw conclusions regarding the scope. In addition, the heading 'data communication and (other) laser applications' is not a sufficiently precise definition for the purposes of including or excluding certain types of lighting products.

A first remark is that not all laser applications should be disregarded a priori. There are already lighting applications on the market that have the main function being targeted in the current study, i.e. to 'make objects or scenes visible', and that are based on laser sources (see par. 1.6.4). It could be necessary to consider these technologies as BAT or BNAT, so they should not be excluded from the scope.

A second remark is that the examples in Annex D.15 also include 'dashboard and indicator lights'. If this is considered as 'data communication', other signalling and signage lamps could also be conceived to belong to this group, e.g. traffic lights, rail-road signals, exit signs, advertisement signs, etc. A better definition would be required.

Maybe a useful criterion for exclusion of some light sources from the current study could be if the emitted light is primarily intended to be seen by humans. This could be used to exclude for example IR lighting for remote controls, laser light used for cutting or automatic positioning, or light sources used for transmission of signals through fibre-optical cables.

Remarks regarding coverage by (other) EU measures

At the moment there is a preparatory study on the energy use of data servers (ENTR Lot 9), which may lead to measures regarding one of the more energy-intensive applications of light in data transmissions (i.e. large capacity routers).

In principle the study team proposes to exclude lighting products used for the transmission of signals between instruments (data communication in a strict sense; better definition needed).

It is NOT recommended to exclude a priori all laser lighting products.

1.4.2.17. Emergency lighting

See also par. 1.4.2.5 for exit signs. Although both have a safety purpose, emergency lighting is different from exit signs. Emergency lighting has a lighting function, even if in special circumstances, while the primary purpose of exit signs is NOT lighting. Exit signs are always 'on' while emergency lighting is sometimes switched 'on' only in special circumstances [154].

Emergency Lighting is subject to specific standards, see Annex H.11.

Status in current regulations

In Regulation 244/2009, emergency lighting is not mentioned explicitly. Lamps used in emergency lighting could be excluded from the scope of this regulation if they are not 'household lamps'. Considering that household rooms usually will not have emergency lighting, this exemption seems reasonable, but some doubt remains. Lamps that can be used both for household room illumination and for emergency lighting are not exempted.

Regulation 245/2009 explicitly exempts "*emergency lighting **luminaires** and emergency sign luminaires within the meaning of Directive 2006/95/EC*". Contrary to the expectation, the reference directive (Low Voltage Directive) does NOT mention emergency lighting. The exemption is for luminaires; lamps used inside these luminaires do not seem to be excluded. They could be excluded if they are considered to be 'not for general lighting', but that is rather vague for emergency lighting.

Regulation 1194/2012 exempts "*Products for (…) special applications (…) that require technical parameters not necessary for the purposes of lighting average scenes or objects in average circumstances*". Among the specific examples are "*lighting applications where (…) lighting is required only for emergency situations (such as emergency lighting luminaires or control gears for emergency lighting)*". The formulation suggests that only luminaires and ballasts are excluded, not the lamps used inside emergency lighting luminaires, but this is not completely clear.

In Regulation 874/2012, there is no clear exemption for lamps in emergency lighting. They might be exempted if they are "*marketed for operation with batteries* ". As for all lamp types, if the lamps are excluded from the ecodesign regulations, they can be considered excluded from the labelling regulation as well if they are interpreted as being 'non-compliant' with the ecodesign regulations.

Emergency lighting is specifically mentioned in the draft Ecodesign Working Plan 2015-2017, see par. 1.4.1.7.

[154] In its comments on this report, IALD states that: "There seems to be a fundamental misunderstanding of building emergency lighting. In many cases this is required to be maintained, therefore is on whenever the building is occupied." This does not exclude that there are two different functions: a lighting function and a signage function.

Remarks regarding the scope of the current study

In the current regulations the lamps and light sources (not luminaires) used for emergency lighting are not clearly excluded. In addition, the same lamps and light sources could probably also be used for other applications: it would be difficult for market surveillance to establish that a light source is being marketed only for emergency lighting purposes.

No energy consumption estimates are currently available for emergency lighting, but considering that operation hours are low, the environmental impact is not expected to be significant.

The study team proposes not to specifically exclude lamps and light sources for emergency lighting from the scope of the study.

1.4.2.18. Battery-operated lighting

No high-level exclusion of battery-operated equipment has been found in the Ecodesign Directive, so in principle battery-operated lighting could be subject to ecodesign measures.

Status in current regulations

Regulation 244/2009 does not make a distinction between battery-operated lighting and other lighting. It is difficult to state that per definition battery-operated lighting is not suitable for 'household room illumination'. Even Recital (5) that states "*Products subject to this Regulation are designed essentially for the full or partial illumination of a household room*" does not lead to exemption because there are numerous battery-operated lamps (luminaires) designed and marketed for use in households.
The regulation explicitly excludes "*incandescent lamps with E14/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer (…)* " and this could indicate some battery-operated lamps, but this exclusions is only for stages 1-5, not for stage 6.
Battery-operated lamps do NOT seem to be excluded from this regulation.

Regulation 245/2009 does not exclude battery-operated lamps. Not even the generic exemption "*products intended for use in applications other than general lighting*" is applicable.

Regulation 1194/2012 does NOT seem to exclude battery-operated lamps. There is no 'special application' that applies to these lamps.

Regulation 874/2012 explicitly excludes "*lamps and LED modules marketed for operation with batteries*" from the labelling requirements. Luminaires that are designed exclusively to operate such lamps are also exempted. For luminaires, it will usually be clear if they are intended for battery-operation or not. For the light sources, this might be more difficult to verify. The criterion does not seem to exclude all low voltage lamps that will work on DC.

The difference between the labelling regulation and the ecodesign regulations as regards battery-operated lamps is a topic that needs attention when drafting a new regulation.

Remarks regarding the scope of the current study

Battery-operated lights include a wide range of lighting products among which torches, warning lights for road works, lights working on solar energy power, emergency lights, many lights used on board of means of transport, etc.

At the moment, there does not seem to be a valid reason to exclude battery-operated lights from the scope of the current study.

1.4.2.19. Non-electric lighting

Lighting can also be supplied using non-electric power supplies, based for example on gas, oil, paraffin- or beeswax (candles), wood fireplaces, radio-activity, etc.

Status in current regulations

Regulation 244/2009 (surprisingly) does not specifically exclude non-electric lamps, nor does it specifically apply to electrical lamps. The entire regulation is clearly written however with electrical lamps as the target products. Many non-electric lamps could be indirectly excluded if they have a luminous flux of less than 60 lumen.

Regulation 245/2009 specifically applies to 'fluorescent lamps without integrated ballast' and 'high intensity discharge lamps'. From the definitions, it is clear that these operate on an electric discharge and that seems to exclude non-electric lamps.

Regulation 1194/2012 explicitly states that it applies to 'electrical lighting products' (article 1), and the corresponding definition in article 2 clearly excludes non-electric lamps.

Regulation 874/2012 already clarifies in its title that it only applies to electrical lamps.

Remarks regarding the scope of the current study

From a theoretical point of view, ecodesign studies should regard the function performed by the lighting product and not exclude a priori some possible types of power supply. However, from the practical point of view the study team expects that neither the Commission nor the stakeholders intend to include non-electric lamps in the study. An exception could be made for very specific applications such as 'self-luminous' exit signs using tritium (H_3) gas, where the radioactive isotope makes the signs light up (no electricity, works reportedly for 15 years, 130 000 hours).

The study team proposes to exclude non-electric lamps from the scope of the study.

1.4.2.20. Lamps with more than 12,000 lumen

The assignment for the study specifies to analyse excluded lamps and to identify if they should be included in the study (Task 0 report). Lamps with more than 12,000 lumen are explicitly mentioned as an example.

These lamps are excluded as such only in Regulation 244/2009. They could be excluded for other criteria in other regulations, see also par. 1.4.2.8 and 1.4.2.9. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Lamps with a light output over 12,000 lumen are mainly professional projection or spot (arc-) lamps. Some examples are presented in Annex D.7.

Additional data have to be gathered in other MEErP tasks to verify if it is possible/worthwhile to include these lamps.

1.4.2.21. Lamps with less than 60 lumen

Lamps with a light output less than 60 lumen are mainly decorative lamps (low-wattage incandescent, e.g. 11 W).

Note that these lamps are excluded as such only in Regulation 244/2009. In other regulations they could be excluded for other criteria.

Regulation 874/2012 exempts lamps with less than 30 lumen. Lamps between 30 and 60 lumen would be exempted from 874/2012 if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify if it is possible/worthwhile to include these lamps.

1.4.2.22. Double capped fluorescent lamps with diameter 7 mm (T2) and less

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

These lamps might be used for backlighting, food display lighting, integration in household appliances or furniture, for example.

Additional data have to be gathered in other MEErP tasks to verify all applications for these lamps, why they were exempted, and if exemption is still necessary.

1.4.2.23. Double capped fluorescent lamps with diameter 16 mm (T5) and power ≤ 13 W

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

These lamps might be used for backlighting, food display lighting, integration in household appliances or furniture, for example.

Additional data have to be gathered in other MEErP tasks to verify all applications for these lamps, why they were exempted, and if exemption is still necessary.

1.4.2.24. Double capped fluorescent lamps with diameter 16 mm (T5) and power > 80 W

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify the applications for these lamps, why they were exempted, and if exemption is still necessary.

1.4.2.25. Double capped fluorescent lamps with diameter 38 mm (T12) and special characteristics

Lamps with a diameter of 38 mm (T12), lamp cap G-13 Medium BiPin base, +/– 5 m (+magenta, –green) colour compensating filter value limit (cc). CIE coordinates x=0.330 y=0.335 and x=0.415 y=0.377.

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify the applications for these lamps, why they were exempted and if exemption is still necessary.

1.4.2.26. Double capped fluorescent lamps with diameter 38 mm (T12) and external ignition strip

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify the applications for these lamps, why they were exempted, and if exemption is still necessary.

1.4.2.27. Single capped fluorescent lamps with diameter 16 mm (T5) and special characteristics

Single capped fluorescent lamps having a diameter of 16 mm (T5) 2G11 4 pin base, Tc = 3 200 K with chromaticity coordinates x=0.415 y=0.377 and Tc = 5 500 K with chromaticity coordinates x=0.330 y=0.335.

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify the applications for these lamps, why they were exempted and if exemption is still necessary.

1.4.2.28. High intensity discharge lamps with Tc > 7 000 K

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify the applications for these lamps, why they were exempted and if exemption is still necessary.

1.4.2.29. High intensity discharge lamps not having lamp cap E27, E40, PGZ12

These lamps are explicitly exempted in Regulation 245/2009. In Regulation 874/2012 they would be exempted if considered 'non-compliant' with ecodesign regulations.

Additional data have to be gathered in other MEErP tasks to verify the applications for these lamps, why they were exempted, and if exemption is still necessary.

Question:
Stakeholders are explicitly invited to provide information, opinions and comments regarding the lamp types discussed in par. 1.4.2.

1.5. Mains voltage directional filament lamps

Regulation 1194/2012, Annex III point 1.1 sets **Energy Efficiency Requirements for Directional lamps** by prescribing a maximum Energy Efficiency Index (EEI).

In stage 3 (September 2016), **directional mains voltage filament lamps** should have an EEI< 0.95 (for all Φ_{use}), corresponding to class B of CDR 874/2012 (see Task 0 report).

As specified in the regulation, this stage 3 requirement will be applicable only if no later than September 2015 evidence is produced by the Commission through a detailed market assessment and communicated to the Consultation Forum that there are mains voltage lamps on the market that are:

- compliant with the maximum EEI requirement in stage 3;
- affordable in terms of not entailing excessive costs for the majority of end-users;
- broadly equivalent in terms of consumer-relevant functionality parameters to mains voltage filament lamps available on the date of entry into force of Regulation 1194/2012, including in terms of luminous fluxes spanning the full range of reference luminous fluxes listed in Table 6 of Regulation 1194/2012;
- compatible with equipment designed for installation between the mains and filament lamps available on the date of entry into force of this Regulation according to state-of-the-art requirements for compatibility.

According to the assignment (see Task 0 report) this market assessment has to be performed as part of this preparatory study. Consequently, the study will pay special attention to mains voltage directional lamps.

Question:
Stakeholders are explicitly invited to provide information, opinions and comments regarding directional mains voltage lamps in relation to Regulation 1194/2012 annex III point 1.1.

1.6. Recent lighting technologies

1.6.1. OLED lighting

In the OLED Handbook [155] OLED lighting is defined as follows:

> *"An OLED is a solid-state semiconductor made from a thin film of organic (carbon-based) material that emits light when electricity is applied. OLEDs have a similar structure to LEDs (which can be referred to as inorganic LEDs), but unlike LEDs, OLEDs can be used to make displays and area lighting panels.*
>
> *An OLED is a diode. When current is applied, electrons flow from the cathode to the anode. When these electrons go through the OLED emissive layer, photos are released. The cathode 'pushes' electrons into the emissive layer, while the anode removes electrons from the conductive layer (which leads to 'holes' in the conductive layer). The 'new' electrons in the emissive layer combine with the holes in the conductive layer and create excitons. This process releases photons—and thus light is created. Different types of emissive materials can be used to change the colour of the light. The intensity of the light is controlled by the amount of current applied."*

OLEDs are similar to LEDs in the sense that both use solid-state semiconductor materials that emit light from a p-n-junction. They are different in the sense that LEDs use inorganic materials while OLEDs use organic (carbon) materials. LEDs use a small semiconductor crystal with reflectors and other parts to make the light brighter and focused into a single point. OLEDs use a flat sandwich of materials: at least two layers (p-layer + n-layer) between a cathode and an anode. Consequently, LEDs are

[155] The OLED Handbook, A Guide to OLED Technology, Industry & Market , 2014 edition, Ron Mertens, http://www.oled-info.com/handbook/

directional point light sources while OLEDs emit a diffuse (non-directional) light over a larger area[156]. Potentially, in future, OLED lighting panels can be flexible, transparent and colour-tuneable.

Most of the large lighting manufacturers and several smaller companies are performing research on OLED lighting and several commercial products are for sale [157] . However, these sales seem to be mainly sample kits for designers and premium lighting installations and luminaires. New targeted applications include museums, signage and emergency lighting. OLED lighting panels are still too expensive to be considered for general lighting service. In addition, due to their shape, they will not retrofit into existing luminaires. According to the OLED Handbook [155]:

> *"Most OLED panels available today can realistically only be considered prototypes or technology demonstrators: they are expensive, made in small quantities in pilot lines, small, rigid (on glass) and not very efficient or bright. Real mass production of OLED lighting samples is still some years away as companies struggle with the technical issues that still prevent them from making cheaper, larger and better panels. Real market adoption of OLED lighting is not expected before 2016. Some analysts believe that OLEDs will only ever fit in niche markets such as in-vehicle lights, emergency lighting and decorative and premium lighting."*

Some 'typical' characteristics of current OLED panels:

- Size: Typically 1 dm^2 or smaller, but larger ones exist for example: 119x119 mm by Osram, 210x105 mm by Philips, 150x150 mm by Lumiotec and 320x320 mm advertised by LGchem. Expected up to 1000x1000 mm flexible and colour tuneable in 2018.
- Efficiency: Current best for commercialised panels are 50 – 60 lm/W [158]. Expected by major manufacturers around 2018: 130 lm/W. US Department of Energy target for 2020: 150-170 lm/W. The potential future efficiency for OLEDs is expected to remain below the efficiency foreseen for LEDs.
- Lighting quality: Typical CRI > 80, available > 90, expected > 95 in 2018. OLED panels that are tuneable from cool white to warm white exist. In principle, light output could be adapted to match natural sun light.
- Luminous intensity: From 1000 to 3000 cd/m^2, expected 5000 cd/m^2 in 2018.
- Lifetime: Currently 8000 - 10000 h, expected 40000 h in 2018.
- Prices: Luminaires with OLED lamps > 400-500 euros, OLED panels: 150-300 $euros/dm^2$, expected 6 $euros/dm^2$ by 2018. If manufacturers succeed in entering into mass production, prices could go down by 90-95% but high investments are needed and OLED prices might continue to lag behind LED prices [155].
- Materials: Easy to dispose and recycle; no harmful materials; tiny amounts of non-toxic heavy material iridium.

[156] Description adapted from text in http://www.edisontechcenter.org/LED.html

[157] Examples: Philips Lumiblade OLED Panel Brite FL300 http://www.lighting.philips.com/main/led/oled/ http://www.lumiblade-experience.com/information.html ; OSRAM Orbeos http://www.osram.com/osram_com/products/led-technology/ oled-light-design/ ; Lumiotec P03 P04 P05 http://www.lumiotec.eu/index-en.html ; LG Chem OLED panels http://www.lgchem.com/global/green-energy/oled-lighting ; Verbatim Velve http://www.verbatimlighting.com/ article/oled/ ; others

[158] In March 2014 Konica Minolta announced the world's most efficient OLED lighting panel at 131 lm/W, raised to 139 lm/W in June 2014. This panel has 15 cm^2, life 55,000 h, 1000 cd/m^2, CRI 81, CCT 2857 K. www.oled-info.com/konica-minolta-break-their-own-record-worlds-most-efficient-oled-panel-139-lmw

The estimated global OLED lighting market is $100 - $150 million in 2013 (revenue) mostly from large premium installations [155] [159]. There is a general expectation that the market will continue to grow, but some doubt whether it will really ever take off.

In a press release of March 2014 [160] Konica Minolta announce that they will start mass production (1 million panels per month) of flexible OLED lighting panels in the autumn of 2014. A white panel of 150x60 mm (weight 5 g) and a colour tuneable panel of 50x30 mm (0.6 g) will be produced.

Conclusion

At this moment (June 2014), the impact of OLED lighting on the European market for general lighting applications is negligible. Given the information above, this is unlikely to change significantly before 2020. The future of OLED lighting is uncertain. OLED lighting may never obtain a significant share of the general lighting market, but the situation might also develop exponentially in favour of OLEDs.

However, there is a reasonable chance that any new lighting regulation(s), emitted as a follow-up of this preparatory study, will be in place for a fair period of time, during which at least some OLEDs are likely to come to the market. There is a risk that the early OLEDs perform poorly and cause market souring (as was the case with early CFLs). This has the potential to cause problems beyond OLEDs as the unsophisticated consumer is unlikely to know an LED from an OLED product, and so poorly performing OLEDs could create widespread dissatisfaction. Hence, it could be desirable / necessary to regulate OLEDs with the same performance requirements as LEDs.

1.6.2. FIPEL lighting

FIPEL stands for 'field-induced polymer electroluminescent' lighting technology. It consists of several thin layers of polymers (plastic) between an aluminium electrode (on the inside) and a conducting transparent electrode (on the outside). The polymers are iridium-doped and composited with single- or multi-walled carbon nano-tubes (SWNT or MWNT). An electric field caused by alternating current causes the polymer material to emit light through electroluminescence.

A press release [161] in December 2012 by the Wake Forest University (professor David Carroll) of North Carolina (USA) announced FIPEL as the new revolutionary lighting technology that would replace CFLs and LEDs. Backed by a scientific publication [162], the release indicated the following advantages of FIPEL technology:

- no annoying buzz as created by fluorescent lamps, flicker free, shatter resistant
- soft, white light – not the yellowish glint from fluorescents or bluish tinge from LEDs
- can be made in any colour and any shape – from 2×4-foot sheets to replace office lighting to a bulb with Edison sockets to fit household lamps and light fixtures
- at least twice as efficient as compact fluorescent (CFL) bulbs and on par with LEDs (but potentially in future slightly less efficient than LEDs)
- no mercury content; do not use any caustic chemicals in manufacturing and can easily be recycled because they're made of plastic.
- long-lasting (25,000-50,000 h)
- will cost less than LEDs and slightly more than CFLs.

[159] For comparison: industry revenue from light sources (not luminaires) in EU-27 is estimated to be around 6000 million euros in 2013 (VHK study, Future 2030).

[160] http://www.konicaminolta.com/about/releases/2014/0318_01_01.html

[161] http://news.wfu.edu/2012/12/03/taking-the-buzz-out-of-office-lights/ accessed June 2014

[162] Effect of multi-walled carbon nanotubes on electron injection and charge generation in AC field-induced polymer electroluminescence, Yonghua Chen et al, Organic Electronics Volume 14, Issue 1, January 2013, Pages 8–18, http://www.sciencedirect.com/science/article/pii/S1566119912004831

Several articles appeared in the media with positive reactions and appealing titles [163], but there were sceptic comments as well [164], underlining the lack of numbers and evidence and criticizing in particular the low luminous intensity obtained so far (100 – 350 cd/m^2).

Research on the same topic was previously being performed by the Seoul's Yonsei University [165].

Recent articles on the subject show that research is ongoing [166].

An exclusive worldwide license for the FIPEL technology is held by CEELITE Technologies. This company announced end 2012 that the first units for commercial use would be available by the end of 2013, but currently their website [167] says '*coming soon*' and '*CeeLite is currently targeting a launch of the FIPEL™ technology in 2015 – 2016*'.

This technology is clearly in a research and development phase. No commercial products seem to be available yet. The technology could be considered when determining BAT or BNAT.

1.6.3. ESL lighting

ESL stands for 'Electron Stimulated Luminescence' [168].

An ESL lamp has a transparent glass envelope coated on the inside with a light-emitting phosphor layer. Electrons emitted from a cathode strike the phosphor and the current returns through a transparent conductive coating on the envelope. The phosphor layer then emits light through the transparent face of the envelope. Consequently, the light is produced by cathodoluminescence in the same way as in the cathode ray tubes (CRT) applied in legacy displays. Different from the CRT displays, in the lamps the electron beams are not magnetically or electrostatically deflected.

The only company producing ESL lamps is the VU1 Corporation (New York, USA). On their website [169] they publicise the lamps as follows:

- Energy efficient: 70% more efficient than the incandescent bulb
- Long life: 10 years, up to 5 times longer than incandescent
- Superior light quality: unlike CFL or LED bulbs, ESL technology features a perfect light quality, indistinguishable from that of an incandescent lamp
- Turns on instantly, fully dimmable, uniform glare-free appearance
- No degradation from repeated use; no ballast burn-out due to heat
- Mercury free: household disposable and safe to recycle
- Affordable: ESL technology adapts to existing light bulb shape, reducing production costs and providing consumers and businesses with a competitive and cost-effective solution

[163] New Lighting Could Replace Fluorescents, CFLs, and LEDs As The Light Source Of The Future - FIPEL technology produces the soft, white light our eyes crave without that annoying fluorescent hum. http://www.popsci.com/science/article/2012-12/new-kind-lighting-could-replace-fluorescents-cfls-and-leds-light-source-future
Professor Invents The Best New Light bulb In 30 Years http://www.businessinsider.com/fipel-lighting-technology-david-carroll-wake-forrest-2013-1#ixzz34QC2jP91

[164] FIPEL wonder-light: Where are the numbers? - World's next great light may now exist, but announcement lacks credibility so far. http://arstechnica.com/science/2012/12/fipel-wonder-light-where-are-the-numbers/

[165] AC Field-Induced Polymer Electroluminescence with Single Wall Carbon Nanotubes, Jinwoo Sung et al, Nano Lett., 2011, 11 (3), pp 966–972, http://pubs.acs.org/doi/abs/10.1021/nl103458g

[166] High-color-quality white emission in AC-driven field-induced polymer electroluminescent devices, Yonghua Chen et al, Organic Electronics Volume 15, Issue 1, January 2014, Pages 182–188, http://www.sciencedirect.com/science/article/pii/S1566119913004527

[167] http://www.ceelite.com/products/fipel-panel-lighting

[168] Part of the following description has been taken from: http://en.wikipedia.org/wiki/Electron_stimulated_luminescence

[169] http://www.vu1corporation.com/

- Smaller carbon footprint: bulbs generated by ESL technology have a smaller carbon footprint throughout their lifecycles than those generated by LED and CFL technology
- Lower production costs: ESL bulbs have lower manufacturing and disposal costs compared to LED and CFL bulbs

Since October 2010, VU1 produces only one lamp model (Figure 3): the R30 ESL bulb that is intended as a replacement for the 65W incandescent R30 flood bulb in recessed light fixtures. As announced on the VU1 website, "*plans are in place to introduce the classic A-type lamp for US and European consumers, the R40 for the US commercial market and the R25 in Europe*".

The production process for ESL lamps is proprietary to VU1, and is patented or patent pending [170].

VU1 Corporation had considerable difficulties before the lamp could actually be placed on the market [171]. The fact that the new models, announced in 2011, are still not available, and the fact that the price of $15 did not go down since 2011 are indications that the ESL lamp does not sell in large quantities.

Considering in addition that the technology is proprietary and that the lamp type does not seem to be for sale in Europe, these lamps will not be considered in this preparatory study. The technology could be considered when judging BAT or BNAT.

Figure 3 ESL lamp from VU1 Corporation. R30 Reflector for use in place of standard 65W incandescent R30 bulbs for recessed light fixtures. Declared characteristics: 500 lm, 19.5 W, 115 V AC, CCT 3200 K, CRI 90+, power factor >0.99, life 11,000 hours without significant colour shift, full dimming (triac), illuminance (at 1m) in Cooper Halo™ recessed luminaire: 0˚ 180 Lux, 45˚ 138 Lux, 60˚ 103 Lux, price: $15 / piece (source: http://www.vu1corporation.com/)

1.6.4. Laser-diode based lighting

Recently, lighting products have appeared on the market that employ laser-diodes as the basic light source for the emission of white light, in applications such as projection systems and automotive high-beam front lighting. Research on this topic is ongoing and seems promising, but the technology is still expensive and limited to niche-markets for the named applications.

There are several techniques being experimented among which a laser-diode that emits blue light which is converted in white light by means of a phosphor disc (also referred to as 'phaser' technology, for phosphor-laser) and a technique that uses four laser-diodes of different colours. Compared to LEDs, the laser-diode technology is stated to have the advantages of enabling higher light intensity, higher luminous efficacy, smaller beam angle, and more compact lamp design.

[170] http://sound.westhost.com/lamps/esl-lamps.html

[171] http://gadgetwise.blogs.nytimes.com/2011/04/04/vu1-light-bulb-delayed again/?_php=true&_type=blogs&_r=0

This technology will be further discussed in MEErP Task 4 and could be worthwhile to consider as BAT or BNAT. For further information see the references [172].

1.7. Coding of lighting products for statistical and trade purposes

There are several worldwide, European and national product coding systems for statistical and trade purposes. A comprehensive explanation of the backgrounds and purposes of these systems and of the relations between them can be found in a Eurostat publication on the NACE Rev. 2 coding [173].

For the current study, the following three coding systems are relevant:

- The ProdCom coding [174], which is directly related to the CPA code [175] and to the NACE rev.2 code,
- The CN8 [176] coding, which is based on the HS coding [177],

[172] http://www.laserfocusworld.com/articles/2013/09/ucsb-laser-plus-phosphor-white-lighting-is-efficient-and-stable.html (UCSB laser-plus-phosphor white lighting is efficient and stable)
http://www.ledsmagazine.com/articles/2011/11/lasers-could-offer-alternative-to-led-light-sources.html
A. Neumann, J. J. Wierer, W. Davis, Y. Ohno, S. R. J. Brueck, and J.Y. Tsao, "Four-color laser white illuminant demonstrating high color-rendering quality." Opt. Express 19, A982-A990 (2011). http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-19-104-a982 (abstract)
http://www.osram-os.com/osram_os/en/news--events/spotlights/technology/2014/perfect-vision/index.jsp (laser light in automotive high-beam front lighting)
http://europe.autonews.com/article/20140107/ANE/301109994/bmw-audi-will-introduce-laser-headlamps-this-year (laser light in automotive high-beam front lighting)
http://www.christiedigital.com/Documents/Presentations/simuniversity2014/SIM%20U%202014%20-%2008%20-%20Solid%20state%20illumination%20challenges%20and%20opportunities%20-%20Arlington%20-%20Simon%20Guthrie.pdf (solid state illumination challenges; lasers as a projection light source)
http://www.christiedigital.com/SupportDocs/Anonymous/Christie_laser_phosphor_article.pdf (laser light use for projectors)
http://dmd.hitachi-america.us/supportingdocs/forhome/DisplayTechnologiesGroup/lcdprojectors/SupportingDocuments/Hitachi-Lamp-Technology-Facts.pdf (laser light use for projectors)
http://www.osram.com/osram_com/products/led-technology/specialty-lighting/led-modules/itos/itos-phaser-3000/index.jsp?productId= (laser light use for projectors)

[173] "NACE Rev.2, Statistical classification of economic activities in the European Community", Eurostat Methodologies and Working papers, Luxembourg: Office for Official Publications of the European Communities, 2008. http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-07-015/EN/KS-RA-07-015-EN.PDF
NACE is the acronym for 'Nomenclature statistique des activités économiques dans la Communauté européenne'. The comparison of various coding systems can be found in chapter 4 of the publication.

174 ProdCom originates from the French "PRODuction COMmunautaire". It is the EU system of production statistics for mining (NACE section B) and manufacturing (NACE section C). The product classification (PRODCOM list), upon which production statistics are based, is drawn up each year by the PRODCOM committee. The headings of the PRODCOM list are derived from the CN , but their code is a further breakdown of the CPA code. PRODCOM headings are coded using an eight-digit numerical code, the first six digits of which are identical to those of the CPA code, of which the first four digits are identical to the NACE rev.2 code.

[175] CPA 2008, Statistical Classification of Products by Activity

[176] The Combined Nomenclature contains the goods classification prescribed by the European Union for international trade statistics. The CN is an 8-digit classification consisting of a further specification of the 6-digit Harmonised System. See http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_GEN_DESC_VIEW_NOHDR&StrNom=CN_2014&StrLanguageCode=EN.
The definition of product codes for the Combined Nomenclature 2014 can be found in: COMMISSION IMPLEMENTING REGULATION (EU) No 1001/2013 of 4 October 2013 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff (OJ 31.10.2013 p1) http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri= CELEX:32013R1001&from=EN

[177] The **Harmonized Commodity Description and Coding System**, also known as the **Harmonized System** (**HS**), of tariff nomenclature is an internationally standardized system of names and numbers for classifying traded products which came

- The ILCOS code [178] (and LBS lamp coding system).

1.7.1. ProdCom coding

The **ProdCom coding** is used by Eurostat for access to data on lamp and luminaire production in the EU. It is an 8-digit code of which the first six digits correspond to the CPA code and the first four digits to the NACE rev.2 code. The codes relevant for lighting products are shown in Annex F. These codes differ from the ones used in preceding preparatory studies on lighting because the NACE codes, and consequently the CPA and ProdCom codes, were changed in 2008. The old NACE rev1.1 code for '*lighting equipment and electric lamps*' was 31.50 [179]; the new NACE rev.2 code is **27.40**.

1.7.2. CN and HS coding

Whereas ProdCom only refers to production data, **Europroms** refers to the combination of production and external trade data (import, export). Europroms uses the **Combined Nomenclature CN8 coding** (derived from the Harmonized System, HS), but on the Eurostat website [180], for user-convenience, the data is anyway displayed by ProdCom heading, and the equivalent CN8 headings are aggregated to provide the data equivalent to the ProdCom heading. See Annex F for the CN codes relevant for lighting products. Lamps are coded mainly under **85.39** and luminaires under **94.05**.

1.7.3. Coding for LED lighting products

Neither the ProdCom coding nor the CN/HS coding explicitly distinguish **LED lighting products**. According to a publication of LightingEurope (LE) [181], the CN-codes currently used for classification of LEDs are:

> LEDs (Light Emitting Diodes) are sometimes classified by national customs offices into CN subheading **85.41** 4010:
>
> *"Diodes, transistors and similar semiconductor devices, photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels (excluding photovoltaic generators),* ***light emitting diodes****, mounted piezoelectric crystals, parts thereof"*
>
> In other instances, LEDs are classified into CN subheading **85.43** 7090:
>
> *"Electrical machines and apparatus, having individual functions, not specified or included elsewhere in this chapter"*
>
> Finally, we also find LEDs being classified into CN subheadings 94.05 4039 or 94.05 4099 under HS heading **94.05**:

into effect in 1988, developed and maintained by the World Customs Organization (WCO) (formerly the Customs Co-operation Council), an independent intergovernmental organization with over 200 member countries based in Brussels, Belgium.

[178] International Lamp Coding System as originally defined in IEC/TS 61231 in 1993 and updated and amended in IEC 61231:2010+A1:2013, 27 June 2013. Standard for sale at: http://webstore.iec.ch/webstore/webstore.nsf/artnum/048201!opendocument

[179] See: http://ec.europa.eu/environment/emas/pdf/general/nacecodes_en.pdf

[180] http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction/europroms

[181] LightingEurope Position Paper – Custom Codes for LED Lighting Products, February 2014. http://www.lightingeurope.org/uploads/files/LightingEurope_Position_Paper_on_LED_Customs_Codes_February 2014.pdf

"Lamps and lighting fittings, including searchlights and spotlights, and parts thereof n.e.s, illuminated signs, illuminated nameplates and the like having a permanently fixed light source, and parts thereof, n.e.s."

As the different CN/HS codes are related to different applied taxes and duties, a 'smart' choice of the code leads to lower import duties for LEDs into Europe. In the publication, LE states that the lack of an adequate coding currently entails competitive disadvantages for European producers of lighting products.

In the same publication, LE formulates a **proposal for modification of the CN/HS coding** for the proper inclusion of LED lighting products. They ask to consider this proposal during the next review of the HS coding system in 2017:

- LEDs (i.e. LED chips and LED packages) should be covered under new/modified sub-headings of appropriately amended heading 85.41.
- LED light sources (i.e. LED lamps and LED modules/assemblies) should be covered under new/modified sub-headings of appropriately amended heading 85.39.
- LED Luminaires should be covered under new/modified sub-headings of appropriately amended heading 94.05.

The LE publication gives a useful survey of the variety of existing LED products and attempts definition of LEDs, LED packages, simple LED assemblies, complex LED assemblies, LED lamps and LED luminaires. For this reason, the publication has been integrally included in Annex G.

1.7.4. ILCOS codes for lamps

The **ILCOS lamp code** was developed by IEC to support the worldwide identification of compatible lamp types. The code is quite flexible and can contain more or less information. In the short form (ILCOS 'L') only the initial letter-part of the code is used, indicating the main lamp type and its shape. Examples of this short code can be found in Annex F.

The ILCOS 'D' code gives a more complete designation of the lamp, including both the letter-part and the numbers-part. The most extensive form of the code is ILCOS 'T' that also includes the full lamp denomination, information on norms, and all data relevant for usage of the lamp. All lamp manufacturers made a direct link between their private brand code and the ILCOS system. The responsibility for maintaining the ILCOS system is with the IEC lamp technical committee.

An example of the ILCOS code, illustrating its construction, is:

IAG/C//RS-40-220/230-E27-60

The first letter indicates the lamp category, in this example I=Incandescent lamp. The following letters indicate the shape of the lamp, A= Diameter over 45 mm, G=Globe / Sphere lamp shape. Additional letters separated by slashes can give many other lamp characteristics, in this case /C = Clear lamp, //RS = Resistant (shockproof). The following two numbers represent power (40 W) and operating voltage (220/230 V). The indication E27 gives the socket type and the last 60 is the nominal lamp diameter.

1.7.5. LBS lamp code system

In 1994 the German industry federation ZVEI (ZentralVerband Elektrotechnik und Elektronik-Industrie) produced a lamp coding system called Lampenbezeichnungs-system or LBS for short [182]. The codes according to this system are widely used by luminaire makers and clients in Europe. The system is of simple codes, has short descriptions and is maintained by ZVEI, but it is not supported by all lamp-makers or by international standards.

A full description of the code construction can be found in the reference, which also provides an extensive table with correspondence between LBS-codes and ILCOS-D codes. See also Annex F.

1.8. Lamp types for which sales data are available

As explained in the previous paragraph both ProdCom production data and Europroms import and export data are presented by Eurostat organised per ProdCom code. The relevant codes for lighting products are presented in Annex F. Europroms sales/trade data are available for the following lamp types:

- Tungsten halogen filament lamps, for a voltage > 100 V (excluding ultraviolet and infrared lamps, for motorcycles and motor vehicles) (ProdCom code 27401293; CN-code 85392192). These are **mains voltage halogen lamps, MV-HL**

- Tungsten halogen filament lamps for a voltage <= 100 V (excluding ultraviolet and infrared lamps, for motorcycles and motor vehicles) (ProdCom code 27401295; CN-code 85392198). These **are low voltage halogen lamps, LV-HL**

- Filament lamps of a power ≤ 200 W and for a voltage > 100 V including reflector lamps (excluding ultraviolet, infrared lamps, tungsten halogen filament lamps and sealed beam lamp units) (ProdCom code 27401300; combines CN-code 85392210 reflector lamps and CN-code 85392290 non-reflector lamps). These are the legacy **incandescent lamps for general lighting service (GLS)**

- Fluorescent hot cathode discharge lamps, with double ended cap (excluding ultraviolet lamps) (ProdCom code 27401510; CN-code 85393110). These are mainly **linear fluorescent lamps (LFL)**.

- Fluorescent hot cathode discharge lamps (excluding ultraviolet lamps, with double ended cap) (ProdCom code 27401530; CN-code 85393190). These are mainly **single-capped (compact) fluorescent lamps (CFL)**.

- Other discharge lamps (excluding ultraviolet lamps) (ProdCom code 27401550; combines CN-codes 85393210 mercury vapour lamps, 85393250 sodium vapour lamps, 85393290 metal halide lamps and 85393900 other discharge lamps). This includes all **high intensity discharge lamps (HID)** but it also includes lamp types that are exempted from the current regulations such as cold-cathode fluorescent lamps (CCFL), external electrode fluorescent lamps (EEFL) and neon lamps.

[182] LAMP DESIGNATION SYSTEM L B S Standardised system for the designation of electrical lamps for general lighting (including ILCOS-codes according to CEI IEC TS 61231), ZVEI 28 July 2010. http://www.zvei.org/Publikationen/Lampenbezeichnungssystem%20LBS.pdf

- Filament lamps n.e.c. (ProdCom code 27401490). This groups all filament lamps not elsewhere classified. In particular classical incandescent lamps (excluding tungsten-halogen lamps) with power > 200 W or for a voltage < 100 V.

- Sealed beam lamp units (ProdCom code 27401100) [183]. These are filament type PAR lamps. The major part of these lamps is used in vehicles and are outside the scope of the present study. Data on PAR lamps used for general lighting purposes in the context of this study are taken into account; see the section below on lamp sales data from LightingEurope.

- Ultraviolet or infrared lamps, arc lamps (ProdCom code 27401570; combines CN codes 85394100 arc lamps, 85394910 UV lamps and 85394930 IR lamps). These are special purpose lamps that are mainly outside the scope of the present study. These lamps are usually not taken into account in energy estimates for lamps in this study, except where special purpose lamps are being considered.

- Tungsten halogen filament lamps (HL) for motorcycles and motor vehicles (ProdCom code 27401250). These lamps are outside the scope of the present study.

- Filament lamps for motorcycles or other motor vehicles excluding sealed beam lamp units, tungsten halogen lamps (ProdCom code 27401460). These lamps are outside the scope of the present study.

Since 2009 LightingEurope provides sales data for lamps to the European Commission. These data are confidential but they can be used and elaborated in the context of ecodesign lighting studies. Elaborated and aggregated data are usually free for publication.

The LightingEurope data are provided for the following lamp types:

- Linear fluorescent lamps (LFL):
  - T12
  - T8 halophosphor
  - T8 triphosphor
  - T5 new (14 – 80W) including circular
  - All others (including T5 old types 4 – 13W and special fluorescent)
- Compact fluorescent lamps (CFL):
  - Retrofit CFLi (integrated ballast)
  - Non-retrofit CFLni (non-integrated ballast)
- Tungsten halogen lamps (HL):
  - Single ended, mirrored (low voltage) (M16, M25, etc.)
  - Linear (high voltage) (R7s)
  - LV halogen capsule (G4, GY6.35)
  - HV halogen capsule (G9)

[183] From http://en.wikipedia.org/wiki/Sealed_beam:
A sealed beam is a type of unitized lamp with a parabolic reflector, one or more filaments, and a glass or polycarbonate lens all permanently attached together and sealed. Originally introduced for road vehicle headlamp service, sealed beams have since been applied elsewhere. Halogen sealed beam lamps have an inbuilt halogen lamp with the filaments contained in a quartz or hard glass envelope.
Sealed beams are technically known as parabolic aluminized reflector or "PAR" lamps. Round PAR lamp diameter is expressed in non-metric units of measurement equal to one eighth of an inch, so a PAR56 lamp, for example, is 56/8" (i.e., 7 inches) in diameter. Other popular sizes are PAR30, PAR36, PAR38, PAR46, and PAR64.

  - Incandescent shape - GLS, decorative & reflector [184]
  - Other Mains Halogen - PAR 16/20/25/30 Hard glass reflectors, GU10 etc.
- Classical incandescent lamps (GLS):
  - Reflector
  - GLS (Including clear/pearl, candles, coloured & decorative)
- High intensity discharge lamps (HID):
  - All mercury lamps (including mixed)
  - All sodium lamps
  - Quartz metal halide lamps
  - Ceramic metal halide lamps [185]
- Light emitting diode lamps (LED):
  - Directional
  - Non-directional

The above subdivision of LightingEurope will be used in this study for the presentation of sales data, energy consumption estimates and potential energy savings.

1.9. Ballasts, control gears and drivers

For definitions of 'control gears/ballasts/drivers' [186] see par. 1.2.2.

The assignment for this study (see Task 0 report) does not explicitly mention 'control gears/ballasts/drivers', but it does refer to "*all lighting products currently regulated under Ecodesign and Energy Labelling*". This paragraph therefore identifies if and how 'control gears/ballasts/drivers' are treated in the existing regulations.

Regulation 244/2009 does not have specific requirements for control gears or ballasts. The target lamps for this regulation are GLS, HL and CFLi, which either do not use control gear or have ballast integrated in the lamp. Fluorescent lamps without integrated ballast and HID lamps are excluded from this regulation.

Regulation 245/2009 applies to fluorescent lamps without integrated ballast (LFL, CFLni) and to high intensity discharge lamps (HID). Ballasts to operate such lamps are explicitly included and the regulation repeals the previous Regulation 2000/55 on ballasts [187].

Annex III 2.1 specifies energy performance requirements for ballasts for fluorescent lamps without integrated ballast and for ballasts for high intensity discharge lamps. Energy performance at 100% load, during dimming, and in the no-load mode is addressed. See the summary of requirements in the Task 0 report.

Annex III 2.2 specifies product information requirements for ballasts, which mainly regards reporting of the energy efficiency index (EEI) class (for dimmable and non-dimmable fluorescent lamps) or directly the ballast efficiency (for high intensity discharge lamps).

[184] Also indicated in this study as: 'mains halogen (substitute for GLS and reflector) [E14, E27]'.

[185] In this study, the data for the two metal halide types are usually summed into a single figure.

[186] According to a LightingEurope comment on the draft report, the term 'driver' should be avoided. In IEC language the term 'control gear' is used.

[187] Directive 2000/55/EC of the European Parliament and of the Council of 18 September 2000 on energy efficiency requirements for ballasts for fluorescent lighting, 18 September 2000, OJ L 279, 1.11.2000, p. 33, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0055

Regulation 1194/2012 applies to directional lamps and LED lamps. "Equipment designed for installation between the mains and the lamps, including lamp control gear", is explicitly included but the ballasts for LFL, CFLni and HID, already covered in Regulation 245/2009, are excluded here. Ballasts that can be considered a 'special purpose products' (see par. 1.4.1.3) are also excluded.

Annex III 1.2 sets energy efficiency requirements for lamp control gear. This regards the power consumption in no-load mode and in standby mode. In addition, a minimum efficiency value of 0.91 at 100% load is specified for halogen lamp control gear.

Annex III 2.3 sets functionality requirements for equipment designed for installation between the mains and the lamps. In particular such equipment shall be compatible with energy efficient lamps that have EEI <0.24 for non-directional or <0.40 for directional. If the equipment does not comply, Annex III 3.4 prescribes that a warning in this sense must be published.

CDR 874/2012 does not foresee a labelling for ballasts or control gears, but in the calculation of the Energy Efficiency Index for lamps there is a correction factor that depends on the presence of a ballasts / control gear.

Conclusion

Equipment designed for installation between the mains and the lamps such as ballasts, control gears and LED control gears are inside the scope of the current preparatory study, in particular as regards the energy efficiency, the compatibility with energy-efficient lamps, and the compatibility with energy-saving lighting controls (dimmers).

1.10. Control Devices

For a definition of 'control device' see par. 1.2.2.

For other related information, see also the description of the Lot 37 study in the Task 0 report.

Although the assignment for the current study states that "*Lighting controllers previously not regulated, either as part of a luminaire or as an independent product, should be included in the study.*", the topic of lighting control will mainly be handled by the Lot 37 study which is being performed in parallel to the current Lot 8/9/19 study.

Issues related to dimming, and in particular the compatibility between lamps/light sources and dimmers, will be treated in the current Lot 8/9/19 study.

1.11. Luminaires

According to the assignment (see Task 0 report) "*The study should aim at setting more ambitious targets for all lighting products currently regulated under Ecodesign and Energy Labelling,* ***including luminaires*** *(both with or without built-in light sources such as LED-modules).*" This paragraph therefore identifies if and how 'luminaires' are treated in the existing regulations.

Regulation 244/2009 does NOT handle luminaires.

Regulation 245/2009 applies to fluorescent lamps without integrated ballast (LFL, CFLni) and to high intensity discharge lamps (HID). Luminaires to operate such lamps are explicitly included. Emergency

lighting **luminaires**, emergency sign luminaires, and luminaires covered by specified directives (see 1.4.1.2(m)) are excluded.

Annex III 3.1 specifies energy performance requirements for luminaires. Their power consumption shall not exceed the power consumptions of the incorporated ballasts when the lamps normally operated by the luminaire do not emit any light. In addition, they shall be compatible with energy efficient ballasts.

Annex III 3.2 specifies product information requirements for luminaires with total lamp luminous flux above 2000 lumen. These regard the efficiency of the contained lamps and ballasts (if they are sold together with the luminaire), the types of lamps and ballasts that are compatible with the luminaire, and maintenance and disassembly instructions.

Regulation 1194/2012 applies to directional lamps and LED lamps. "*Equipment designed for installation between the mains and the lamps, **including luminaires***", is explicitly included but the luminaires for LFL, CFLni and HID, already covered in Regulation 245/2009, are excluded here. Luminaires that can be considered as 'special purpose products' (see par. 1.4.1.3) are also excluded.

Annex III 2.3 sets functionality requirements for '*equipment designed for installation between the mains and the lamps*' and for Regulation 1994/2012 this includes also luminaires (see article 1(c)). In particular such equipment shall be compatible with energy efficient lamps that have EEI <0.24 for non-directional or <0.40 for directional. If the equipment does not comply, Annex III 3.4 prescribes that a warning in this sense must be published.

Annex III 2.3 also states that: "*When a luminaire is placed on the market and intended to be marketed to the end-users, and lamps that the end-user can replace are included with the luminaire, these lamps shall be of one of the two highest energy classes, according to Commission Delegated Regulation (EU) No 874/2012, with which the luminaire is labelled to be compatible*."

The regulation does NOT specify energy performance requirements for luminaires comparable with those in 245/2009. It is important to note however that the requirements applicable to 'LED lamps' also apply to integrated LED luminaires. In this context, the following points from Regulation 1194/2012 are relevant (see also the discussion in par. 1.2.1):

- Recital (16): "*LED luminaires from which no LED lamp or module can be extracted for independent testing should not offer a way for LED manufacturers to escape the requirements of this Regulation.*"
- *" 'lamp' means a unit whose performance can be assessed independently and which consists of one or more light sources. It may include additional components necessary for starting, power supply or stable operation of the unit or for distributing, filtering or transforming the optical radiation, in cases where those components cannot be removed without permanently damaging the unit*;"
- *" 'LED lamp' means a lamp incorporating one or more LED modules. The lamp may be equipped with a cap;"* This definition covers both an LED lamp for retrofitting of a non-LED lamp as well as a completely integrated LED luminaire.
- In the 245/2009 definition of 'luminaire' it is explicitly stated that it does NOT include the light sources. In the 1194/2012 definition this has been changed so that the light sources can be included, thus covering an integrated LED luminaire.
- In Annex IV there are separate verification procedures for "*LED lamps that are meant to be replaced in the luminaire by the end-user*" and "*LED modules not intended to be removed from the luminaire by the end-user*". For the verification of the latter, the authorities shall obtain "*LED modules or luminaires as applicable*". It is also specified that: "*If the technical*

documentation file of the luminaire provides for testing the whole luminaire as a lamp, the authorities shall test 20 luminaires as lamps."

CDR 874/2012 provides labelling requirements for luminaires that operate filament lamps, fluorescent lamps, high intensity discharge lamps, LED lamps and LED modules, "*including when they are integrated into other products that are not dependent on energy input in fulfilling their primary purpose during use (such as furniture).*" Luminaires that are designed to operate exclusively lamps and LED modules that are exempted from 874/2012 (see par. 1.4.1.4) are excluded from the requirements.

The definitions for 'lamp', 'LED lamp' and 'luminaire' are the same as in 1194/2012.

Annex I point 2 defines the possible labels for luminaires. The label information focuses on the energy efficiency classes of the lamps that are compatible with the luminaire, the class of the lamp supplied together with the luminaire (if any), if the lamp can be substituted by the user, if the luminaire contains or can contain LED lamps.

Conclusion

Luminaires designed to operate all the lamp types considered in this study are also inside the scope of the current preparatory study, in particular as regards the compatibility with energy-efficient lamps and the compatibility with energy-saving lighting controls (dimmers).

Considering the large variety of shapes and materials used for luminaires, the material use efficiency, production aspects, and end of life aspects of luminaires cannot be included.

1.12. Summary of the product scope

The initial scope of the study regards all light sources, lamps, ballasts and lamp control gears according to the definitions provided for these lighting products [188]. The definition for light sources limits their scope to "*surfaces or objects designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wavelength of 380-780 nm.*"

In addition the study also includes control devices and luminaires, but only as regards their integration with the lamps or as regards their compatibility with separately marketed lamps or light sources [189].

This extensive initial scope can be restricted using the eligibility criteria for the application of ecodesign measures of article 15 of the Ecodesign Framework Directive 2009/125/EC. The scopes, exemptions, definitions and lighting functions of the current regulations have to be ignored for the purpose of establishing a scope for the current study, at least in this stage.

As explained in par. 1.1, the possibilities to restrict the scope in the current MEErP Task 1 are limited, because information that should be gathered in future MEErP tasks is still missing. Nevertheless a first analysis of the scope was performed (par. 1.4, in particular par. 1.4.2), including a review of the status of the various types of lamps in the existing regulations, and a proposal for their inclusion in or exclusion from the scope of the current study, where possible (see Table 1). Note that lamp types that are clearly in the scope of the current regulations have usually not been discussed as it is implicitly assumed that these will also be in the scope of the current study.

[188] See chapter 5 of the Task 0 report and par. 1.1, 1.2 and Annex B of this Task 1 report.

[189] In their comments to the report, ANEC&BEUC highlight the importance for the consumer of including luminaires in the scope of the study.

In many occasions the review highlights a lack of accurate definitions; in particular a lack of technical parameter definitions that enable market surveillance to establish in a straightforward and affordable manner if a lamp is of the declared type. The priority in this moment is to establish these definitions, rather than to decide if a certain type of non-well-defined lamp should be in or out the scope of the current study. Establishing these definitions is a task of the current study, that has been initiated with the information and analysis presented in this report, but should now proceed in cooperation with the stakeholders.

When interpreting Table 1 [190] the following should be taken into account:

- Consider the Table together with the contents of Annex D and of the referenced paragraph.
- Including lamps in the study is a momentary MEErP Task 1 decision: lamps could anyway be excluded in future after additional information has been gathered in other MEErP tasks.
- Including as many lamps as possible might seem attractive to avoid definition problems and possible loopholes for later regulations. However, lamps that have special characteristics or that have different functions are likely to need different minimum requirements. This means that, when included, they have to be accurately defined anyway to distinguish them from other lamps with other requirements, and each lamp type may need its own preparatory study (standards, sales, usage-characteristics, base case technology, BAT, scenarios, consumer impact, industry impact, health issues, etc.).
- Including lamps in the study consequently is an effort. This effort should be made only if retained really necessary and the amount of invested work should be in proportion to the ecodesign savings that can be expected. By including too many lamp types in the study, there is a risk of decreasing the quality of the study on the bulk of the lamps, i.e. on the most important part.

Lamp type description	(Momentary) Proposal for the scope of the current study			Reference par.
(usually better definition required)	included	excluded	open/undefined	*(see also D.15)*
LFL covered by current regulations	x			
CFLni covered by current regulations	x			
CFLi covered by current regulations	x			
HL-MV covered by current regulations	x			
HL-LV covered by current regulations	x			
GLS-MV covered by current regulations	x			
GLS-LV covered by current regulations	x			
HID covered by current regulations	x			
LED covered by current regulations	x			
Lamps for extreme physical environments				1.4.2.1
Shock resistant	x			
Vibration resistant	x			
Shatter resistant	x			
Temperatures below -20˚C	x			
Temperatures above +50˚C	x			
Explosion proof	x			
Non-white lamps				1.4.2.2
Fixed or variable non-white colour			too generic	
Colour-changing-ability including white	x			
Ultra-Violet lamps				1.4.2.3
Tanning			x	

[190] A similar table has been presented during the 1st Stakeholder meeting on 5 February 2015 (see presentation available on the project website). That table contains additional information and is recommended.

Lamp type description	(Momentary) Proposal for the scope of the current study			Reference par.
(usually better definition required)	included	excluded	open/undefined	*(see also D.15)*
Waste-water treatment			x	
Industrial processes			x	
Other UV lamps			x	
Infrared and collagen lamps				1.4.2.4
IR lamps for imaging equipment			x	
IR lamps for electric hobs			x	
Collagen lamps			x	
Other IR lamps			x	
Signalling and signage lamps				1.4.2.5
Exit signs	x			
Traffic lights	x			
Neon and (static) billboards	x			
Other signalling and signage	x			
Appliance integrated lamps [191]				1.4.2.6
Range hoods		x		
Aquaria	x			
Swimming pools	x			
Vending machines	x			
Other appliance integrated	x			
Decorative and architectural				1.4.2.7
Flood lights for buildings [192]	x			
Decorative			too generic	
Projection, microscopy, light guides				1.4.2.8
Lamps used in imaging equipment		x		
Other projection lamps			no proposal	
Movie/TV or photo studio/theatre/event				1.4.2.9
TV/video/film studio lamps	x			
Outdoor stadium lamps	x			
Other in this category	x			
Backlighting for displays		x		1.4.2.10
Grow lights (greenhouses)	x			1.4.2.11
Food display lights	x			1.4.2.12
Scientific lights		x		1.4.2.13
Transport lights				1.4.2.14
Motor vehicles, categories M, N, O		x		
Motor cycles, category L		x		
Aeroplanes		x		
Ships, specific lighting		x		
Trains, specific lighting		x		
Ships, trains, busses, interior lighting	x			
Bicycles	x			
Other Mobile Lighting			too generic	1.4.2.15
Data-communication and (other) lasers				1.4.2.16
Signal transmission between instruments		x		
Dashboard and indicator lamps			no proposal	
Industrial process lasers		x		
Laser-diodes for general lighting	x			
Emergency lighting	x			1.4.2.17

[191] In their comments to the report, ANEC&BEUC welcome the proposal to include appliance integrated lamps in the scope of the study, both in terms of minimum requirements and in terms of labelling.

[192] In their comments to the report, IALD states: "We look at the specific inclusion of building floodlighting with concern. Given the wide variety of approaches to building lighting, we would like to avoid finding certain current styles and techniques of lighting constrained. The same applies with any definitions of "Decorative" lighting and even signage. We have also not seen references to Light Art whether it is an installation, projection or media façade type of project."

Lamp type description	(Momentary) Proposal for the scope of the current study			Reference par.
(usually better definition required)	included	excluded	open/undefined	*(see also D.15)*
Battery operated	x			1.4.2.18
Non-electric lamps		x		1.4.2.19
Lamps with more than 12,000 lumen	x		study	1.4.2.20
Lamps with less than 60 lumen	x		study	1.4.2.21
Double capped fluorescent lamps with diameter 7 mm (T2) or less	x		study	1.4.2.22
Double capped fluorescent lamps with diameter 16 mm (T5) and power ≤ 13 W	x		study	1.4.2.23
Double capped fluorescent lamps with diameter 16 mm (T5) and power > 80 W	x		study	1.4.2.24
Double capped fluorescent lamps with diameter 38 mm (T12) and special characteristics (see reference)	x		study	1.4.2.25
Double capped fluorescent lamps with diameter 38 mm (T12) and external ignition strip	x		study	1.4.2.26
Single capped fluorescent lamps with diameter 16 mm (T5) and special characteristics (see reference)	x		study	1.4.2.27
HID lamps with Tc > 7000 K	x		study	1.4.2.28
HID lamps not having lamp cap E27, E40, PGZ12	x		study	1.4.2.29
OLED lighting	x			1.6.1

Table 1 Summary of temporary proposal for inclusion in or exclusion from the scope of the current study for a variety of lamp / light source types. The table should be interpreted together with the text in the references and with the contents of Annex D. For discussion.

2. EUROPEAN STANDARDS

According to the MEErP the aim of this task is to:

- *Identify and shortly describe*
  - *EN or ISO/IEC test standards*
  - *Mandates issued by the European Commission to the European Standardisation Organisations (ESOs)*
  - *if applicable, test standards in individual Member States*
  - *where relevant, third country test standards (e.g. ASHRAE, ANSI, JIS, etc.) regarding the test procedures for*
    - *a primary and secondary functional performance parameters under 1.1*
    - *b resources use (energy and materials, incl. waste) and emissions*
    - *c safety (flammability, electric safety, EMC, stability, etc.)*
    - *d noise and vibrations (if applicable)*
    - *e other product-specific test procedures possibly posing barriers for Ecodesign measure*
- *Do a comparative analysis for overlapping test standards on performance, resources use and/or emissions*
- *Analyse and report on*
  - *a new test standards being developed (describe major changes)*
  - *b possible problems on accuracy (tolerances), reproducibility and to what extend the test standards reflect real-life; draft outlines of mandate(s) to the ESOs as appropriate.*
  - *c differences between standards covering the same subjects (comparative analysis)*

2.1. Standards organisations

The organisations involved in the development and maintenance of standards regarding lighting products are:

- CEN, European Committee for Standardisation
- CENELEC, European Committee for Electrotechnical Standardisation
- ETSI, European Telecommunications Standards Institute
- ISO, International Organization for Standardisation
- IEC, International Electrotechnical Commission
- CIE, International Commission on Illumination

CEN, CENELEC and ETSI are European Standards Organisations (ESOs). To support its policies and legislation, the European Commission requests the ESOs to develop and adopt European Standards, by means of 'standardisation mandates'. Those European Standards developed in response to a mandate are called 'Harmonised Standards'.

See Annex H for details.

2.2. European standards and related documents

A survey of European standards, guides and technical papers relevant for the product scope is provided in a table in Annex H. The table is limited to reference number and title, but the remainder of the Annex also provides short descriptions of the standards.

Standards have been grouped per type of product or application as indicated by the subheadings in the table and as reflected by the paragraph subdivision of the Annex. Some standards may appear in more than one group, e.g. a standard regarding safety of LEDs is listed both under safety and under LEDs.

The list of standards and related similar documents has been drawn up by consulting previous studies on lighting and by checking for updates on the websites of EC, CEN, CENELEC, CIE, IEC and ISO in May 2014, see Annex H for details.

For most standards, the year of publication and the last amendment are indicated. Standards that are currently under drafting or under approval are also listed. For example '*EN 60969:1993/ A2:2000 ; FprEN 60969:2013*' means that the standard was originally published in 1993, with the last amendment in the year 2000 and a new version under drafting or under approval since 2013.

Standards or measurement procedures that have been indicated by the EC as being relevant for the application of Regulations 244/2009, 874/2012 and 1194/2012 [193] or of Regulation 245/2009 [194] have been indicated by means of red *italic* text in the table in Annex H. Note that the indicated applicable versions of the standards (red *italic*) are not always the most recent ones available (black).

Harmonised standards, following mandates of the European Commission, are not explicitly indicated in the Table, but additional information can be found in Annex H.20 and in reference [195].

Annex H.21 provides information on the Zhaga Interface Specifications for LED Lighting products.

2.3. Mandates from European Commission to ESO's

The following mandates from the European Commission to European Standardisation Organisations (ESOs) may be relevant for the product scope of this study:

- M519 Mandate on **LED lighting** (Feb. 2013): Key areas include LED luminaire lifetime, definition of acceptable colour shift or power consumption over the lifetime of LED luminaire, enhanced quality of light metric definitions (CRI vs. CQS, PSD for LEDs), flicker and stroboscopic effects, test methods for photometric and colorimetric performance of LED lamps, LED luminaires, and LED modules, completion of prEN 13032-4[196] ;
- M518 Mandate in the field of the **WEEE Directive** (Jan. 2013): Addresses proper collection of CFLs;
- M499 Mandate in the field of the **RoHS Directive** (Oct. 2011): Addresses mercury content limits of fluorescent lamps;
- M495 Mandate in the field of the **Ecodesign Directive** (Oct. 2011): Generic mandate on test and measurement standards, display of information on ErP, how to perform LCA and Ecoprofile assessment of environmental parameters;
- M485 Mandate in the field of **lamps and ballasts** (Feb. 2011): Addresses all parameters in the ecodesign regulation for fluorescent and HID lamps;

[193] (OJ C 22/17 24.1.2014): http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2014:022:0017:0031:EN:PDF

[194] (OJ C 92/11 10.4.2010): http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:092:0011:0014:EN:PDF

[195] http://ec.europa.eu/enterprise/policies/european-standards/standardisation-requests/index_en.htm
http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/index_en.htm

[196] prEN 13032-4 'Lighting Applications — Measurement and presentation of photometric data of lamps and luminaires — Part 4: LED-lamps, modules and luminaires'

- M439 Mandate for **standby power** (Dec. 2008): Potentially relevant for parasitic energy use of lighting solutions;
- M341 Mandate for **Ecodesign** (Jan. 2004): First Ecodesign mandate, asks to deal with definitions etc. of environmental parameters (energy and material resources, emissions, etc.).

For more details and full references, see Annex H.20.

3. NON-EUROPEAN STANDARDS

The objective of this section is to examine non-European standards (test methods) and determine the degree to which other countries test lighting products differently to the EU, or test products where there are currently no test methods defined by the EU. Where such differences occur, the drivers for these differences are investigated to establish if there is technical or other merit in the EU amending current practice or adopting test methods from elsewhere, either in part, whole or in an amended form. Note that in a number of cases, the 'standards' used by the EU and other countries often combine elements of the method of test and direct or indirect performance requirements. Where possible, this section refers only to the test method elements of the standard, with the direct and indirect performance requirements addressed in section 6, although by necessity there is overlap in places.

Lamps and associated components are one of the world's most heavily traded products. They must physically fit into standard light sockets and must produce a known and consistent product – light. This has led to these products generally being one of the most 'standardised' products, i.e. typically test parameters and methodologies are very similar in much of the world. Fortunately, for the most part this has meant that lighting test methods are very centralised. The CIE is the single key originator of the 'deep' photometric and colourimetric test methods which underpin many lighting test methods discussed in section 3.1. Relevant examples include:

- CIE 084 - The Measurement of Luminous Flux.
- CIE 15 - Colourimetry.
- CIE 13.3 - Method of Measuring and Specifying Colour Rendering Properties of Light Sources (currently being updated).
- CIE technical committee TC 2-71 has been developing photometric and colourimetric test methods for LEDs.

These CIE photometric and colourimetric test methods are frequently referenced by the world's two main 'camps' of product specific lighting test standards, the IEC and the Illuminating Engineering Society of North America (IES [197]).

Europe and Asia (with the partial exception of Japan) tend to require the regulatory testing of lighting products based on IEC test methodologies (indeed these are often direct copies of IEC standards). The USA and Canada tend to use or base their lighting performance standards on IES test methods. South American countries also tend to use IEC, with the exception of Mexico which leans towards the North American approach. Until very recently, few African countries had recognised standards although that has just started to change with a commitment by the Economic Community Of West African States (ECOWAS) to introduce test methods to enable the introduction of harmonised MEPS for Omni-directional lamps, although it appears these will be broadly based on IEC methodologies.

[197] Formerly IESNA.

Thus, in the context of this study, the standards from the following standards organisations and countries are of most interest:

- CIE - as central originator of photometric test methods.
- IEC / ISO / EN - as central standards writer from which European standards are derived.
- IES/ANSI of North America - as the other large 'camp' of lighting standards.
- China - as the largest manufacturer of lighting products.
- Japan - as Japan tend to develop some lighting standards independently of IEC.
- India - as India have recently introduced several LED standards.

3.1. Primary and secondary functional performance parameters

Drawing from Annex B (which also contains definitions for these parameters), the following is a consolidated list of the lamp primary and secondary functional performance parameters currently requiring testing under the various EC lighting product regulations:

- Luminous flux / light distribution
- Lumen maintenance
- Chromaticity / colour temperature / colour consistency / colour rendering
- Electrical power / power factor
- Lamp life / premature failure
- Start time
- Warm-up time
- Rapid switching withstand
- UV radiation
- Compatibility / dimmability
- Mercury content
- Ballast efficiency
- Luminaire light output
- Luminaire lumen maintenance
- Luminaire utilisation factor (UF)

Generally, the definitions of these parameters are relatively consistent around the world.

Annex I lists key test methods for measuring the lamp parameters above from the standards organisations and countries of interest. The following subsections examine how other countries test these parameters to establish where there are differences with current EU practices, and to establish if benefit exists in modifying EU practice to align with practices elsewhere.

Luminous flux / light distribution

For the most part, test methods for the measurement of luminous flux and light distribution are well established. Almost all photometric test methods for these will reference CIE test procedures, or are based on these. For luminous flux, this includes the method of integration of the light source in order to calculate total luminous flux - e.g. integrating sphere or goniophotometer, as well as the method of light detection – e.g. spectroradiometer or photometer. There are subtle differences in the setup conditions required – e.g. stabilisation time, test voltage and temperature – but for the most part there are not significant differences for the measurement of luminous flux and light distribution.

However, the measurement of the total luminous flux of LEDs is worthy of mention. The North American Test Method for LED light output is IES LM-79. This method specifies the use of a

goniophotometer or integrating sphere to integrate the light output, with light detection done by either a spectroradiometer or photometer (photometer less preferred due to the potential for large spectral mismatch errors in the measurement of luminous flux of LEDS, which may require mismatch corrections to be applied).

The IEC standard 62612 (self-ballasted LED lamps >50V) covers a broad range of techniques for the measurement of LED luminous flux - it refers to several test methods - CIE 84, LM-79 and Annex B of Japanese standards JIS-C-8155. For directional LEDs, IEC 62612 requires use of a goniophotometer, as luminous flux is required to be measured in a solid angle of 90° (0.6π steradians) or in a solid angle of 120° (π steradians) (the latter for directional lamps having a beam angle greater than 90°). This also applies to other types of directional lamps (e.g. incandescent and tungsten halogen) as required by EU regulations and IEC test methods.

Luminous flux - key conclusion(s): The key difference embodied in non-EU test methods is that, outside of the EU, light output from directional lamps is typically measured in a 180° hemisphere, which allows the use of an integrating sphere (although several point readings may also be taken in order to calculate centre beam intensity and beam angle, for directional lamps). The EU regulations and subsequent test methods require measurement in a solid angle of 90° or 120°, which requires a full goniophotometer test, i.e. a significantly more expensive test, which is potentially a barrier to development testing for smaller supplier and particularly in increasing the cost for any enforcement testing given the significant number of samples requiring test.

Lumen maintenance

For most light sources, measuring the lumen maintenance of the source involves testing the initial luminous flux, ageing the light source for a period of time, retesting the luminous flux and calculating the ratio of the depreciation between the two measurements. Again, this is a relatively straightforward test. Differences do exist regarding the procedure for ageing the light source. For example the ageing 'cycle times' vary, the IEC test method for CFL lumen maintenance requires a cycle of 2 hours and 45 minutes on and 15 minutes off, while the North American test requires a cycle time of 3 hours on and 20 minutes off. For some light sources, it is possible that these kinds of subtle differences between test methods may yield differences in results, but there is very little publicly available data from which to draw conclusions.

The lumen maintenance testing of LEDs is however more complex. LEDs typically have very long lifetimes, often 25,000 hours or more. Therefore, testing an LED to the end of life, or a significant proportion thereof, is not practical either from a product declaration standpoint (it would delay the introduction of new products in a rapidly evolving market) or from a enforcement standpoint (given the speed of product evolution, and long term tests would result in outcomes long after the product under test has been withdrawn from the market). LEDs therefore rely on predictive lumen maintenance testing. Again there are two 'camps' of testing – the IEC and IES.

The North American Test Method for LED lumen maintenance is IES LM-80. This method involves ageing the LED at three difference case temperatures, for a minimum of 6000 hours. Data from this test can then be analysed using IES TM-21 to project the lumen maintenance of LED light sources. For luminaires this test is LM84 with TM28 (yet to be released) with a minimum test of 3000 hours.

The IEC standard 62612 (self-ballasted LED lamps >50V) has opted for lumen maintenance 'categories' based on the initial decrease in luminous flux after a certain ageing time (typically 6000 hours).

Interestingly, the Technical Committee on Standardization of the International Solid State Lighting Alliance (ISA) [198] has recently proposed a new lumen maintenance test procedure (*Accelerating Depreciation Test Method for LED Lighting Products).* The approach uses the Arrhenius equation [199] and an exponential luminous flux model to propose a 'master curve' that allows the lumen maintenance test to be conducted within 2000 hours.

Lumen maintenance - key conclusion(s): In general, lumen maintenance tests follow similar approaches. However, there are differences in approach between the IEC and other test methods for LED lumen maintenance and at this point it is not clear whether the IES or IEC test is superior, nor whether there is likely to be widespread acceptance of the proposed ISA methodology, although the later has the clear benefit of a much reduced testing time (with the associated potential of bring products to market faster and *likely* lower compliance/enforcement costs). These issues are a subject of ongoing discussion in the industry and so it is not clear if (non-EU) test methods offer significant advantage in terms of speed and cost reductions compared with *potential* increases in the uncertainty levels of results.

Chromaticity / colour temperature / colour consistency / colour rendering

Chromaticity testing involves accurately measuring the colour of a light source, and plotting it using coordinates such as those defined in the CIE X/Y colour space. This test is guided universally in all jurisdictions using the test method CIE 15 - Colourimetry. From this testing the colour temperature and colour consistency (difference between intended colour temperature and actual colour) can be calculated. The CIE is currently developing new colourimetry test methods for LEDs and these are discussed in section 4.1.1.

Similarly, the measurement of the colour rendering index (CRI) of a light source is universally applied in all jurisdictions using CIE 13.3 - Method of Measuring and Specifying Colour Rendering Properties of Light Sources. The CIE is also in the process of updating this test and it is again discussed in section 4.1.1.

Note that there is also ongoing discussion regarding the usefulness of CRI as a measurement tool. A number of research actions are underway, in particular at the Lighting Research Centre in New York State, evaluating alternative approaches that provide a more useful measure of human response/recognition of comparative colour of light and associated illuminated objects.

Colour related parameters - key conclusion(s): Research is underway to potentially develop alternative approaches that provide more useful measures of human response/recognition of comparative colour of light and associated illuminated objects. Should this research provide successful it will almost inevitably lead to changes in test requirements, although such changes are unlikely in the near future.

At present, there are currently no key differences in approach between the IEC and other test methods; although the CIE is updating colourimetry test methods to better suit LEDs (see section 4.1.1). There is a possibility that these new colourimetry measures could be used across light sources other than just LEDs, but at present, this is open to question. However, if they are product-specific

[198] The ISA website (www.isa-world.org/) states *"ISA is an international and not-for-profit organization, registered in Hong Kong, aiming to promote the sustainable development and application of Solid State Lighting (SSL) worldwide. ISA currently has 76 members with more than 4,000 associated members, representing 70% of the output of global SSL industry. ISA members consists of almost all the major players of the global SSL community, including leading industry, academic and application entities."* However, it is currently unclear how widely their activities and proposals are recognised by the lighting industry in general.

[199] In this context providing the empirical relationship between temperature dependence and decay.

which currently seems likely, then this is potentially a barrier to generic 'technology-neutral' specification.

Electrical power / power factor

Test methods for electrical power are well established, and these do not vary significantly by region. Electrical power is typically measured using an accurate power meter or digital power analyser.

In the most recent IEC lighting standards, the treatment of power factor has been made more sophisticated. Power factor, or to avoid confusion 'true power factor' is defined as [real power] divided by [rms voltage x rms current]. However, true power factor for electronic equipment (including CFLs and LEDs) is actually comprised of two components:

- Displacement factor ($K_{displacement}$) is the fundamental frequency (50 or 60Hz) component of power factor, which is the degree to which the current waveform drawn by the device is out of phase with the voltage waveform.
- Distortion factor ($K_{distortion}$) is due to the device drawing harmonic currents, which are currents at higher frequencies than the fundamental frequency – multiples of the fundamental frequency.

These two factors mathematically combine to calculate true power factor as follows:

$$\text{True power factor} = K_{displacement} \cdot K_{distortion}$$

The most recent IEC lighting product standards deal with both of these components of power factor, requiring each of them to be measured using sophisticated power measurement/analysis equipment. This approach leads the world.

Electrical power / power factor - key conclusion(s): This current IEC/EN approach leads the world and thus currently there are no perceived benefits from the EU adopting a test method from another country.

Lamp life/premature failure

For most non-LED lamps in the majority of jurisdictions, lamp lifetime is based on ageing a set of lamps to the point at which *n%* of lamps have failed. The aging processes used to reach the failure point is an extension of that for lumen maintenance described above, so again this is a relatively standard test with only the subtle differences (and the potential for yielding of differing results for some lighting products) noted in the lumen maintenance section.

For filament and most HID lamps, the point of failure is easy to establish as there is a catastrophic failure of some component in the lamp and light output ceases. More recently, this has become more of a problem with CFLs (and to a lesser extent fluorescent tubes) where lumen output degrades over time, but there is no actual catastrophic failure of the lamp and hence the point at which the lamp 'fails to continue to fulfil the designated illumination function' is unclear. Suggestions have been made on how such 'end of life' may be determined, e.g. the lumen output falls below a percentage of initial lumen value. However, to date it appears there has been no *practical* definition of what constitutes end of life in such circumstances that has been combined with an affordable and practical test methodology.

Further, typically the direct or in-direct performance requirements normally set a 50% failure of a defined sample size as the definition of lifetime (and the soon to be adopted IEC 60969 for CFLs further

softens this requirement). Hence, as the failure of most lamps does not follow a normal distribution, the reported value is not the average lifetime of the lamp. Rather this performance requirement provides the *median* life of a sample of lamps. Hence, as a claimed 'lamp lifetime value', this is potentially misleading to consumers as it represents neither the average life of the lamp, nor accounts for premature failure (the failure of a lamp before a certain minimum number of hours operation has been reached).

The failure mode of LEDs is typically loss of lumen output, similar to that described for non-catastrophic failure of florescent lamps above. However, the lumen maintenance test is the proxy test for LED life (again as discussed above) which allows a practical end of life lumen level to be applied.

Lamp life/premature failure - key conclusion(s): In general, the approaches to testing of lamp lifetime/premature failure are relatively consistent around the world. However, as with lumen maintenance, there are differences in approach between the IEC and other test methods for testing/defining LED and at this point, it is not clear whether the IES or IEC test is superior. However, for all international methodologies, there are challenges in defining the end of life for fluorescent lamps where catastrophic failure has not occurred, and a practical test method to measure that point appears yet to have been developed. Further, the defined indirect performance requirement that defines lifetime as the median (or other) failure point of a sample of lamps has the potential to mislead consumers, but this is investigated further in section 4.1.2.

In its comments to the report, the Danish Energy Agency remarks that LED lamp functionality is sensitive to the heat conditions in the fixture. They therefore recommend to change lifetime test conditions from 25˚C to 40˚C (specifying them in accordance with the conditions in the respective standards).

Start time

Start time is a very straightforward test and involves measurement of the time period between energising of the lamp to the point where the lamp remains continuously alight (note alight, not reaching any predefined light output), although the test requires measurement and recording equipment capable of measuring the change in light output on a scale of milliseconds. Once again, there are subtle differences between the EU and other test methods, for example definitional differences and differences in equipment setup. However, while these differences result in differing technical outcomes that require slightly different regulatory requirements, the net results are similar.

Start time - key conclusion(s): There are currently subtle differences in approach between the IEC and other test methods, although net resulting outcomes are similar.

Warm-up (run-up) time

Where used, the test method for warm-up (or run-up) time is again very similar across international borders and is substantively the same as for start-up, with the warm-up time being the period taken by the lamp to reach a specified percentage of its initial luminous flux (the notable differences in equipment terms is that the light sensor reaction time is less critical).

However, there are differences in the regulatory requirements (normally indirectly applied as part of the test method itself) defining the percentage of luminous flux that is deemed to be 'sufficiently warm'. For example, the IEC/EN CFL standard defines warm-up time as the time taken by the lamp to reach 60% of its initial luminous flux, whereas the US standard uses 80%. This potentially has repercussions for consumer acceptance of lamp types replacing traditional filament lamps where luminous flux reaches a very high proportion of initial flux within very short periods of time.

Warm-up (run-up) time - key conclusion(s): There are currently subtle differences in approach between the IEC and other test methods. However, while the net resulting *test* outcomes are similar, the application of these outcomes in (indirectly) defining the warm up time is different with potential impact on consumer acceptance.

Rapid switching withstand

The rapid switching withstand test seeks to determine how many fast cycles of on/off switching a lamp can withstand without failure. This test is primarily applied to CFLs, and to a lesser extent LEDs (some HIDs *specifically* require rapid switching not to take place). Again, the test method is simple and is broadly similar across international borders.

However, again there are direct and indirect differences in the regulatory framework associated with the test, in particular the number of cycles required (often defined in regulations) and the particular time period requirements of those cycles (often defined in the test method). The current IEC 60969 draft standard for CFLi products mirror the current European legislation in requiring a switching cycle of 1 minute on and 3 minutes off. However, the US MEPS for CFLi products requires a cycle of 5 minutes on and 5 minutes off. The US Energy Star requirement for integrated LED lamps requires 2 minutes on and 2 minutes off.

Clearly the combination of number of cycles and the time periods of those cycles (particularly the cooling/off period), have a significant impact on the elapsed time required for testing, with impacts on both the period required to bring products to market and for the cost of testing for manufacturers and enforcement agencies. Extensive ongoing research is currently underway in California [200] to try and establish the impact of the various switching cycles on lamp lifetime and the interim report indicates that the variations are significant (particularly related to CFLs). Further, there is no clear (consumer orientated) reasoning for different switching cycles between different lamp types (although there are obvious requirements for differing number of cycles for lamps of radically differing lifetimes).

Rapid switching withstand - key conclusion(s): While the test method for rapid switching withstand is straightforward and broadly similar where applied, there are marked differences in the number of cycles required and switching cycle times (defined variously within the test methods or associated regulations) with potential associated implications for the length and costs of testing. However, there is clear evidence that these variations impact on the lifetime of lamps (at the very minimum in the case of CFLs) and as such the switching cycle adopted by the EU should resemble as closely as possible. However, at present there is limited evidence as to which switching cycle may be more appropriate for EU consumers and it is an area to be investigated during MEErP Task 3. Should a clear switching cycle become evident, it may be appropriate to revise EU regulations (and assign ESO to examine the associated test methods) to more closely align with actual consumer usage patterns to increase the likelihood of lamp survival under typical operational conditions. Further, at present there appears to be no good (consumer orientated) reasoning for different switching regimes for different product types that are likely to be used in similar applications (e.g. CFL and LED lamps). Therefore, consideration should be given to whether similar switch withstand requirements could be applied across lamps of similar typical application.

[200] CFL Laboratory Testing Report, Preliminary Results from a CFL Switching Cycle and Photometric Laboratory Study, Submitted by James J. Hirsch and Associates, Erik Page & Associates, Inc. Submitted to California Public Utilities Commission Energy Division, May 2012.

UV radiation

IEC/EN 62471 Photobiological Safety of Lamps and Lamp Systems, is fully applied to all LED lighting products [201] [202]. IEC/EN 62471 gives guidance for evaluating the photobiological safety of lamps and lamp systems including luminaries. Specifically it defines exposure limits, references measurement techniques and the classification scheme for the evaluation and control of photobiological hazards from all electrically powered incoherent broadband sources of optical radiation, including LEDs (but excluding lasers), in the wavelength range from 200 nm through 3000 nm. This standard was prepared as Standard CIE S 009:2002 by the International Commission on Illumination.

Created by Underwriters Laboratories, ANSI/IESNA RP-27 is the original photobiological safety standard for lamp systems in the United States. This set of regulations was the basis for the IEC/EN 62471. Similarities between the two documents include:

- Associated risk
- Exposure limits for spectral distribution of optical radiation
- Representative radiometric magnitudes
- Methods of measurements

The ANSI/IESNA RP-27 and the IEC/EN 62471 contain minor differences including weighting functions for calculations of radiance, and labelling requirements (only specified in ANSI/IESNA RP-27).

UV radiation - key conclusion(s): Test methods for UV are almost identical globally where applied.

Compatibility / dimmability

IEC technical committees are currently examining the issue of compatibility between light sources and control devices. In 2013, SC23B and TC34 agreed to start common work aiming to define requirements and tests concerning the compatibility between light sources and control devices. For this purpose, the JAHG16 and JAHG17 committees have been created. JAHG16 has the responsibility to identify existing standards relevant to ensure compatibility, to offer modifications of those standards to the maintenance teams of those standards, and to coordinate that the modifications adopted preserve the compatibility requirements that have been identified by JAHG17. JAHG17 has the responsibility to identify the technical aspects that are necessary for compatibility, and to document the requirements in technical reports. JAHG16 will draw from those technical reports to propose modifications to the relevant standards. These two committees intend to publish draft technical reports in June 2014 with final publication in June 2015, and implementation into standards by 2017.

There are very few test methods that can be applied to test for dimmability of lamps, in other words for compatibility between lights and dimmers (and other controllers). The Energy Star CFL/LED lamp specification requires that lamps designed for phase cut dimming operation (alterations to the line voltage to the lamp) shall be tested against all dimming performance requirements with a minimum of five dimmers from at least two different manufacturers. The US Environmental Protection Agency's intent is for the dimmers selected to be varied in electrical construction and to represent a wide range of potential consumer situations. For example, a selection of five dimmers might include at least one dimmer specified for use with energy efficient lighting (such as CFL or LED lamps), one that has pre-set levels, one forward-phase dimmer rated 600W, and one reverse-phase dimmer. As an alternative, a lamp designed to be compliant with NEMA SSL7A may be tested against all dimming performance requirements with a corresponding NEMA SSL7A compliant dimmer.

[201] http://webstore.iec.ch/Webstore/webstore.nsf/ArtNum_PK/36396!opendocument&preview=1
[202] http://smartvisionlights.com/wp-content/uploads/pdf/IEC_62471_summary.pdf

The National Electrical Manufacturers Association (NEMA) published NEMA SSL 7A-2013 Phase Cut Dimming for Solid State Lighting: Basic Compatibility [203]. This standard provides compatibility requirements when a forward phase cut dimmer is combined with one or more dimmable LED Light Engines (LLEs). An LLE comprises one or more LED modules, LED control gear (integral or remote), and a connection to the mains circuit. This includes both screw-in integrated LED lamps, as well as fixtures which contain separate LED control gears. NEMA SSL 7A-2013 is meant to reduce the testing burden by utilizing synthetic loads and waveform generators to represent LLEs and dimmers during testing. All dimmers and LLEs tested against the criteria set forth in SSL 7A will be compatible with one another, without the need for specific testing of every lamp and dimmer pairing. In addition, it supports modern digital dimmers by providing dimmer power supply current requirements for compatibility with LLEs. The requirements do not limit its use to any specific lighting product type or application. The standard was developed with input from global participants and includes requirements for a range of supply voltages and frequencies, making it suitable for global use.

Dimmability - key conclusion(s): Testing for compatibility between dimmers and lights sources is clearly an issue, particularly with the more recent replacement lamp types. However, as yet there appear to be limited testing solutions that are broadly applicable to resolve the problem. However, the issue is the subject of ongoing investigation in the IEC, and firm test methods for compatibility have not yet been established in this forum. NEMA has published NEMA SSL 7A-2013 Phase Cut Dimming for Solid State Lighting: Basic Compatibility, which provides compatibility requirements when a forward phase cut dimmer is combined with one or more dimmable LED light engines.

Mercury content

Mercury is dealt with in section 3.2.

Ballast efficiency

There is a variety of metrics used to describe ballast efficiency. The current EU legislation use 'Ballast Efficiency' (ηballast) which means the ratio between the lamp power (ballast output) and the input power of the lamp-ballast circuit. This is a relatively simple test requiring only power measurements and no photometric measurements. The USA is currently transitioning from using MEPS that rely on a photometry-based metric (ballast efficacy rating or BEF) to one that is purely based on the electrical efficiency of the ballast (ballast luminous efficiency or BLE). The BLE is the ratio of total lamp arc power that the ballast delivers to the total input power that the ballast draws. For example, an ideal ballast (i.e. no ballast losses) would convert all of its input power into lamp arc power and thus would have a BLE of 1.0. The EU and new US metrics are essentially the same, and test methods are very similar, with only subtle differences.

Ballast efficiency – key conclusion(s): There are currently only subtle differences in approach between the EU/IEC and other test methods, although adoption of these is unlikely to yield any benefits.

Luminaire light output

Similar to luminous flux (discussed above) test methods for the measurement of luminaire light output are well established. Almost all photometric test methods reference CIE test procedures, or use the CIE procedures as a base. This includes the method of integration of the light source – e.g. integrating

[203] http://www.nema.org/news/Pages/NEMA-Publishes-NEMA-SSL-7A-2013-Phase-Cut-Dimming-for-Solid-State-Lighting-Basic-Compatibility.aspx

sphere or goniophotometer, as well as the method of light detection – e.g. spectroradiometer or photometer. There may be subtle differences in the setup conditions required – e.g. stabilisation time, test voltage and temperature – but for the most part there are not significant differences between EU and non-EU test methods for luminaire light output.

Luminaire light output - key conclusion(s): There are currently subtle differences in approach between the IEC and other test methods, although differences in net resulting outcomes are of little consequence.

Luminaire utilisation factor

Utilisation factor is used to describe an installation. It is the ratio of the luminous flux received by the 'work surface' to the total luminous flux emitted by the lamp(s) installed inside the luminaires. This metric is used extensively in lighting design and associated software. It is universally applied in all jurisdictions and it is *not* the subject of a test method.

Luminaire utilisation factor - key conclusion(s): This metric is universally applied in all jurisdictions and it not the subject of a test method, thus adoption of any approaches of other countries is unlikely to yield any benefits.

3.2. Resources use (energy and materials, incl. waste) and emissions

There are very few standards related specifically to resource use during lighting product manufacture, other than generic production standards.

During lamp operation the primary resource consideration is the electrical energy used, and there are various test methods for measuring lamp power and derivative efficiency and performance measures are discussed in section 3.1.

At the end of life of a lamp, lamp disposal has certain waste impacts. These may broadly be described as general waste/recycling issues, and issues related to 'hazardous substances'.

Looking first at general waste/recycling issues; at present, there are no lamp specific waste or recycling standards. However, particularly with the advent of LEDs and the high volumes of products with significant integral materials (e.g. heat sinks), there have been suggestions that specific metrics/measurement methods be developed for 'recyclability', e.g. the degree to which products can be easily dissembled and reused/recycled. Nevertheless, at present there appear to be no widely recognized metrics nor test method to address this issue.

Moving to hazardous substances, currently the only significant test is for the measurement of mercury present in the lamp. The IEC relies on two test methods for measurement of mercury in lamps:

- IEC 62554 Sample preparation for measurement of mercury level in fluorescent lamps.
- IEC 62321-4 Determination of certain substances in electro-technical products - Part 4: Mercury in polymers, metals and electronics by CV-AAS, CV-AFS, ICP-OES and ICP-MS.

The first of these test methods specifies the procedure for extracting mercury from the lamp. The second outlines the chemical laboratory testing procedure and equipment used to measure the actual quantity of mercury present. Most other countries including the US and China rely on these IEC test methods directly or via very close derivation.

However, the advent of new technologies, particularly LEDs and *potentially* OLEDs, potentially introduces a new range of hazardous substances into the waste stream. While there are chemical tests to measure almost all such substances, at present there appear to be no lamp specific methodologies, although significant research is underway in this area, notably in China.

Key conclusion(s) – resource use: There are no specific test methods associated with resource use in lighting production, but there seems little requirement for such. Resource use during operation is currently dealt with appropriately through the existing test methods (or where this is not the case, it is signalled in section 3.1). However, at end of life there appears to be benefit in adopting methods for measurement of 'recyclability/reuse' and for the measurement of hazardous substances beyond mercury. However, at present there appear to be no such lamp specific methodologies, although research is underway.

3.3. Safety (flammability, electric safety, EMC, stability, etc.)

For lighting products, safety standards typically embody both flammability and electrical safety. The IEC is the key originator of safety standards for lighting products, although countries may adopt their own standards and variations. EMC requirements for lighting products rely heavily on CISPR [204] standards for radio-frequency interference and IEC 61000 series standards for harmonics. Proliferation of CFLs and LEDs as replacements for incandescent and tungsten halogen lamps may increase EMC issues, however the IEC and CISPR standards are considered best practice in this area (e.g. the treatment of displacement factor and distortion factor as discussed in section 3.1) thus currently there are no perceived benefits from the EU adopting a safety or EMC test methods from another country.

Key conclusion(s) - safety: The IEC and CISPR are the key originators of safety and EMS standards globally, thus currently there are no perceived benefits from the EU adopting a safety or EMC test method from another country.

3.4. Noise and vibrations

At present, the EU legislation employs no lamp specific noise requirements, and as such deploys no test methods. Known areas where noise and vibration issues intersect with non-European lamp standards are discussed below.

Early in the development of LED products, several LED MR16 downlight models were developed which incorporated a mechanical fan to cool the LED chip. When a number of these products were installed in a room, a significant noise was audible. With the advancement of LED chip efficacy and passive heat removal techniques, this type of product is no longer widely available and thus this issue is not particularly relevant.

The Energy Star (voluntary) Program Requirements for Integral LED Lamps (Version 1.4) requires that complying lamps have an audible noise sound rating of Class A. The Energy Star (voluntary) Program Requirements for Lamps (Light Bulbs) (Version 1.0) also has audible noise requirements and test methods for dimmable lamps as follows:

204 The Comité International Spécial des Perturbations Radioélectriques (CISPR), in English the special international committee on radio interference, is part of the IEC with specific focus on setting standards for controlling electromagnetic interference in electrical and electronic devices.

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps Marketed as Dimmable	Lamp shall not emit noise above 24dBA at 1 meter or less. 80% of tested lamp/dimmer combinations must meet the requirement.	**Measurement:** ENERGY STAR Recommended Practice - Noise **Reference:** ISO 7574-4:1985, B.2.1 ANSI S12.55-2006/ISO3745:2003	**Sample Size**: 1 lamp per dimmer and 4 lamps per dimmer Measurement shall be on a single lamp. See Section 8 of the Recommended Practice – Noise, for reporting information. The reported sound level value shall be the loudest measurement of all lamp/dimmer combinations.

Table 2 Noise test methods for dimmable lamps as specified by Energy Star

The noise test methods specified by Energy Star are as follows:

- ISO 7574-4:1985 - Acoustics - Statistical methods for determining and verifying stated noise emission values of machinery and equipment -- Part 4: Methods for stated values for batches of machines.
- ISO 3745:2003 - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Methods Anechoic and Hemi-Anechoic Rooms.

Measurement of noise is a well-developed area of test procedures, thus it is unlikely that noise test methods will create any impediments to ecodesign measures. Note, however that the current EU legislation does not require adherence to noise limits for lighting products. Thus, incorporation of noise requirements in EU legislation could be considered. As noise test methods are dominated by ISO standards, should regulation of noise be desired, simple adoption of the existing ISO standards should be sufficient.

Key conclusion(s) - noise: At present, there is no requirement to measure noise within the EU, but it is a requirement elsewhere and appropriate test methods exist. If incorporation of noise requirements is deemed for EU legislation, then existing test methods are well developed and simple adoption of existing ISO standards would be possible.

3.5. Other product specific test procedures possibly posing barriers

Outside of the issues discussed in the previous sections, there are no known other product specific test procedures which might pose barriers for ecodesign measures. Other, more generic, problems are however discussed in section 4.1.2.

4. DISCUSSION AND ANALYSIS OF STANDARDS

4.1.1. New test standards being developed

The purpose of this section is to report on, and analyse, the relevant new test standards being developed and describe any major changes. There have been, and are ongoing, a number of additions and major changes to test methods. These are grouped and discussed below.

Draft CIE test method for LEDs

The CIE is currently developing an international standard test method for LED lamps, LED luminaires and LED modules. This draft is being developed by CIE technical committee TC 2-71. It provides requirements to perform reproducible photometric and colourimetric measurements on LED lamps, LED modules, and LED luminaires, and provides advice for the reporting of the data. The standard aims in particular to cover measurement methods for testing the compliance of LED lamps, LED modules and LED luminaires with the photometric and colourimetric requirements of LED performance standards issued by IEC technical committee TC 34 - Lamps and related equipment. The photometric and colourimetric quantities covered in the draft CIE test method include total luminous flux, luminous efficacy, partial luminous flux, luminous intensity distribution, centre-beam intensity, luminance and luminance distribution, chromaticity coordinates, correlated colour temperature (CCT), colour rendering index (CRI), and spatial uniformity of chromaticity. Note that the test method does not cover LED packages/engines and products based on OLEDs (organic LEDs). The draft CIE test method covers LED testing using the following instruments:

- Integrating sphere (including hemisphere):
    - Sphere - photometer (photometer head as detector)
    - Sphere - spectroradiometer (spectroradiometer as detector)
    - Sphere - colorimeter (tristimulus colorimeter head as detector)
    - 4π geometry: For all-types of LED devices, in particular, devices with omni-directional distribution, the test unit is usually mounted at the center of the sphere in the specified burning position, if possible, it is oriented in such a way that the minimum amount of direct light falls on the baffle. Linear sources should be positioned so that their axis coincides with the line between the detector head and the center of sphere. The sphere is calibrated with a luminous flux standard lamp placed at the same location as that of the test unit.
    - 2 π geometry: For LED sources with hemispherical or directional distribution with no backward emission, the test unit may be mounted at a sphere wall position where specified operating position of the test unit is fulfilled. A small baffle shall be used to prevent direct illumination of the detector head by the light source. In this case, the sphere is calibrated with a luminous flux standard lamp with hemispherical distribution placed at the same location as that of the test unit.
- Goniophotometer (including near-field goniophotometer):
    - Goniophotometer (photometer head as detector)
    - Gonio-spectroradiometer (spectroradiometer as detector)
    - Gonio-colorimeter (tristimulus colorimeter as detector).

- Luminance meters:
    - Luminance meters include image luminance measurement devices (ILMD).

The draft standard also covers partial luminous flux – defined as total luminous flux emitted within the specified cone angle. This is also called 'useful flux' in some legislation (e.g. EU legislation) and is expressed for example as luminous flux within a 90° cone or 120° cone. Partial luminous flux must be measured with a goniophotometer.

The following colourimetric quantities are also covered in the standard:

- Chromaticity coordinates
- Correlated colour temperature
- Distance from Planckian locus (Duv)
- CRI (refers to CIE 13.3 – see immediately below)
- Spatial (angular) colour uniformity.

The draft also provides guidance on the use of tolerances when determining rated LED performance claims.

Key conclusion(s) - CIE test method for LEDs: Clearly this is an important document for harmonisation purposes and over time is highly likely to be the primary reference document for LED (and likely OLED) testing. However, given the close cooperation between standards bodies (in particular the IEC) during the development, and the extensive adoption of existing techniques, there is likely to be little impact from the EU perspective.

Draft CIE test method for CRI

The colour rendering index (CRI) has been used to compare lamps for over 40 years [205] but the CIE does not recommend its use with white light LEDs. CIE Technical Report 177:2007 concludes that "*the CIE CRI is generally not applicable to predict the colour rendering rank order of a set of light sources when white LED light sources are involved in this set*". This recommendation is based on a survey of numerous academic studies that considered both phosphor-coated white light LEDs and red-green-blue (RGB) LED clusters. Most of these studies involved visual experiments where observers ranked the appearance of illuminated scenes using lamps with different CRIs. In general, there was poor correlation between these rankings and the calculated CRI values. In fact, many RGB-based LED products have CRIs of 20 to 30, yet the light source appears to render colours well. Figure 4 shows how the spectrum of LEDs differs from other light sources [205] and a recent article [206] highlights some of the technical issues well, and the current areas of contention.

The CIE are currently investigating this issue in two technical committees [207]:

- TC 1-90: Colour Fidelity Index - evaluate available indices based on colour fidelity for assessing the colour quality of white light sources with a goal of recommending a single colour fidelity index for industrial use.
- TC 1-91: New Methods for Evaluating the Colour Quality of White Light Sources - evaluate available new methods for evaluating the colour quality of white light sources with a goal of

[205] http://cool.conservation-us.org/byorg/us-doe/color_rendering_index.pdf

[206] "Review of measures for light-source colour rendition and considerations for a two-measure system for characterizing colour rendition" Houser, Wei,1 Aurélien David, Krames, Shen; Optics Express, Vol. 21, Issue 8, pp. 10393-10411 (2013)

[207] http://www.cie.co.at/index.php/Technical+Committees

recommending methods for industrial use. (Methods based on colour fidelity shall not be included.)

TC 1-91 will produce a new test method for CRI, which is expected to compare, using spectral distribution analysis, how well a test light source renders a set of colour samples, compared to a reference light source. However, it should be recognised that this is a highly contentious area, with the specific approach adopted having commercial impacts related to proprietary rights associated with phosphors and other specifics of lamp designs.

Figure 1

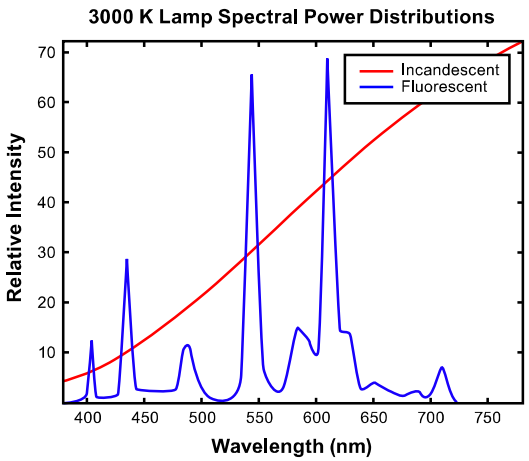

Figure 2

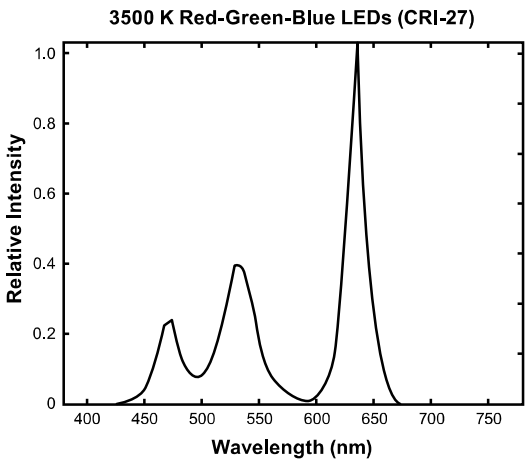

Figure 4 Difference in spectral power distributions between LEDs (right) and other lamps (left)

Key conclusion(s) - CIE test method for CRI: Over and above the issues with the usefulness of CRI as a consumer orientated measurement (as briefly discussed in section 3.1), the use of CRI for the comparison of colour rending of LEDs (both between LEDs and in comparison with other lamps) is a significant issue. Nevertheless, the alternative approaches currently proposed are disputed and, as they are at least partially related to proprietary issues, timeframes for resolution are unknown but are not expected imminently. Therefore, although not ideal, CRI is likely to be the only internationally recognised measure of colour quality for the foreseeable future and will remain a barrier to truly generic 'technology neutral' specifications.

IEA 4E SSL test method for LEDs

The IEA 4E SSL Annex [208] has developed a test methodology for measurements of electrical, photometric, and colourimetric quantities of LED lamps and LED luminaires (Inter-Laboratory Comparison Test Method for LED lamps and LED luminaires [209]). The test method addresses complete SSL products (LED lamps and LED luminaires) that require AC mains power or a DC voltage power. Non-integrated LED lamps (including tubular LED lamp) and luminaires with a separate LED control gear/driver (physically separate from the lamp or the luminaire) are also covered in the document if its control gear/driver is sold together or clearly specified by the product specification. LED light

[208] The Solid State Lighting (SSL) Annex sits under the framework of the International Energy Agency's Efficient Electrical End-Use Equipment (4E) Implementing Agreement. The Annex is an international collaboration between the governments of Australia, China, Denmark, France, Japan, The Netherlands, Republic of Korea, Sweden, United Kingdom and United States of America. China works as an expert member.

[209] http://ssl.iea-4e.org/task-2-ssl-testing/2013-ic

engines, LED modules and LED packages are not covered in this document. Testing of the lifetime of the products is also not covered.

The test method is written in such a way that the measurement requirements encompass those in:

- IES LM-79-08
- EN 13032-4 (Draft)
- CIE TC2-71
- the test method drafts included in the Annexes of draft IEC performance standards on LED lamps and LED luminaires
- The test methods covering LED lamps and LED luminaires in the Japanese standards: JIS C 7801:2009, JIS C 8105-5:2011, and JIS C 7801 Amendment 1: 2012
- The test methods covered in the Chinese standards: GB standards Drafts for self-ballasted LED reflector lamps, and CQC3127-2010, CQC3128-2010, CQC3129-2010, CQC3130-2011.

Further, issues such as difference in tolerance levels have been addressed through adopting the most stringent among alternative approaches. Thus, by complying with the IEA Inter-laboratory Comparison Test Method, all the measurement requirements for LED lamps and LED luminaires in the above listed test methods are considered to be satisfied. (Note: the document is expected to be revised when the above referred test method standards drafts have been published.)

Key conclusion(s) - IEA 4E SSL test method for LEDs: The adoption of test methodology elements from the various sources, and associated efforts to rationalise tolerances and other internal differences, makes the test approach suitable for consideration for the majority of LED performance metrics. Further, the potential of cross regional harmonisation has appeal. However, the document would not be suitable for direct used as a test method in its own right.

IEC standards for LEDs

The IEC is currently developing the following new or amended standards for LED light sources:

- IEC 62031 Ed.1: LED modules for general lighting - Safety specifications
- IEC 62560 Ed.1: Self-ballasted LED-lamps for general lighting services >50V - Safety specifications
- IEC 62612: Self-ballasted LED lamps for general lighting services - Performance requirements
- IEC 62663-1 Ed.1: Non-ballasted LED-lamps - Part 1: Safety specifications
- IEC 62663-2 Ed.1: Non-ballasted LED lamps - Performance requirements
- IEC 62663-2 Ed.1: Non-ballasted LED lamps for general lighting - Part 2: Performance
- IEC 62707-1 Ed.1: LED-binning - Part 1: General requirements and white colour grid
- IEC 62717 Ed.1: LED modules for general lighting - Performance requirements
- IEC 62776 Ed.1: Double-capped LED lamps for general lighting services - Safety specifications
- IEC 62838 Ed.1: Self-ballasted LED-lamps for general lighting services with supply voltages not exceeding 50 V a.c. r.m.s. or 120 V ripple free d.c. - Safety specification
- IEC 62868 Ed.1: Organic light emitting diode (OLED) panels for general lighting - Safety requirements
- IEC 62922 Ed.1: Organic light emitting diode (OLED) panels for general lighting - Performance requirements
- LED packages - Long-term luminous flux maintenance projection
- LED packages: Performance requirements

Note that the performance test methods within these standards are primarily photometric and colourimetric methods, which are still based on underlying CIE methods. The development work being undertaken by the IEC committees involves pass/fail requirements for these products, as well as subtle changes in test setup conditions required for specific types of light sources.

Key conclusion(s) - IEC standards for LEDs: Extensive development of LED test methods are underway at the IEC, but these are still based on underlying CIE methods and so, in general, should have little significant impact on the EU regulation provided the most recent method is referenced. However, the pass/fail requirements for some performance parameters being built into these standards has the obvious potential to indirect impact on EU regulation. Hence, caution needs to be exercised when adopting as EN standards to ensure the intent of any technology neutral regulation is not undermined by the implicit pass/fail criteria defined in the IEC tests under development.

IES/NEMA/ANSI standards for LEDs

The IES is currently developing the following new or amended standards for LEDs [210]:

- ANSI C78.377-2008, Specifications for the Chromaticity of Solid-State Lighting Products - Specifies recommended chromaticity (colour) ranges for white LEDs with various correlated colour temperatures (CCTs).
- IES G-2, Guideline for the Application of General Illumination ('White') Light-Emitting Diode (LED) Technologies - Provides lighting and design professionals with a general understanding of LED technology as it pertains to interior and exterior illumination, as well as useful design and application guidance for effective use of LEDs.
- IES LM-79-2008, Approved Method for the Electrical and Photometric Testing of Solid-State Lighting Devices - Specifies a standard test method for measuring the photometric properties of SSL devices, allowing calculation of luminaire efficacy.
- IES LM-80-2008, Approved Method for Measuring Lumen Depreciation of LED Light Sources - Specifies a standard method for measuring the lumen depreciation of LEDs, allowing calculation of LED lifetime.
- IES LM-82-2012, Approved Method for the Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature - Provides a method for measuring the lumen degradation of light engine products at various temperatures in support of manufacturers determining LED luminaire reliability and lifetime characteristics.
- IES RP-16 Addenda a and b, Nomenclature and Definitions for Illuminating Engineering - Provides industry-standard definitions for terminology related to solid-state lighting.
- IES TM-21-2011, Projecting Long Term Lumen Maintenance of LED Light Sources - Specifies a recommended method for projecting the lumen maintenance of LED light sources based on LM-80 collected data.
- NEMA SSL 1-2010, Electronic Drivers for LED Devices, Arrays, or Systems - Provides specifications for and operating characteristics of non-integral electronic drivers (power supplies) for LED devices, arrays, or systems intended for general lighting applications.
- NEMA SSL 3-2011, High-Power White LED Binning for General Illumination - Provides a consistent format for categorizing (binning) colour varieties of LEDs during their production and integration into lighting products.
- NEMA SSL 4-2012, Retrofit Lamps: Minimum Performance Requirements - Provides performance criteria standards for integral LED lamps, including colour, light output, operating voltage. lumen maintenance, size, and electrical characteristics.

[210] http://www1.eere.energy.gov/buildings/ssl/standards.html

- NEMA SSL 6-2010, Solid State Lighting for Incandescent Replacement—Dimming - Provides guidance for those seeking to design and build or work with solid-state lighting products intended for retrofit into systems that previously used incandescent screw base lamps. Addresses dimming of these products and the interaction between the dimmer (control) and the bulb (lamp).
- NEMA SSL 7A-2013, Phase Cut Dimming for Solid State Lighting: Basic Compatibility - Provides recommendations for applying and matching phase cut dimming technology to LED products.
- UL 8750, Safety Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products - Specifies the minimum safety requirements for SSL components, including LEDs and LED arrays, power supplies, and control circuitry.
- Other standards in development:
    - ANSI C82.XX1, LED Drivers Reliability
    - CIE TC1-69, Colour Quality Scale
    - IES LM-79 (revision), Approved Method for the Electrical and Photometric Testing of Solid-State Lighting Devices
    - IES LM-80 (revision), Approved Method for Measuring Lumen Depreciation of LED Light Sources
    - IES LM-84, Method for Measuring Lumen Maintenance of LED Lamps, Light Engines, and Luminaires
    - IES LM-85, Approved Method for the Measurements of High Power LEDs
    - IES LM-XX4, Method for the Electrical and Photometric Measurements of Organic LED (OLED) Light Sources
    - IES LM-XX5, LED Reliability Tests
    - IES LM-XX6, AC LED Measurements
    - IES TM-26, Method for Estimating the Rated Life of an LED Product
    - IES TM-28, Prediction of Lumen Maintenance of LED Lamps and Luminaires
    - UL 1598C (revision), Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits

It is unlikely that EU legislation would directly reference North American Test methods – the links between North American institutions and IEC/EN processes would however be relied upon to ensure the most appropriate test methods are adopted.

Key conclusion(s) - IES/NEMA/ANSI standards for LEDs: It is unlikely there is a need for EU regulations to directly reference these North American test methods and existing activities through the CIE and IEC are likely to capture any relevant requirements.

IEC standards for CFLi

The IEC has been developing a new standard, IEC 60969, for self-ballasted CFLs. This standard incorporates significantly more detail (than the current published standard) on lamp testing, and includes detailed test methods (and expansion of pass/fail criteria with the potential impact on the EU regulatory framework for CFLs) for the following parameters:

- Photometric characteristics
- Electrical characteristics
- Starting time
- Run-up time
- Lumen maintenance
- Low temperature and low voltage starting
- Switching withstand
- Lamp life

- Compatibility with dimmers and switches (limits on inrush currents in order to avoid damage to dimmers)
- Displacement factor

Key conclusion(s) - IEC standards for CFLi: The soon to be completed revision of IEC 60969 is likely to be referenced by the EU regulation. However, the revised test methodology extends the parameters tested, alters the pass/fail criteria for a number of parameters and also has inbuilt allowances; all of which have the potential to directly or in-directly impact the EU regulatory framework. These items are further discussed in section 3.1 and 4.1.2.

Test methods for flicker

Although not currently covered in EC legislation, the flicker [211] of lamps, particular LED lighting is also a current topic of research [212, 213]. Flicker is defined by the IEC as the "*impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time*" [214]. The flicker found in some LEDs (and some CFLs) can be a significant barrier to adoption – furthermore, the pairing of dimming controls with LEDs and CFLs can increase or induce flicker. Flicker has been shown to induce photosensitive epilepsy, migraines and headaches, and increased autistic behaviours in certain people. Reduced task performance, stroboscopic or phantom array motion effects, distraction, and annoyance are other possible consequences [212].

The IES define per cent flicker as a relative measure of the cyclic variation in output of a light source (per cent modulation) given by the expression 100(A-B)/(A+B), where A is the maximum and B is the minimum output during a cycle (IES RP-16-10).

The Energy Star (voluntary) Program Requirements for Lamps (Light Bulbs) (Version 1.0) requires that the highest per cent flicker and the highest flicker index be reported for dimmable lamps. The test method sighted is the Energy Star Recommended Practice [215]. A more formal, accepted test procedure for flicker is not available.

Key conclusion(s) – Test Methods for Flicker: Flicker is not current the subject of EU regulation but is clearly an important area for consumer acceptance. However, existing test methods do not as yet provide generic protocols to enable measurement of flicker (and hence regulation) across lamp types, particularly where paired with control devices (particularly dimmers) where the operational characteristics of the ultimate device type is unknown.

For further remarks regarding flicker, see also the Task 3 report par. 5.1 (health aspects) and par. 7.2 (dimming). See also the IALD comments on this report [216].

[211] http://www.ledjournal.com/main/blogs/flicker-shimmer-and-ripple-lessons-in-light-quality/

[212] http://www.lichtundgesundheit.de/Lichtundgesundheit/Blog/Eintrage/2013/5/31_Auf_wie_vielen_Augen_darf_man_blind_sein_files/Poplawski%20and%20Miller%20CIE%20Flicker%20Paper%202013%20shorter-1.pdf

[213] http://www.cie.co.at/index.php/Technical+Committees

[214] http://www.electropedia.org/iev/iev.nsf/display?openform&ievref=161-08-13

[215] https://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Lamps%20V1%200%20Final%20Test%20Methods%20and%20Recommended%20Practices.pdf

[216] IALD comment on this section of the report: "We believe this is an urgent problem that should be addressed. Work has been done and published by Professor Arnold Wilkins and others from Surrey University with methodologies for testing flicker and with recommendations for acceptable limits (Lehman, B. and Wilkins A.J. (2014). Designing to mitigate the effects of flicker in LED lighting. IEEE Power Electronics Magazine, Vol. 1, No. 3, September. http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/documents/2014-09-). These should be studied and used as is or with documented variations until such time as broader standards are developed; the introduction of new methodologies in future regulations should be addressed with care. Flicker is a specific and particular problem with LED given the generalised use of switch mode power supplies and PWM dimming from digital signals."

4.1.2. Possible problems

The purpose of this section is to outline possible problems on accuracy (tolerances), reproducibility and to what extend the test standards reflect real life. In addition to the issues outlined in the preceding sections, the following possible problems have been identified.

Measurement of lamp lifetime

Currently, for most lamp types in almost all jurisdictions, proving the claimed life of the lamp involves ageing a set of lamps to the claimed lifetime and checking that at least 50% of the samples have survived. Thus, this test actually proves the claimed *median* life of the lamp model. However, it could be argued that consumer expects that the claimed lamp life, as printed on the product packaging, is a *minimum* expected lifetime, or possible a *mean* lifetime. Consumers may be surprised to learn that a claimed lifetime of 10,000 hours means that, even under ideal laboratory conditions, only half of the lamps will survive to 10,000 hours.
Additionally, lifetime testing of lamps is undertaken under ideal laboratory conditions of voltage and temperature, which may mean that, under real-world conditions, actual lamp lifetime is shorter [217].

Use of IEC performance standards as 'type tests'

Most IEC lamp performance standards contain a clause stating that the standard is suitable only for 'type testing'. For example IEC 60081 for double-capped fluorescent lamps states: "*The requirements of this standard relate only to type testing. Conditions of compliance, including methods of statistical assessment, are under consideration*." This means that the standards are to be used for testing products in order to produce a test certificate description of the product, for example to provide the specifications of the product to a factory, or for the ongoing monitoring of product quality over an extended period (with samples drawn over this extended period).

However energy efficiency regulators, including within the EU, currently use these standards for regulatory purposes, which is technically not their intended use. This potentially introduces issues, particularly related to compliance/enforcement action; in particular related to sampling. Even high quality manufacturers with extremely high levels of control of production will still produce a proportion of non-compliant products, even if this proportion is very small. Under 'type testing' conditions this is of little relevance as statistically such occurrences are rare and their appearance would be of no consequence where samples are taken over a significant period from ongoing production.

However, for compliance/enforcement activities there is the potential for *relatively* small sample sizes to be drawn from a single source/batch/etc. Under such circumstances, mathematical analysis (e.g. Monte Carlo simulations) shows that even the highest quality producers supplying *almost* 100% compliant products could fail under certain circumstances and so the enforcement action is potentially open to challenge.

This is obviously an area of potential concern which *could* be addressed by extending 'allowances' for compliance, but to deal with the extreme possibilities of non-compliance by 'good manufacturers' would lead to significant 'false passes' by the less scrupulous suppliers.

Alternatively, a zero tolerance approach could be taken (and written into the regulations) which explicitly states that failure of products to meet performance requirements during compliance/enforcement testing cannot be subject to challenge based on sampling provided the

[217] In their comments on the report, ANEC&BEUC state that they agree with the remarks in this section, and that they "consider this practice misleading for consumers, who cannot conclude that a particular lamp will last as long as its package says it will."

sample *sizes* comply with those stated in the test method (or regulation) irrespective of the sample sources with respect to production batch, date of production, etc. However, such action requires an understanding that, in limited circumstances, this may lead to enforcement actions being taken where products are to the greater extent compliant.

IEC pass/fail requirements incorporated into test methods:

IEC/EN lamp performance standards typically include pass/fail requirements. For example, IEC 60081 - Double-capped fluorescent lamps – performance specifications - requires that "*the initial reading of the luminous flux of a lamp shall be not less than 92% of the rated value*." The test method for measuring luminous flux is then contained in Annex B of the standard, which (among other things) calls up the CIE method: "*Photometric characteristics shall be measured in accordance with the relevant recommendations of the CIE*." Thus in this example, it is Annex B of the IEC standard which is of most relevance to policy making. However, typically it is the 'performance standard' that is referenced in regulation which, by the very reference, includes the 'pass/fail' requirement, including a tolerance between rated and tested values (which has led to confusion as EU legislation is couched in terms of rated values). Other countries do not tend to use tolerances when describing MEPS and labelling requirements, as this leads to confusion for regulators, suppliers and consumers.

Use of IEC/EN standards may be considered appropriate, but it must be recognised that by doing so the legislator is passing part of the regulatory process to standards committees, with the potential for these 'indirect regulations' to be amended at a future date without express regard to the legislator.

Such pass/fail requirements are not included in North American equivalent - IES method LM-9 - Electrical and Photometric Measurement of Fluorescent Lamps – which simply sets out the test method. In the US, the product test method is often detailed by the regulator (US Department of Energy). For example, the North American test method LM-9 for linear fluorescent lamps is also called up in the official MEPS regulatory test method known as *Pt 430 Subpt B App R* [218] which states (for example):

> *"The measurement procedure shall be as described in IES LM–9 (incorporated by reference; see §430.3), except that lamps shall be operated at the appropriate voltage and current conditions as described in ANSI C78.375 (incorporated by reference; see §430.3) and in ANSI C78.81 (incorporated by reference; see §430.3) or ANSI C78.901 (incorporated by reference; see §430.3), and lamps shall be operated using the appropriate reference ballast at input voltage specified by the reference circuit as described in ANSI C82.3 (incorporated by reference; see §430.3)."*

This may create confusion - effectively there are two test methods in existence – the IES method and the DoE method.

Measurement of network-connected 'smart lamps'

There is a growing proliferation of 'smart lamps' that can be connected to a communications network (for example WiFi, Zigbee, etc.). While currently the 'functionality' of these smart lamps is generally limited to either the control of the lamp (dimming, colour change, etc.), or as a 'daisy chain' to extend data connectivity/transmission to wider areas, the potential functionality is extensive (as has been the case with smart phones – once the platform was developed, new functionality was enabled). For example, a Korean supermarket has a fully functioning pilot store where lamps are used as WiFi nodes

[218] http://www.gpo.gov/fdsys/pkg/CFR-2011-title10-vol3/pdf/CFR-2011-title10-vol3-part430-subpartB-appR.pdf

that provide information to the consumer to help them navigate the store, but use the same location information to activate visual and aural advertising for specific products as the consumers pass shelves where those products are stocked.

As yet, the energy impact of such 'smart lamps' is difficult to predict as it is dependent on the functionality developed (and the mode of deployment) by the suppliers, and the acceptance of that functionality by users. However, it is clear that there is potential for major increases in energy consumption as many of these functions/technologies have 'always on' or 'network standby' requirements, so even low wattage functionality has the potential for significant annual energy consumption. Hence, it may be desirable to regulate this energy consumption at an early stage to provide an envelope of consumption under which the functionality may be developed, but which does not inhibit the potential for innovation. However, at present there appears to be no definition that adequately encapsulates the potential functionality, nor the 'network standby' modes, of these smart lamps, and consequently no suitable test methodology against which to regulate.

This clearly presents a challenge for the regulator. A 'wait and see' strategy to establish what functionality is developed before attempting to develop suitable test methods/regulation is high risk as technology may be rapidly embedded. Hence, the development of interim test methodologies and associated regulation may be considered appropriate.

Dimming (and other electronic switches including movement sensors, detectors, etc.)

As noted in section 3.1, the development of test methods for lamp/dimmer compatibility is ongoing. However, should such a methodology actually be developed, it will almost certainly be based on knowledge of the type of dimmer (or other electronic control device) installed, knowledge that is not generally available to the consumer [219]. Hence, even with an appropriate test methodology and associated declarations on lamps, it is unlikely consumers will consistently be able to select lamps that will operate on their existing circuits. Given that the EU has an estimated 120 million dimmers installed, this potential creates a barrier to migration to energy saving lamp technologies. However, options do exist. Obviously the existing dimmer systems could be replaced with units compatible with specific lamp types. In many cases, adoption of dimming via 'remote' means, e.g. via smart phones, has the potential to bypass the installed dimmer problems. Alternatively, some of the newer lamp designs are capable of operation under almost any dimmer/control configuration; albeit with an efficiency penalty of approximately 15% (first cost should not be effective significantly). Nevertheless, it should be recognised all options have a degree of economic cost which appears unavoidable.

Dimming and related technological problems will be further addressed in the Task 4 report.

4.1.3. Comparative analysis for overlapping test standards

The previous sections highlight many of the key differences between IEC/EN test procedures used for EU regulation, and relevant non-EU test procedures, particularly the North American methods (as most other countries are IEC-based).

There is however considerable overlap within the existing set of IEC/EN lighting performance standards. Primarily, the objective of IEC performance standards is to outline pass/fail requirements (including test methods) for the following parameters:

[219] In some EU countries, the standard wiring configurations will lead to the predominant use of a particularly dimmer type. However, the use will not be universal and consumers will typically be unable to make reliable assumptions on the type of dimmer installed.

- Dimensions
- Power and power factor
- Luminous flux and light distribution
- Efficacy
- Colour
- Colour rendering
- Life
- Lumen maintenance

The test methods for these parameters are outlined in the appendices of the standards, and are at their core very typical. For example, each of the numerous IEC/EN lamp standards contains an appendix for measurement of lamp luminous flux. This appendix typically incorporates:

- Test setup requirements for temperature, air movement, lamp orientation, test voltage, etc.
- Instructions for the actual photometric test for luminous flux, which is typically a direct reference to the appropriate CIE method. For example, the draft IEC CFLi standard simply states: "*photometric characteristics shall be measured in accordance with the relevant recommendations of the CIE"*.

It is the first of these - the setup requirements - that tend to differ between different lamp products - for example a linear fluorescent lamp test requires use of a reference ballast, which of course does not apply to a CFLi which has an inbuilt ballast.

The second - photometric (and colourimetric) testing - is where the overlap occurs.

Thus, in order to reduce the number of standards and inherent duplication, it may be possible to consolidate a number of IEC/EN standards - for example by having a single standard for 'lamps' which contains differing setup requirements for various lamp types but has a common photometric / colourimetric test.

4.1.4. Draft outlines of mandates to the ESOs

From the analysis conducted above, the following issues might require addressing with respect to test methods (to be discussed with Commission and stakeholders):

- Lamp luminous flux: address current situation for directional lamps which requires goniophotometer testing of light output within 90° or 120° cone [220].
- LED lumen maintenance: address differences in approach between the IEC and other test methods, and across product types.
- Lifetime: generate approaches to define lifetime in a consistent manner across product types and in line with consumer understanding.
- Rapid switching withstand: address differences in switching cycle times between the IEC and other test methods, and across lamp types.
- Warm-up (run-up) time: address subtle differences in run-up performance definitions within test methods to ensure compatibility across lamp types.

[220] In their comments on the report, the Danish Energy Agency suggests to reconsider if it has been favourable for EU to choose a different path than the rest of the world by introducing the "useful flux in a cone of 90° or 120°" as basic parameter for directional lamps.

- Colour, in particular CRI: engage with the evolving measurements approaches for CRI to attempt to ensure compatibility across lamp types.
- Dimmability: continue to address testing for compatibility between dimmers and light sources.
- Noise: potential adoption of existing international test methods, should noise be deemed appropriate for EU regulation.
- Consolidation of test methods: consider consolidating photometric (and colourimetric) testing methods into a single standard for all lamp types with differing, lamp-specific, set-up requirements.
- Network-connected 'smart lamps': devise appropriate test methods for functionality and network standby power consumption.

In a comment on the original issue of this document, LightingEurope requested that:

"*The regulator should in future take into account much more than in the past current standards and standards in preparation. One of root causes of un-clarity in the market today, including surveillance issues, is the big gap between existing regulations and regulatory definitions with available standards and formal standardized definitions. With as result the need for repair actions (mandates) which could to a large extend have been avoided*."

5. EUROPEAN LEGISLATION

According to the MEErP the aim of this task is to:

> *Identify and shortly describe the relevance for the product scope of*
> *1.3.1 EU legislation (legislation on resources use and environmental impact, EU voluntary agreements, labels)*
> *1.3.2 Member State legislation (as above, for legislation indicated as relevant by Member States), including a comparative analysis.*
> *1.3.3 Third country legislation (as above, for third country legislation), including a comparative analysis*

5.1.1. Directive 2009/125/EC on Ecodesign

The Ecodesign Directive [221] provides the context in which the current preparatory study is performed.

In general, the Directive provides with consistent EU-wide rules for improving the environmental performance of energy related products (ErPs) through ecodesign. It prevents disparate national legislations on the environmental performance of these products from becoming obstacles to the intra-EU trade. This should benefit both businesses and consumers, by enhancing product quality and environmental protection and by facilitating free movement of goods across the EU [222].

The Ecodesign Directive is a framework directive and does not contain ecodesign measures for specific products groups. Such measures are introduced by means of separate regulations, see Task 0 report for examples regarding lighting products.

Only some points from article 15 of the Directive are recalled here.

A product shall be covered by an ecodesign implementing measure or by a self-regulation measure if it fulfils the following criteria (article 15.2):

> *(a) the product shall represent a significant volume of sales and trade, indicatively more than 200 000 units a year within the Community according to the most recently available figures;*
>
> *(b) the product shall, considering the quantities placed on the market and/or put into service, have a significant environmental impact within the Community, as specified in the Community strategic priorities as set out in Decision No 1600/2002/EC; and*
>
> *(c) the product shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs, taking into account in particular:*
>
> *(i) the absence of other relevant Community legislation or failure of market forces to address the issue properly; and*
> *(ii) a wide disparity in the environmental performance of products available on the market with equivalent functionality.*

[221] DIRECTIVE 2009/125/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast, repealing Directive 2005/32/EC), (Ecodesign Directive) OJ L285/10 31/10/2009, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0125&from=EN

[222] For more general information on the Ecodesign Directive, see the dedicated websites:
http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/index_en.htm
http://ec.europa.eu/energy/efficiency/ecodesign/eco_design_en.htm

In preparing a draft implementing measure the Commission shall (article 15.4):

(a) *consider the life cycle of the product and all its significant environmental aspects, inter alia, energy efficiency. The depth of analysis of the environmental aspects and of the feasibility of their improvement shall be proportionate to their significance. The adoption of ecodesign requirements on the significant environmental aspects of a product shall not be unduly delayed by uncertainties regarding the other aspects;*

(b) *carry out an assessment, which shall consider the impact on the environment, consumers and manufacturers, including SMEs, in terms of competitiveness — including in relation to markets outside the Community — innovation, market access and costs and benefits;*

(c) *take into account existing national environmental legislation that Member States consider relevant;*

(d) *carry out appropriate consultation with stakeholders;*

(e) *prepare an explanatory memorandum of the draft implementing measure based on the assessment referred to in point (b); and*

(f) *set implementing date(s), any staged or transitional measure or periods, taking into account, in particular, possible impacts on SMEs or on specific product groups manufactured primarily by SMEs.*

Implementing measures shall meet all the following criteria (article 5.5):

(a) *there shall be no significant negative impact on the functionality of the product, from the perspective of the user;*

(b) *health, safety and the environment shall not be adversely affected;*

(c) *there shall be no significant negative impact on consumers in particular as regards the affordability and the life cycle cost of the product;*

(d) *there shall be no significant negative impact on industry's competitiveness;*

(e) *in principle, the setting of an ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers; and*

(f) *no excessive administrative burden shall be imposed on manufacturers.*

5.1.2. Commission Regulation (EC) No 244/2009 on Non-Directional Household Lamps

See description and references in Task 0 report.

5.1.3. Commission Regulation (EC) No 245/2009 on Tertiary Lighting

See description and references in Task 0 report.

5.1.4. Commission Regulation (EC) No 859/2009 amending 244/2009

See description and references in Task 0 report.

5.1.5. Commission Regulation (EC) No 347/2010 amending 245/2009

See description and references in Task 0 report.

5.1.6. Commission Regulation (EU) No 1194/2012 on Directional Lamps and LEDs

See description and references in Task 0 report.

The following issues have been indicated by stakeholders as being relevant for the review of the regulation (that is to be performed as part of this preparatory study):

- All definitions have to be reviewed to align them with new definitions in the standards (see also stakeholder comment in par. 4.1.4. [223]

- The definition of LED Modules and distinction from lamps should be reviewed and clarified to be aligned with standards (IEC 62504). [223]

- Article 2 (23) (control device definition), and Annex III point 2.3 where it states "*When a dimming control device is switched on at its lowest control setting for which the operated lamps consume power, the operated lamps shall emit at least 1 % of their luminous flux at full load*", should be reconsidered. The possibility to exclude DALI and similar systems should be checked. There are applications where less than 1% is needed, and there are other ways to control that lights are not left on unintentionally at the level below 1%. Full load definition is required as well. [223]

- Annex IV point 3, "*Verification procedure for equipment designed for installation between the mains and the lamps*". Limitation for variance at 2.5% should be changed to a maximum for power limit up to 2.5% and minimum for efficiency down to – 2.5%. [223]

- Annex III point 3 and tables 6 and 7, on equivalence claims. It is suggested to remove the equivalence claims tables during the review. They are only valid against the "original" lamp which will soon be phased out. The lamp types specified in table 6 are not completely covered by standard definitions. [223]

- Article 2 (9), definition of directional lamps: " *'directional lamp' means a lamp having at least 80 % light output within a solid angle of π sr (corresponding to a cone with angle of 120°)*". A further discussion is needed on this definition as it sometimes leads to practical problems, i.e. lamps intended as DLS being tested as NDLS and vice versa [223] [224]. In addition it is not always clear from published datasheets if a lamp is directional or non-directional.

- Replace 'power factor' by 'distortion factor' and 'displacement factor' [223] [225]. See also Task 3 report par. 7.3 and annex F.3.

[223] See comments of LightingEurope on the original Task 0, 1, 2, 3 reports.

[224] In their comments on the report, the Danish Energy Agency suggests to reconsider if it has been favourable for EU to choose a different path than the rest of the world by introducing the "useful flux in a cone of 90° or 120°" as basic parameter for directional lamps. If the current definition is maintained, DEA recommends that it becomes a requirement that for all directional light products, the manufacturer or sales company has to provide the light distribution as a photometric file in the IES format at their web sites.

[225] In its comments to the report, the Danish Energy Agency recommends to keep the PF > 0.5 requirement as this is fulfilled by products of quality and there is no reason to impose extra costs on LED for adding electronics which will be the consequence of requiring PF>0.7.

- The total number of information parameters should be drastically reduced for market verification and enforcement purposes, and the threshold levels should take into account the interest/technical possibilities of SMEs [223].

- Annex III point 2.2 and table 5. The requirements concerning 6000 h to be used to qualify LED (the same modifications on the way in the standardization field) should be modified. This is also necessary to ensure a comfortable time in the market for new products (taking into consideration other methods in use in other standards, e.g. the LED module standard, IEC 62717, provides means for applying a "family" testing concept. [223]

- Annex II (l), lifetime definition. The current definition allows different interpretations, which should be avoided. The LxByCz or LxBy and L0Cz lifetime information should be used, see also IEC 62717 and IEC 62722-2-1. [223]

- Annex III point 3.2: "*Claims that an LED lamp replaces a fluorescent lamp without integrated ballast of a particular wattage may be made only if (…) the luminous intensity in any direction around the tube axis does not deviate by more than 25 % from the average luminous intensity around the tube ..* ". Where does the tolerance of 25% apply? IEC 62717, for example, always refers to the individual LED module when applying 10% tolerance to the rated power and the rated luminous flux and 25% tolerance to peak intensity and to the beam angle. And what kind of tolerance is contained within the 25%? Is it applied on the average of measured 20 pieces, wherever measured – at the manufacturer's premises or at the market surveillance labs? [223]

- In its comments to the report, the Danish Energy Agency remarks that LED lamp functionality is sensitive to the heat conditions in the fixture. They therefore recommend to change lifetime test conditions from 25˚C to 40˚C (specifying them in accordance with the conditions in the respective standards).

- In its comments to the report, the Danish Energy Agency states that information about colour rendering (Ra value) should be required to be shown at the packing. The IEE PremiumLight market research found that this is a very important light quality parameter for the consumers and several EU member countries have a long tradition for recommendation of a high colour rendering for some activities both at work and in the home.

- In its comments to the report, the Danish Energy Agency suggest that the minimum colour rendering requirement CRI > 80 be extended with R9 > 0 as recommended by IEA SSL. It might also be recommended to provide LED lamps with CRI >90 for a future stage.

5.1.7. Commission Delegated Regulation (EU) No 874/2012 on Energy Labelling of Lamps

See description and references in Task 0 report.

The following issues have been indicated by stakeholders as being relevant for the review of the regulation (that is to be performed as part of this preparatory study):

- Recital 5 and Annex V point 2: "*The luminaire shall be considered to comply with the requirements laid down in Articles 3 and 4 if it is accompanied by the required product information, and if it is found to be compatible with any lamps with which it is claimed to be compatible according to point 2.2(IV)(a) and (b) of Annex I, applying state-of-the-art methods and criteria for assessing compatibility*." This requirement should be modified as regards the

'state-of-the-art methods and criteria for assessing compatibility' [223]. See also the corresponding LightingEurope position paper [226].

- Annex VII, point 2, "Energy Consumption per 1000h" to include on the Energy Label for LED lamps. Regulation 874 states that the energy consumption value should include a factor for the losses in the electrical control gear. LED tubes do not strictly require external gear and therefore it could be argued that no correction factor should be applied. However, these are basically being sold as retrofits for ordinary LFL lamps, and it is therefore obvious to some people that they will end up being used on traditional ballasts and should therefore acknowledge the external control gear losses. This point should be clarified. [223]

- Modify the method to be used to update the Energy label following to the availability of new lamps (no mandatory new model identification due to the change of the energy label). [223]

- It should be analysed, if life-time information can be confusing for consumers as the declared values for LEDs might not be achieved in practice, because they do not rely on measurements. The study should thus consider information requirements specifically for LED-based light sources which take this into account [227] [228].

- In their comments, some stakeholders argue that the use of the square root function ($0.88\times\sqrt{\Phi} + 0.049\times\Phi$) for determination of the EEI should be reconsidered. For LEDs the use of the efficacy in lm/W is deemed more adequate [229].

5.1.8. Commission Delegated Regulation (EU) No 518/2014 on Energy Labelling of products on the Internet

In March 2014 Regulation 874/2012 was amended by Regulation 518/2014, that prescribes information requirements and energy label display for the sale of lamps on Internet [230].

5.1.9. Commission Decision 2011/331/EU on the EU Ecolabel for light sources

Commission Regulation (EC) No 66/2010 [231] regards the awarding of the EU Ecolabel to those products with a reduced environmental impact during their entire life cycle. The regulation provides that specific EU Ecolabel criteria are to be established according to product groups.

[226] http://www.lightingeurope.org/uploads/files/State_of_the_Art_Compatibility_-_LE_Position_Paper_140704_FINAL.pdf

[227] not specific for regulation 874/2012, but listed here as a reminder

[228] See comments from the Federal Environment Agency of Germany (UBA)

[229] See comments from the Federal Environment Agency of Germany (UBA) and of the Danish Energy Agency (DEA). The study team will try to come back to this point in the Task 4 report.

[230] COMMISSION DELEGATED REGULATION (EU) No 518/2014 of 5 March 2014 amending Commission Delegated Regulations (EU) No 1059/2010, (EU) No 1060/2010, (EU) No 1061/2010, (EU) No 1062/2010, (EU) No 626/2011, (EU) No 392/2012, (EU) No 874/2012, (EU) No 665/2013, (EU) No 811/2013 and (EU) No 812/2013 with regard to labelling of energy-related products on the Internet, OJ L147/1 17.5.2014, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0518&from=EN

[231] Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel, OJ L27/1 of 30.1.2010, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri= CELEX:32010R0066&rid=3

Commission Decision 2011/331/EU [232] provides these criteria for awarding the Ecolabel to light sources. This decision applies to (article 1):

> "*all light sources of a luminous flux ≥ 60 and ≤ 12 000 lumens for general lighting applications with direct or indirect connection to the public electricity supply equipped with a lamp cap listed in EN 60061 and made in order to produce a visible radiation*."

Light sources that are excluded from the scope of the decision (article 2):

> "*directional lamps, high intensity discharge lamps, coloured lamps, projector lamps, photographic lighting, solarium tubes, battery driven systems and other light sources that are not intended for general lighting applications. The following types of light sources are not included in the product group if they are not supplied directly from the mains: integral compact fluorescent lamps, filament lamps, LED lamps*."
>
> (according to article 3 these excluded lamps can NOT be awarded the EU Ecolabel).

The criteria require:

- a minimum energy efficiency of 10% better than the 'A' class (as defined in the lamp energy label of Directive 98/11/EC),
- a life time of 15 000 h for single ended lamps and 20 000 h for double ended lamps,
- a lumen maintenance of 80% at 9 000 hours for single ended lamps and 90% at 16 000 h double ended lamps,
- a mercury content < 1.5 mg for single ended lamps and < 3.0 mg double ended lamps [233],
- for compact fluorescent lamps (CFLs) and LEDs, the number of switch on/off cycles that the light source can withstand before premature failure shall be greater than the lamp life time expressed in hours or greater than 60 000 if it is claimed that the lamp withstands frequent switching,
- a colour rendering index (Ra) > 85,
- a spread of correlated colour temperature (CCT) within a 3-step MacAdam ellipse or better,
- absence of hazardous substances defined in the REACH-directive [234],
- limits on plastic parts,
- limits on packaging materials and % recycled material used in packaging,
- adequate user instructions, social accountability, adequate label information.

Article 3 of Decision 2011/331/EU states that the above criteria shall be valid for two years from the date of adoption, which implies until June 2013. Consequently they are currently (May 2014) not valid anymore.

The criteria are being reviewed by the Eco-lighting project [235], which is a consortium of stakeholders led by lighting manufacturers' organisation LightingEurope. This project initiated in January 2012 and

[232] COMMISSION DECISION, of 6 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for light sources, (2011/331/EU). OJ L148/13, 7.6.2011, repealing decision 2002/747/EC. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri= OJ:L:2011:148:0013:0019:EN:PDF

[233] This is more severe than the RoHS2 directive, see par. 5.1.14

[234] REGULATION (EC) No 1907/2006 of The European Parliament and of the Council of 18 December 2006 ('REACH'). OJ L 396/1, 30.12.2006. Relates to substances under Article 59(1). http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1400669747476&uri=CELEX:02006R1907-20140410

[235] Eco-lighting project : http://www.eco-lighting-project.eu/the-project

produced a report including a draft criteria proposal in January 2014 [236]. The criteria were presented and discussed during a meeting in February 2014 [237].

5.1.10. Commission Communication COM (2008) 400 on Green Public Procurement (GPP)

In 2004, the Council and the European Parliament adopted two directives aimed at clarifying, simplifying and modernising existing European legislation on public procurement:

- Directive 2004/18/EC covers public works contracts, public supply contracts and public service contracts.
- Directive 2004/17/EC covers the procurement procedures of entities operating in the water, energy, transport and postal services sectors.

In contrast with the earlier EU Directives governing procurement, the 2004 Directives contain specific reference to the possibility of including environmental considerations in the contract award process.

In 2008, the European Commission issued a Communication [238] on Green Public Procurement (GPP) [239], stressing the importance of common criteria. Since then GPP-criteria have been developed for the public procurement of several types of products among which lighting products.

In 2012, GPP-criteria were published for '*indoor lighting*' [240] and for '*street lighting and traffic signals*' [241]. Both sets of criteria are accompanied by a Technical Background Report. The GPP-criteria for '*office lighting*' [242] are under development, with a target date of mid-2014.

The EU GPP is a voluntary system. However, Member States are invited to formally endorse the already developed common GPP-criteria in the National Action Plans. Such plans or equivalent documents have now (May 2014) been adopted in all EU-28 member states, except Croatia, Estonia, Greece, Hungary, Luxembourg, Romania [243].

[236] "Revision of European Ecolabel and Green Public Procurement Criteria for Lamps – Eco-lighting project – Background Report including Draft Criteria Proposal – Working document for 2nd AHWG meeting for the development of ecolabel criteria for lamps", January 2014, http://www.eco-lighting-project.eu/uploads/docs/docs1_Eco_lighting_Background_Repor_including_Draft_Criteria_Proposal_amended_version.pdf

[237] Presentation "EU Ecolabel criteria revision for Lamps – Commented version after 2nd AHWG meeting of 13th February 2014", Eco-lighting project March 2014, http://www.eco-lighting-project.eu/uploads/ docs/docs1_Eco_lighting_2nd_AHWG_meeting_criteria_presentation_140213_comments_minutes.pdf

[238] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Public procurement for a better environment, COM(2008) 400, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri= COM:2008:0400:FIN:EN:PDF

[239] Main GPP website: http://ec.europa.eu/environment/gpp/index_en.htm

[240] "Green Public Procurement , Indoor Lighting , Technical Background Report", BRE 2011, http://ec.europa.eu/environment/gpp/pdf/tbr/indoor_lighting_tbr.pdf
"EU GPP Criteria for Indoor Lighting", 2012, http://ec.europa.eu/environment/gpp/pdf/criteria/indoor_lighting.pdf

[241] "Green Public Procurement, Street Lighting and Traffic Lights,Technical Background Report", BRE 2011 http://ec.europa.eu/environment/gpp/pdf/tbr/street_lighting_tbr.pdf
"EU GPP Criteria for Street Lighting & Traffic Signals", 2012, http://ec.europa.eu/environment/gpp/pdf/criteria/street_lighting.pdf

[242] http://ec.europa.eu/environment/gpp/gpp_criteria_wp.htm

[243] http://ec.europa.eu/environment/gpp/action_plan_en.htm

5.1.10.1. GPP-criteria for indoor lighting

For the purposes of these criteria, indoor lighting is defined as covering lamps, luminaires (light fittings) and lighting controls installed inside buildings. The criteria do not cover specialist types of lighting (see the reference for a listing of types).

Three sets of EU GPP-criteria are proposed:

a) for purchasing of resource and energy efficient lamps
   - minimum energy class, per type of lamp, for replacement lamps
   - minimum energy class, per type of lamp, for new and renovated installations
   - minimum lamp life in hours, per type of lamp
   - maximum mercury content, per type of fluorescent lamp

b) design of a new lighting system or renovation of the existing lighting system
   - for entire buildings, maximum lighting power density in W/m^2, per type of building
   - for single spaces, maximum normalised lighting power density in $W/m^2/100lux$, per type of space or building part
   - recommendations on lighting control (occupancy sensors, time-switches, use of daylight, dimming …)

c) installation work

The criteria are envisaged to be reviewed in 2013. The Eco-lighting project [244] is working on this (May 2014).

5.1.10.2. GPP-criteria for street lighting and traffic signals

Public street light is defined as a: "*Fixed lighting installation intended to provide good visibility to users of outdoor public traffic areas during the hours of darkness to support traffic safety, traffic flow and public security*". This does not include tunnel lighting, private car park lighting, commercial or industrial outdoor lighting, sports fields or installations for flood lighting (for example monument, building or tree lighting).

Traffic signals are defined as: "*Red, yellow and green signal lights for road traffic with 200mm and 300mm roundels. Portable signal lights are specifically excluded*."

Outline of the EU GPP-criteria for Street Lighting:

- High Pressure Sodium (HPS) lamps with Ra<60, minimum luminous efficacy for clear and coated lamps in function of wattage
- Metal Halide (MH) lamps with Ra<80, minimum luminous efficacy for clear and coated lamps in function of wattage
- Metal Halide lamps with Ra≥80, minimum luminous efficacy for clear and coated lamps in function of wattage
- Ballasts for HID lamps, minimum efficiency in function of wattage
- Ballasts for CFL lamps shall all be electronic
- HPS and MH lamps: reference burning hours, minimum lamp lumen maintenance factors and survival factors
- Minimum ingress protection rating (IP) per road class
- Recommended maximum mercury content for HPS and MH lamps
- Recommendations for resource and energy efficient design of new or renovated lighting systems

[244] Eco-lighting project : http://www.eco-lighting-project.eu/the-project

- Maximum energy efficiency indicator [245](W/cd/m^2*m^2) in function of lamp wattage or in function of required illuminance
- Limits on ULR, the portion of light that goes above the horizon (spill light), in function of road class
- Instructions for the installation phase (qualified personnel, user instructions, setting of daylight controls and time-switches, handling of waste lamps …)

Outline of the EU GPP-criteria for Traffic Lighting:

- Maximum Operating Wattage levels in function of signal head type
- Requirements concerning packaging

No date for review of these criteria is specified.

5.1.10.3. GPP-criteria for office lighting

The GPP website informs that GPP-criteria for office lighting are under development for mid-2014. In reality these are not new criteria but a substitute for the indoor lighting criteria. The development of the office lighting criteria is actually the announced revision of the criteria for indoor lighting.

5.1.10.4. Report Lighting the Cities

In close relation to the GPP-criteria discussed above, in June 2013 the European Commission issued the report 'Lighting the Cities' [246], aimed at decision makers in European cities responsible for their indoor and outdoor lighting infrastructures. It presents the findings of a Task Force for Cities that was established by the European Commission with the aim of delivering a roadmap for achieving wider deployment and major rollout of new SSL-based lighting technologies for cities throughout Europe. European cities have the potential to become a major lead market for innovative LED lighting solutions, as identified in the Commission Green Paper 'Lighting the Future' published in December 2011 [247] as part of the Digital Agenda for Europe flagship initiative [248] under the Europe 2020 strategy for smart, sustainable and inclusive growth.

5.1.11. Directive 2010/31/EU on Energy Performance of Buildings (EPBD Directive)

The Energy Performance of Buildings Directive (EPBD) is, at European level, the main policy driver affecting energy use in buildings.

[245] maximum energy efficiency indicator = average system power divided by the required road surface luminance and the area to be lit,

[246] "Lighting the Cities – Accelerating the Deployment of Innovative Lighting in European Cities", June 2013, Digital Agenda for Europe, European Commission, http://ec.europa.eu/digital-agenda/en/news/new-commission-report-lighting-cities-accelerating-deployment-innovative-lighting-european

[247] "GREEN PAPER Lighting the Future - Accelerating the deployment of innovative lighting technologies", COM(2011) 889 final of 15 December 2011, European Commission, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0889:FIN:en:PDF

[248] http://ec.europa.eu/digital-agenda

The energy efficiency of lighting is explicitly addressed as a subject --mainly for the non-residential sector-- in the 2010 recast of the Energy Performance of Buildings Directive (EPBD)[249] . The EPBD recast also explicitly formulates that "*Member States should use, where available and appropriate, harmonised instruments, in particular testing and calculation methods and energy efficiency classes developed under measures implementing Directive 2009/125/EC*". [250]

Annex I point 3 stipulates that "*The methodology shall be laid down taking into consideration at least the following aspects: (...) (e) built-in lighting installation (mainly in the non-residential sector)*".

Annex I point 4 stipulates that "*The positive influence of the following aspects shall, where relevant in the calculation, be taken into account: (...) (d) natural lighting*."

5.1.12. Directives 2003/87/EC and 2009/29/EC on Greenhouse gas emission trading (ETS)

Directive 2003/87/EC, last amended in 2009 [251], regards the EU Emission Trading System (EU ETS) [252]. This system is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. It now covers 45% of all GHG emissions in the EU.

The EU ETS works on the 'cap and trade' principle. The overall volume of greenhouse gases that can be emitted each year by the power plants, factories and other companies covered by the system is subject to a cap set at EU level. Within this Europe-wide cap, companies receive or buy emission allowances which they can trade if they wish. From 2013 onwards, the cap on emissions from power stations and other fixed installations is reduced by 1.74% every year. This means that in 2020, greenhouse gas emissions from these sectors will be 21% lower than in 2005.

By putting a price on carbon and thereby giving a financial value to each ton of emissions saved, the EU ETS promotes investment in energy savings and in clean, low-carbon technologies.

The carbon-abatement resulting from more efficient lighting may be part of policy measures such as the Emission Trading Scheme (ETS).

5.1.13. Directive 2012/27/EU on Energy Efficiency (EED)

Directive 2012/27/EU [253] is the Energy Efficiency Directive (EED). This Directive establishes a common framework for promoting energy efficiency in the Union to ensure that the 20% energy efficiency target in 2020 (i.e. reaching a 2020 energy consumption of no more than 1483 Mtoe of primary energy consumption and no more than 1086 Mtoe of final energy consumption) is met and to pave the way for further energy efficiency afterwards.

---

[249] DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings. OJ L153/13, 18.6.2010. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF (recast of directive 2002/91/EC)

[250] Recital (12) of the EPBD recast.

[251] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. OJ L 275, 25.10.2003, p. 32. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:275:0032:0046:en:PDF
Latest amendment: Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009. OJ L140/63, 5.6.2009. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:en:PDF

[252] For details on the ETS, see http://ec.europa.eu/clima/publications/docs/factsheet_ets_en.pdf (state of 2013)

[253] DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. OJ L315/1, 14.11.2012. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF

The Directive states (article 24 point 2) that by 30 April 2014, and every three years thereafter, Member States shall submit National Energy Efficiency Actions Plans (NEEAPs) that cover significant energy efficiency improvement measures and expected and/or achieved energy savings.

Member States have to transpose most of the Directive's provisions into national legislation by 5 June 2014.

Although the Directive does not explicitly mention lighting as a topic, an improved energy efficiency of lighting could be integrated in the NEEAPs.

5.1.14. Directive 2011/65/EU on restriction of hazardous substances (RoHS 2)

The Directive 2011/65/EU [254] on the Restrictions of Hazardous Substances in Electrical and Electronic Equipment is also referred to as RoHS2, being the 2011-recast of the preceding RoHS Directive 2002/95/EC**.**

According to RoHS2 Annex II the limited substances are: Lead, Mercury, Cadmium, Hexavalent Chromium, PBB and PBDE. The maximum allowed concentration by weight in homogeneous materials is 0.1% (for Cadmium 0.01%).

Article 4 specifies that Member States shall ensure that EEE's placed on the market do not contain more than the specified maximum concentrations of these substances.

Articles 13, 14, 15 imply that CE-marking of EEE's according to Regulation 765/2008 is allowed only if requirements of the RoHS2-directive are met.

RoHS2 Annex I explicitly mentions 'lighting' as an electrical and electronic equipment (EEE) category covered by the Directive.

RoHS2 Annex III lists **applications that are exempted** from the restriction in Article 4(1). For lighting products this includes:

- <u>For Mercury in single capped (compact) fluorescent lamps (maximum per burner):</u>
  - for general lighting purposes < 30 W : 2.5 mg (from 31 Dec 2012)
  - for general lighting purposes ≥ 30 W and < 50 W : 3.5 mg (from 31 Dec 2011)
  - for general lighting purposes ≥ 50 W and < 150 W : 5 mg
  - for general lighting purposes ≥ 150 W : 15 mg
  - for general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm : 7 mg (from 31 Dec 2011)
  - for special purposes : 5 mg
  - for general lighting purposes < 30 W with a lifetime equal or above 20 000 h : 3.5 mg (until 31 Dec 2017) [255]
- <u>For Mercury in double capped linear fluorescent lamps for general lighting purposes (maximum per lamp):</u>
  - Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 4 mg (from 31 Dec 2011)
  - Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg (from 31 Dec 2011)
  - Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 mg (from 31 Dec 2011)
  - Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 3.5 mg (from 31 Dec 2012)

[254] DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment ('RoHS 2'). OJ L174/88, 1.7.2011. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02011L0065-20140129&qid=1400669059509&from=EN

[255] This addition is introduced in Commission Delegated Directive 2014/14/EU of 18 October 2013, OJ L4/71 of 9 January 2014, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2014:004:FULL&from=EN

- Tri-band phosphor with long lifetime (≥ 25 000 h): 5 mg (from 31 Dec 2011)

- For Mercury in other fluorescent lamps (maximum per lamp):
  - Linear halophosphate lamps with tube > 28 mm (e.g. T10 and T12): 0 mg (from 13 Apr 2012)
  - Non-Linear halophosphate lamps (all diameters) 15 mg (until 13 Apr 2016)
  - Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9): 15 mg (from 31 Dec 2011)
  - Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg (from 31 Dec 2011)

- For Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes (maximum per lamp):
  - Short length (≤ 500 mm) 3.5 mg (from 31 Dec 2011)
  - Medium length (> 500 mm and ≤ 1 500 mm) 5 mg (from 31 Dec 2011)
  - Long length (> 1 500 mm) 13 mg (from 31 Dec 2011)

- For Mercury in discharge lamps:
  - Other low-pressure discharge lamps (max per lamp) 15 mg (from 31 Dec 2011)
  - High Pressure Sodium (vapour) lamps for general lighting purposes in lamps with improved colour rendering index Ra > 60 (max per burner)
    - P ≤ 155 W 30 mg (from 31 Dec 2011)
    - 155 W < P ≤ 405 W 40 mg (from 31 Dec 2011)
    - P > 405 W 40 mg (from 31 Dec 2011)
  - Other High Pressure Sodium (vapour) lamps for general lighting purposes (max per burner)
    - P ≤ 155 W 25 mg (from 31 Dec 2011)
    - 155 W < P ≤ 405 W 30 mg (from 31 Dec 2011)
    - P > 405 W 40 mg (from 31 Dec 2011)
  - High Pressure Mercury (vapour) lamps (HPMV) no limit (until 13 Apr 2015)
  - High Metal Halide lamps (MH)
  - Other discharge lamps for special purposes not specifically mentioned in this Annex

In addition to the above exemptions for Mercury, the annex also contains some exemptions on **Lead, Cadmium and Hexavalent Chromium** contained in components of lamps such as the glass and ceramic parts, soldering materials, electrical contacts, fluorescent coatings, etc. Some of these exemptions have been added in a series of 2014-directives [256]. See the references for full details.

5.1.14.1. Minamata Convention on Mercury

The Minamata Convention on Mercury [257] is a global treaty to protect human health and the environment from the adverse effects of mercury. It was agreed by the Intergovernmental Negotiating Committee in Geneva, Switzerland on Saturday, 19 January 2013.

The treaty has now (May 2014) been signed by 97 countries and it has been ratified by the U.S.A.

The text of the treaty [258] has aspects that are relevant for lighting products.

Article 4 point 1 of the treaty states:

[256] Directives 2014/1/EU through 2014/16/EU of 18 October 2013, OJ L4/45 through 75, 9 January 2014, amending Directive 2011/65/EU. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2014:004:FULL&from=EN

[257] http://www.mercuryconvention.org/Convention/tabid/3426/Default.aspx

[258] http://www.mercuryconvention.org/Portals/11/documents/conventionText/Minamata%20Convention%20on%20Mercury_e.pdf

"Each Party shall not allow, by taking appropriate measures, the manufacture, import or export of mercury-added products listed in Part I of Annex A after the phase-out date specified for those products, except where an exclusion is specified in Annex A or the Party has a registered exemption pursuant to Article 6."

Apart from the possibility of exemptions according to article 6, also article 4 point 2 allows the parties to propose alternatives to the phase-out of products, but under strict conditions.

In Part I of Annex A the following mercury-added products are excluded from the scope:

(a) Products essential for civil protection and military uses;

(b) Products for research, calibration of instrumentation, for use as reference standard;

(c) Where no feasible mercury-free alternative for replacement is available, switches and relays, **cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays**, and measuring devices;

(d) Products used in traditional or religious practices.

As regards lighting, the following products are explicitly mentioned in Annex I of the treaty:

Part I: Products subject to Article 4, paragraph 1

Mercury-added products	Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	2020
Linear fluorescent lamps (LFLs) for general lighting purposes: (a) Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp; (b) Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp	2020
High pressure mercury vapour lamps (HPMV) for general lighting purposes	2020
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: (a) short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp (b) medium length (> 500 mm and ≤ 1 500 mm) with mercury content exceeding 5 mg per lamp (c) long length (> 1 500 mm) with mercury content exceeding 13 mg per lamp	2020

Table 3 Mercury limits for lighting products according to the Minamata Convention

5.1.14.2. Comparison of RoHS with limits from the Minamata Convention

For CFLs for general lighting purposes < 30 W the RoHS2 mercury limit of 2.5 mg (3.5 mg for long lifetime lamps) per burner from year 2013 is more stringent than the limit of 5 mg in the year 2020 imposed by the Minamata Convention. In addition, this Convention does NOT cover other types of CFL lamps while RoHS2 does.

For LFLs for general lighting purposes with tri-band phosphor the RoHS2 directive allows from 3 to 4 mg per lamp (5 mg for long lifetime lamps). For the same lamps, but limited to < 60 W, the Minamata

Convention allows 5 mg in the year 2020. Therefore, also in this case the RoHS2 directive is more severe.

For LFLs for general lighting purposes with halophosphate and power ≤ 40 W the Minamata Convention allows 10 mg of mercury by 2020. The RoHS2 directive has no mercury allowance for these lamps since 2012 [259].

The Minamata Convention forbids High Pressure Mercury vapour lamps from 2020 while RoHS2 rules them out from 2015.

As regards CCFL and EEFL the Minamata treaty and the ROHS2 directive use the same mercury limits but Minamata activates them in 2020 and RoHS2 in 2012.

Therefore, in general the European RoHS2 Directive is more stringent and more detailed than the International prescriptions of the Minamata Convention.

5.1.15. Commission Regulation (EC) No 1907/2006, REACH

Commission Regulation (EC) No 1907/2006 REACH [260] came into force on 1 June 2007 and deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances. The regulation provides a list of chemical substances, which is updated several times each year [261]. Manufactures are required to register the details of the properties of their chemical substances appearing in the regulation in a central database, which is run by the European Chemicals Agency in Helsinki. The regulation also requires the most dangerous chemicals to be progressively replaced as suitable alternatives are developed.

The list of REACH substances is referred to for example in the criteria for awarding the Eco-label to light sources (see par. 5.1.9).

5.1.16. Directive 2012/19/EU on waste electrical and electronic equipment (WEEE)

Directive 2012/19/EU (WEEE) [262] was issued in July 2012 as a recast of the existing 2002/96/EC, which is repealed with effect from 15 February 2014.

The aim of this directive is expressed, for example, by its article 1: "*This Directive lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste from electrical and electronic equipment (WEEE) and by reducing overall impacts of resource use and improving the efficiency of such use*."

The directive puts the responsibility for handling of WEEE on the producers of such equipment. They shall finance the collection and treatment of their WEEE in a harmonised way that avoids false competition. Producers will shift payments to the consumers under the principle that the '*polluter pays*', avoiding costs for the general tax payer [263].

In a transitional period (from August 2012 to August 2018) the directive applies to the EEE categories and equipment indicated in Annex I and II of the directive. After August 2018, the directive applies to

[259] Halophosphate LFLs have also been phased out for energy efficiency reasons by Regulation 245/2009.

[260] See note 234

[261] For a list of regulations that updated the list of substances since 2007, see the reference in note 234

[262] Directive 2012/19/EU of the European Parliament and of the Council of 4 july 2012 on waste electrical and electronic equipment (WEEE), OJ L197/38, 24.7.2012, repealing directive 2002/96/EC with effect from 15 Feb. 2014, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:197:0038:0071:en:PDF

[263] See, for example, Recital (23) of the directive.

all EEE (indicated in Annex III and IV). Article 2.3 and 2.4 specify equipment to which the directive does NOT apply.

Article 2.3(c) clearly excludes '*filament bulbs'* from the scope of the directive.

Article 5 explicitly mentions '*fluorescent lamps containing mercury'* as items for separate collection.

Annex I distinguishes '*lighting equipment'* as an EEE category (5) to which the directive applies, also in the transitional period. Annex II gives examples of EEE falling into this category: *LFL, CFL, HID (HPS, MH), LPS, "luminaires for fluorescent lamps with the exception of luminaires in households", "other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs"*.

Annex III distinguishes '*lamps'* as an EEE-category (3). The examples given in Annex IV are more or less the same as those from Annex II but additionally '*LEDs'* are mentioned explicitly.

Annex V specifies minimum recovery targets for lighting products as follows:

- From 13/8/2012 to 14/8/2015 : 70% recovered ; 50% prepared for re-use and recycled
  80% recycled for gas discharge lamps
- From 15/8/2015 to 14/8/2018 : 75% recovered ; 55% prepared for re-use and recycled
  80% recycled for gas discharge lamps
- After 15/8/2018 : 80% recycled for all lamps.

Annex VII mentions "*mercury containing components such as switches or backlighting lamps*", "*cathode ray tubes*" and "*gas discharge lamps*" as components to be removed from separately collected WEEE. The fluorescent coating shall be removed from cathode ray tubes and the mercury shall be removed from gas discharge lamps.

5.1.17. Directive 2014/30/EU on harmonisation of laws on EMC

Directive 2014/30/EU [264] regarding Electromagnetic Compatibility (EMC) [265] was issued in February 2014 and will repeal the existing directive 2004/108/EC [266] with effect from April 2016.

On the one hand, the Directive aims to ensure that electromagnetic emissions from an equipment do not disturb radio and telecommunication nor the correct functioning of other equipment. On the other hand, the Directive also governs the immunity of an equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions normally present.

The Directive does not explicitly mention lighting products, but it is relevant for gears / ballasts / drivers and controls operating lamps.

[264] Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast), OJ L 96/79 of 29.3.2014, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:JOL_2014_096_R_0079_01&qid= 1396511671603&from=EN

[265] General web site on EMC: http://ec.europa.eu/enterprise/sectors/electrical/emc/

[266] Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC, OJ L 390/24 of 31.12.2004, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024: 0037:EN:PDF

5.1.18. Directive 2014/35/EU on harmonisation of laws on Low Voltage equipment (LVD)

Directive 2014/35/EU [267] regarding Low Voltage electrical equipment (LVD) [268] was issued in February 2014 and will repeal the existing directive 2006/95/EC [269] with effect from April 2016.

The purpose of this Directive is to ensure that electrical equipment on the market fulfils the requirements providing for a high level of protection of health and safety of persons, and of domestic animals and property, while guaranteeing the functioning of the internal market.

The Directive applies to electrical equipment designed for use with a voltage rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current. These voltage ratings refer to the voltage of the electrical input or output, not to voltages that may appear inside the equipment.

For electrical equipment within its scope, the Directive covers all health and safety risks, thus ensuring that electrical equipment will be used safely and in applications for which it was made. For most electrical equipment, the health aspects of emissions of electromagnetic fields are also under the domain of the Low Voltage Directive.

The Directive does not explicitly mention lighting products, but they are of course in the scope.

[267] Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (recast), OJ L 96/357 of 29.3.2014, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:JOL_2014_096_R_0357_01&from=EN

[268] General web site on LVD: http://ec.europa.eu/enterprise/sectors/electrical/lvd/index_en.htm

[269] Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the approximation of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits, OJ L 390/24 of 31.12.2004, repealing directive 73/23/EEC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

6. NON-EUROPEAN LEGISLATION

6.1. Introduction

The objective of this section is to examine non-European legislative requirements (product scope and legislative requirements), both direct and indirect, to determine the degree to which other countries regulate lighting products differently to the EU. Where such differences occur, an analysis is undertaken of the merit of the EU amending current practice to follow legislative approaches from elsewhere, either as a whole, in part or in an amended form. In particular, this analysis seeks to highlight issues and opportunities that may arise from the potential adoption of a single regulation for lighting and the consequential impact on scope, exclusions and performance requirements.

Note that, as in the preceding section, the legislative requirements used by the EU and other countries often combine elements of the method of test and direct or indirect performance requirements. Where possible, this section refers only to the direct and indirect legislative/regulatory elements with test methodologies addressed in section 3, although by necessity there is overlap in places.

Extent of analysis

The countries analysed in most depth are those known to have broad product scope, or advanced requirements, or both. This section covers MEPS legislation for the following technologies:

- Incandescent and tungsten halogen lamps - non-directional
- Incandescent and tungsten halogen lamps - directional
- Compact fluorescent lamps with integrated ballast (CFLi)
- Compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps)
- LED lamps
- Linear fluorescent lamps
- HID lamps
- Linear fluorescent ballasts
- HID ballasts.

Annex J contains additional information regarding non-EU legislation. Note that this section examines legislation by technology type, which is the way most legislation is framed internationally. There are very few countries, if any, that adopt technology-neutral legislation. An example of why this is difficult can be found with residential NDLS lamps - currently the EU has eliminated incandescent lamps from the market, in favour of tungsten halogen, CFL and LED alternatives. The EU aimed to set a technology-neutral efficacy requirement for tungsten halogen, CFL and LED lamps, which required it to set the 'lowest common denominator' efficacy of around 15 lm/W so that tungsten halogen lamps could continue to be sold [270]. However, this does not extract the maximum benefit from CFL and LED lamps, which are capable of much higher efficacies. Thus, countries typically set separate efficacy requirements for each lamp type.

[270] Regulation 244/2009 has 2 sets of efficacy requirements, for clear lamps and non-clear lamps, that are technology-neutral, although the distinction between clear/non-clear lamps is effectively a technology delineator (e.g. no clear CFLs can be made) and although there are some correction factors depending on the lamp technology. Functionality requirements in this regulation are not technology-neutral. In Regulations 245/2009 and 1194/2012 the efficacy requirements are not technology-neutral.

However, the intent of the technology specific analysis ***is not*** to imply that new EU legislation should be technology specific. EU legislation may benefit from a holistic, technology-neutral approach in some areas and this is examined elsewhere in this study.

The following table is a matrix of MEPS legislation for lighting products from some of the EU's major trading partners and other nations where legislation may have significant relevance to the EU.

	EU	*Australia*	*Canada*	*China*	*Korea*	*Japan*[271]	*Taiwan*	*USA*
Incandescent lamps - non-directional	X	X	X	X	X	X	X	X
Incandescent and tungsten halogen lamps - directional	X	X	X	-	-	-	-	X
Compact fluorescent lamps with integrated ballast (CFLi)	X	X	-	X	X	X	X	X
Compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps)	X	-	-	X	X	X	X	-
LED lamps	X	-	-	X	-	X	planned	-
Linear fluorescent lamps	X	X	X	X	X	X	X	X
HID lamps	X	-	-	X	planned	-	-	-
Linear fluorescent ballasts	X	X	X	X	X	X	X	X
HID ballasts	X	-	X	X	planned	-	-	X
Luminaires [272]	(X)	-	(X)	-	-	X	-	(X)

Table 4 MEPS legislation for lighting products from some of the EU's major trading partners and other nations where legislation may have significant relevance to the EU

A discussion of the comparison of this MEPS legislation appears in the next section, relevant to the context of the proposed changes to the EU legislation.

6.2. Discussion and analysis of legislation

The objective of this section is to discuss how European legislation compares to other countries, and to examine how other countries deal with the opportunities and issues raised in the Omnibus study.

The current EU legislation, in comparison to other countries, is relatively holistic in the way it frames its legislation. For example, the EU has three key pieces of legislation for the regulation of lamps non-directional, directional/LED and tertiary. Within each of these, there is a common scope, but performance requirements do in some cases vary by technology type [273]. However, other countries

[271] Technically, there are no MEPS on CFLs in Japan, but there are similar de facto requirements introduced as part of the Top Runner programme.

[272] EU: Regulation 245/2009 for Fluorescent and HID. Canada and USA: HID, but main effect is on ballast. The luminaire MEPS listed here are not true MEPS in that they don't place an efficacy requirement on the luminaire itself - e.g. minimum Light Output Ratio or similar. These MEPS listed are mainly to do with ballasts as well as compatibility.

[273] Regulation 244/2009 has 2 sets of efficacy requirements, for clear lamps and non-clear lamps, that are technology-neutral, although the distinction between clear/non-clear lamps is effectively a technology delineator (e.g. no clear CFLs can be made) and although there are some correction factors depending on the lamp technology. Functionality

tend to completely separate the technologies - e.g. have a different scope defined for each technology type.

6.2.1. Comparison of scope

Non-directional incandescent and tungsten halogen lamps

This lamp type is probably the most important to discuss regarding scope, as the current EU scope has led to loopholes related to shockproof lamps. For non-directional incandescent and tungsten halogen lamps, a scope comparison between the EU and other relevant countries has been undertaken is as follows:

- Lamp size (light output / wattage):
  - EU: 60-12000 lm
  - US: 310-2600 lm
  - Canada: 310-2600 lm
  - China: ≤ 100W (~1300 lm)
  - Korea: 25-150W (~310-2500 lm)
  - Taiwan: ≥ 25W
  - Australia: <150 W (~2500 lm)
- Shape:
  - EU: all
  - US: all
  - Canada: all
  - China: all
  - Korea: all
  - Taiwan: all
  - Australia: all
- Voltage:
  - EU: all
  - US: 110-130V
  - Canada: 110-130V
  - China: 220-250 V
  - Korea: 220V
  - Taiwan: mains voltage
  - Australia: 5-14V or ≥220V.
- Key exclusions (where available):
  - EU: lamps outside certain spectral parameters, incandescent lamps with E14/E27/B22/B15 caps with rated voltage ≤60V, special purpose lamps (such as traffic signals, terrarium lighting, or household appliances).
  - US: rough, vibration, shatter resistant, 3-way, coloured.
  - Canada: similar to US but with additional exclusions - refer Annex J
  - China: special lighting applications including scientific research, medical treatment, trains, shipping, aircraft, traffic vehicles, household appliances, etc.
  - Korea: nil
  - Australia: coloured, traffic signal, navigation, oven, infra-red, rough use or vibration.

requirements in this regulation are not technology-neutral. In Regulations 245/2009 and 1194/2012 the efficacy requirements are not technology-neutral.

In summary, for non-directional incandescent and tungsten halogen lamps, the EU currently has a broader scope in terms of lamp size (lumen output or wattage). Note however that Australia does not have a lower limit on lamp size, although in practical terms this is unlikely to have any significant impact for general purpose lighting.

Countries including the EU typically cover all lamp shapes. This is to be expected as this would present the opportunity for a significant loophole.

The voltages covered by most countries are typically mains voltages. Note that the EU does cover all voltages but excludes Edison/bayonet cap lamps with voltages ≤60V (e.g. for use in 12VDC homes powered by solar/batteries). Australia covers extra-low-voltage (ELV) lamps (e.g. 12V tungsten halogen capsule lamps such as those used in desk lamps).

Most countries have similar exclusions to the EU, and most have an exclusion for 'shockproof' lamps. In contrast to the EU, the US has a very specific definition for rough service lamps [274] - defined as lamps having a minimum of five supports with filament configurations that are C–7A, C–11, C–17, and C–22 as listed in Figure 6–12 of the 9th edition of the IESNA Lighting handbook or similar which are designated and marketed specifically for 'rough service' applications.

The US also defines 'modified spectrum' lamps as non-coloured lamps with x / y chromaticity coordinates that lie below the black-body locus, lying at least 4 MacAdam steps distant from the colour point of a clear lamp with the same filament and bulb shape. Note that the US has separate MEPS requirements for modified spectrum lamps [275].

The US exempts coloured incandescent lamps, which are defined [274] as *"incandescent lamp designated and marketed as a coloured lamp that has (i) a CRI of less than 50 or (ii) a CCT of less than 2500K or greater than 4600K"*.

In the US, exempted lamp types are monitored (data collected from NEMA) to ensure that their low market share continues [276] and lamps may lose their exemption status if their market share increases significantly. To date, none of the exempted lamp types have crossed the statutory threshold required in order to lose their exemption status. Note however that the US authorities have access to very good market data, which is required to be supplied to the US Department of Energy by NEMA.

The Japanese government has encouraged major manufacturers and retailers to voluntarily halt production and sales of incandescent lamps in June 2012 and the industry has indicated it will oblige. However, this is limited to members of the national lighting association (JLMA) and there is no restriction on 'independent lamp imports'. There is also an anecdotal evidence to suggest imported low cost incandescent and halogen lamps (and poorer quality LEDs) are taking an increasing share of the market.

Scope of non-directional incandescent and tungsten halogen lamps - key conclusion(s): The EU currently has a broader scope than other countries. This means that any further increase in the scope of EU legislation would 'break new ground' and thus there is little to be learned from the current scope of other countries' legislation, other than they have not tackled a wider scope, presumably due to the diminishing energy savings returns available from lamp niches outside of common general purpose illumination. Of significant interest is most countries where regulation exists have an exemption for shockproof (or similar) lamps. In the US, the definition of these lamps is very precise. Further, to prevent the kind of loophole that this exemption has created in the EU, the US regulator (Department

[274] http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap77-subchapIII-partA-sec6291.htm
[275] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/61
[276] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/63

of Energy) also has a market monitoring system in place. As discussed above, this system relies on good market data to ensure that the market share of these lamps remains low; otherwise, they can lose their exemption status.

Directional incandescent and tungsten halogen lamps

Fewer countries regulate directional incandescent and tungsten halogen lamps. The current EU regulation for directional lamps is very broad, covering directional (and LED) lamps of all types but excluding a wide range of special purpose lamps. The US and Canada cover incandescent reflector lamps (IRLs) of shapes R, PAR, ER, BR, BPAR, and similar, with E26 medium screw base, 115-130V, diameter >2.25 inches, ≥40W. Excluded are coloured lamps (refer above for definition), rough or vibration service applications, IRLs ≤50W with shape ER30 BR30 BR40 or ER40, IRLs 65W with shape BR30 BR40 or ER40 lamps, R20 lamps, IRLs ≤ 45W. Australia regulates only 12V MR11-16 reflector lamps.

Scope of non-directional incandescent and tungsten halogen lamps - key conclusion(s): As with non-directional lamps, the EU currently has a broader scope than other countries and consequently there is little to be learned from the current scope of other legislation in other countries.

Compact fluorescent lamps with integrated ballast (CFLi)

For CFLi, the regulatory scope of MEPS most countries is similar. However, the EU scope is technology-neutral, thus CFLs are captured in the same scope described above for incandescent / tungsten halogen lamps (60-12000 lm etc.). Thus, in comparison to most other countries, the EU scope captures significantly larger CFLs.

Scope of CFLi - key conclusion(s): the EU currently has a broader scope than other countries and consequently there is little to be learned from the current scope of other legislation in other countries.

Compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps)

The EU, China, Korea, Japan and Taiwan are the only known economies to regulate CFLs without integral ballast (single-ended fluorescent lamps). All of these MEPS cover typical 'pin-based' lamps used in commercial lighting applications.

Scope of compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps) - key conclusion(s): The EU currently has a similar scope to the only other countries known to regulate these lamps - China and Korea.

LED

Very few countries have MEPS in place for LEDs (endorsement labelling is more popular). MEPS for LEDs do exist in the EU and China. Japan's Top Runner program is a de facto MEPS, and countries such as Taiwan are known to be developing MEPS for LEDs although Taiwan in particular is likely to mirror China.

The scope of MEPS for LEDs in the EU is very broad, effectively covering all LED lamps excluding special purpose lamps as described above. In China, the scope of MEPS for LED lamps is self-ballasted LED lamps used for domestic and general purpose lighting with wattage up to 60W and rated voltage up to 250V.

Scope of LED - key conclusion(s): The EU currently has a broader scope than other countries known to regulate LEDs.

Linear fluorescent lamps

The EU legislation for linear fluorescent lamps currently covers all linear fluorescent lamps (T8, T5, T12 and others). The US and Canadian scope of MEPS for linear fluorescent lamps is as follows:

- 4-foot medium bipin (T8 – T12)
- 2-foot U-shaped (T8 – T12)
- 8-foot slimline (T8 – T12)
- 8-foot high output (T8 – T12)
- 4-foot miniature bipin standard output (T5)
- 4-foot miniature bipin high output (T5HO)

Chinese MEPS cover most T8 and T5 lamps. Australian MEPS covers T12, T8 and T5 lamps from 550mm to 1500mm in length with nominal lamp power of 16 Watts or more (i.e. 2-foot T5 lamps excluded). Korea and Taiwan cover common types of T8 and T12 lamps. Japan covers most types of general-purpose fluorescent lighting equipment.

Most countries have exclusions for special purpose lamps and these are typically for special purpose lamps such as 'non-white' lamps, non-general purpose lamps, very small and very large lamps.

Scope of linear fluorescent lamps - key conclusion(s): The EU coverage of linear fluorescent lamps is broader than the scope applied to most other major economies.

HID lamps

The only known economies with regulation for HID lamps are the EU and China, although Korea is expected to introduce regulation in the near future and the US is also considering the issue [277] and already has indirect regulation of mercury vapour lamps (as discussed in section 6.2.2).

The EU scope for HID lamps covers high-pressure sodium and metal halide lamps, with all HID lamp types (including mercury vapour) to be covered in 2015. Chinese MEPS covers high-pressure sodium lamps ranging from 50W-1000W and metal halide lamps ranging from 175W-1500W.

Note that the US has also banned the sale of all ballasts for mercury vapour lamps, which will ultimately eliminate mercury vapour lamps from the market.

Scope of HID lamps - key conclusion(s): The EU currently has a similar but more extensive scope to that of China, the only other country current known to regulate HID lamps at this time. The US is eliminating mercury vapour technology by way of banning ballasts for mercury vapour lamps.

Other lamp types

Currently no economies appear to regulate induction lamps with the possible exception of the EU. Within the EU, it is currently unclear if induction lamps are covered as 'fluorescent lamps' in legislation. Regulations 245 and 347 consistently refer to non-ballasted 'single-capped' and 'double-capped'

[277] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/60

fluorescent lamps and it is unclear if induction lamps fall within this language. One reference found supports a conclusion that induction lamps are not covered by EU legislation [278].

At present, OLEDs are not yet commercialised and are not known to be regulated in any economy. However, there is a reasonable likelihood that commercialisation will occur (at least in some applications) at some point during the lifetime of any revised regulations. As there is a risk the early OLEDs perform poorly and cause market souring (as was the case with early CFLs), this has the potential to cause problems beyond OLEDs as the unsophisticated consumer is unlikely to know an LED from OLED product. Hence, poorly performing OLEDs could create widespread dissatisfaction. Therefore, consideration should be given to extending the EU scope to capture OLEDs and to regulate with the same performance requirements as LEDs.

Scope of other lamp types - key conclusion(s): The EU may consider the inclusion of OLEDs in the scope of regulation, potentially setting the same performance requirements as for LEDs to ensure no market souring as products begin to commercialise. Consideration should also be given to the inclusion of induction lamps in the scope of MEPS, or to clarification of whether these lamps are currently within scope of EU regulations.

Linear fluorescent ballasts

The EU ballast MEPS covers a very broad range of T8, T5, T12, single-capped and other ballasts. US MEPS for ballasts covers T12 ballasts that operate the following lamps:

- 1x F40T12 lamp
- 2x F96T12 lamps
- 2x F40T12 lamps
- 2x F96T12/ES lamps
- 1x F34T12 lamp
- 2x F96T12HO lamps
- 2x F34T12 lamps
- 2x F96T12HO/ES lamps

Australian MEPS covers only ballasts used for T8 lamps and single-capped fluorescent lamps with a rated power from 10W to 70W (note ballasts for T5 lamps are not covered). Chinese MEPS covers a range of T2, T5 and T8 ballasts. Korea and Taiwan also cover common types of T8, T12 and T5 ballasts. Japan covers most types of general-purpose fluorescent lighting equipment.

Scope of linear fluorescent ballasts - key conclusion(s): The EU coverage of linear fluorescent ballasts is broader than most other countries that regulate these ballasts.

HID ballasts

HID ballasts are regulated in the EU, Canada, China and the US and Korea is expected to introduce regulation in the near future. The scope of EU ballast requirements appears to effectively be all HID ballasts.

The scope of Canada's legislation is restricted to metal halide ballasts used in new fixtures, and ballasts that are used with 150-500W lamps. The US scope is currently the same as Canada, although the US has recently announced new metal halide ballast regulations [279] to come in to force in 2017 - this will

[278] http://www.nf-lights.com/en/technical-information/induction-light/
[279] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/49

include ballasts 50-1000W. The US has also banned the sale of new ballasts for use with mercury vapour lamps [280] as noted in section 6.2.2.

China's ballast MEPS covers high-pressure sodium ballasts 70W-1000W and metal halide ballasts 175W-1500W.

Scope of HID ballasts - key conclusion(s): The EU coverage of HID ballasts is broader all other known country regulation.

Luminaires

Luminaire design has a significant impact on the efficiency of a fluorescent lighting system, although quantifying and regulating luminaire efficiency can be difficult. This is in part due to luminaires having many different applications and often being designed with goals that extend beyond those entirely related to efficiency (e.g. aesthetic design, glare mitigation, etc.). This wide variety of applications and design objectives leads directly to a wide range of luminaire efficiencies - best described as the fraction of total light produced which exits the luminaire. For example, a luminaire that places a light source relatively deep in a reflector cavity (e.g. recessed downlight) in order to control glare and direct light towards a target area, may have a luminaire efficiency of less than 50%. Meanwhile, a luminaire that has only limited glare mitigation and light directing optics (e.g. direct-indirect pendant) can achieve luminaire efficiencies of 90% or more.

Being mindful of these issues, regulators worldwide have been reluctant to develop MEPS for luminaires. The USA and the EU have taken some steps in recent years to investigate standards (MEPS or labelling) that seek to encourage the use of higher optical efficiency designs and/or the expanded use of lighting controls systems. However, the regulatory mechanism that has been most widely used to promote luminaire efficiency has been building standards. Under mandatory buildings standards, building designers are required to meet maximum power density limits for lighting. This encourages designers to select efficient luminaires while allowing flexibility to specify luminaires that are appropriate to the application and to other design goals such as aesthetics.

The only known legislation for luminaires is the EU (both fluorescent and HID luminaires), although Canada and the US do have MEPS in place for HID luminaires. Note however that for all these economies, the luminaire MEPS primarily affects only the ballast installed in the luminaire, rather than the photometric performance of the luminaire itself (e.g. light output ratio).

Scope of luminaires - key conclusion(s): The EU are currently the only known economy to regulate the luminaires, although Canada and the US do have MEPS in place for HID luminaires, however for all these economies this primarily affects only the ballast installed in the luminaire.

6.2.2. Comparison of efficiency requirements

Non-directional incandescent and tungsten halogen lamps

The MEPS efficacy requirements, for a range of countries, for non-directional incandescent and tungsten halogen lamps can be seen in the figure below (note that an efficacy conversion has been used in order to 'normalise' the North American (120V) lamp efficacy requirements) [281].

[280] http://www.superefficient.org/Resources/~/media/Files/CLASP%20Harmonization%20Study.pdf
[281] http://mappingandbenchmarking.iea-4e.org/shared_files/231/download

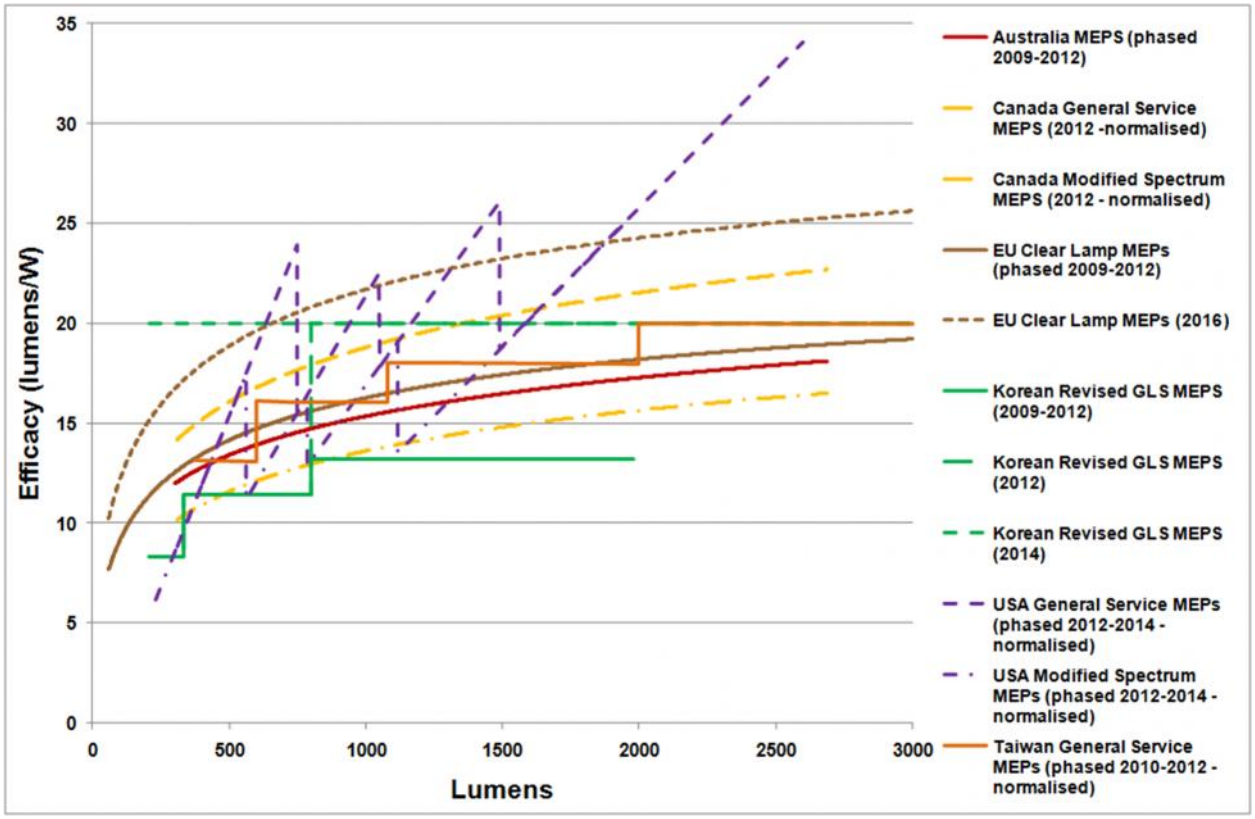

Figure 5 Comparison of MEPS efficacy requirements

For non-directional incandescent and tungsten halogen lamps, most countries have set MEPS at a level that will exclude incandescent lamps but not tungsten halogen lamps. There are variations in approach, and 120V countries have set higher efficacy requirements to take advantage of the natural efficacy that lower voltage lamps offer. However, at the macro level the efficacy requirements have the same effect - phasing out of incandescent lamps only.

The EU 2016 (stage 6) efficacy target was the subject of recent analysis (stage 6 review) which is ongoing. The US also has plans for a change to 40 lm/w by 2020 unless negotiations lead to a compromise with the equivalent net effect.

In Australia, examples have surfaced of MEPS-compliant tungsten-halogen lamps with rated power of 60W - i.e. the same as a conventional incandescent lamp. These lamps were introduced presumably in order to give consumers comfort that these were 'ordinary light globes'. The 60W tungsten-halogen lamps were efficient enough to meet MEPS, but they extracted increased efficacy as increased light output, rather than reduced power. It may be worth considering legislating against this kind of problem. Note that for ELV MR16 lamps Australia successfully introduced a lamp wattage limit of 37W in order to eliminate 50W MR16 lamps from the market (discussed in next section).

Efficiency requirements for non-directional incandescent and tungsten halogen lamps - key conclusion(s): Most countries have currently set MEPS at a level that will exclude incandescent lamps but not tungsten halogen lamps. However, within the EU, implementation of stage 6 of current requirements should remove tungsten halogen lamps from the market (although pending the current review the proposed 2016 timeframe maybe subject to change), with the US removing halogen lamps via a blanket 40 lm/w requirement in 2020 (again, subject to review). It may be worth considering legislating to ensure that increased lamp efficacy results in reduced lamp power, rather than increased light output.

Directional incandescent and tungsten halogen lamps

Few countries have adopted MEPS for directional lamps. In the EU, a detailed market study is required in order to determine if stage 3 of Regulation (EU) No 1194/2012 needs to be changed due to a lack of suitable replacements for mains voltage directional lamps.

The US MEPS requirements for directional lamps (refer Annex J for more detail) set an efficacy level that similarly allows tungsten halogen lamps. For example a 60W mains voltage reflector lamp (120V, >2.5" diameter, standard spectrum) is required to have efficacy of 17.8 lm/W. An equivalent non-directional lamp is required to have efficacy of 20.2 lm/W. The difference between these two requirements is due to the light losses inherent in the reflector.

Mains voltage directional lamps are not current regulated in Australia due to their inability to meet the efficacy curve that was proposed in 2007. However, Australia does regulate only 12V directional MR12-MR16 lamps (using the same efficacy curve as for non-directional lamps). Since 2012, Australian MEPS has also limited the wattage of available 12 volt tungsten halogen downlight lamps to 37 Watts, in order to extract increased efficacy as lower power rather than more light.

Efficiency requirements for non-directional incandescent and tungsten halogen lamps - key conclusion(s): Few countries have adopted MEPS for directional lamps. In the EU, a detailed market study is required in order to determine if stage 3 of Regulation (EU) No 1194/2012 needs to be changed due to a lack of suitable replacements for mains voltage directional lamps. Similar to non-directional lamps, the current US MEPS allows tungsten halogen directional lamps to remain in the market. Australia has adopted a wattage limit for 12V tungsten halogen downlight lamps of 37W, in order to extract increased efficacy as lower power rather than more light.

Compact fluorescent lamps with integrated ballast (CFLi)

For CFLi, generally the efficacy requirements of most countries are within 5-10 lm/W of each other, with the exception of one or two developing countries that have lower requirements. However, the figure below plots a range test results of CFLs purchased on the open market in in Australia in 2008 [282] against the current EU MEPs requirement (black line). This figure shows that, even based on products available in 2008, there is potential to increase the EU MEPS efficacy requirement for CFLs by approximately 10lm/W, particularly at the lower end of the size range.

Efficiency requirements for CFLi lamps - key conclusion(s): Generally, the efficacy requirements of developed countries are within 5-10 lm/W of each other. However, there is potential to increase the EU MEPS efficacy requirement for CFLs by 10 lm/W or more, particularly at the lower end of the size range.

[282] http://www.energyrating.gov.au/products-themes/lighting/compact-fluorescent-lamps/documents-and-publications/?viewPublicationID=254

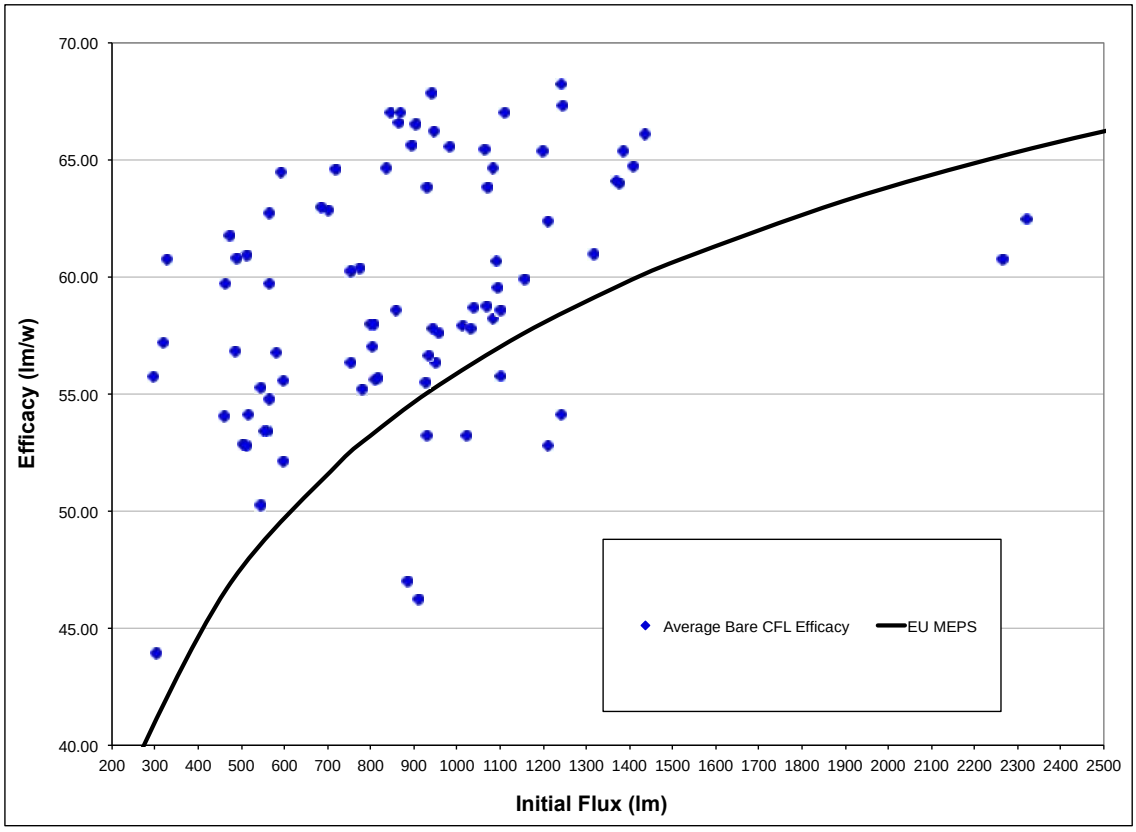

Figure 6 Efficacy for CFL lamps

Compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps)

The EU, China, Korea, Japan and Taiwan are the countries known to regulate CFLs without integral ballast (single-ended fluorescent lamps). The EU requirements are however significantly higher than Asian requirements.

Efficiency requirements for compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps) - key conclusion(s): The EU regulatory requirements for CFLs without integrated ballasts are significantly higher than the other known economies regulating these lamp types (in Asia).

LED

Again, the EU and China are the only countries known to regulate LED MEPS (although Japan has Top Runner which is a de facto MEPS, and countries such as Taiwan are known to be developing MEPS). The EU requirements are however significantly higher than the Chinese requirements.

Efficiency requirements for LEDs - key conclusion(s): The EU regulatory requirements for LEDs are significantly higher than the only other known economy regulating these lamp types (China).

Linear fluorescent lamps

For linear fluorescent lamps, MEPS requirements can be broadly grouped into two categories:

- High MEPS: MEPS for countries such as the EU, Australia, Japan, Korea, Mexico and USA, which require efficacies of 80+ lm/W for 4-foot lamps. Note that Canada currently requires efficacy of

75 lm/W for 4-foot lamps, however Canada has proposed a new MEPS which will harmonize with the USA.
- Low MEPS: for countries such as India (note that India has labelling only - no official MEPS program for linear fluorescent lamps exists) and China, which have relatively low requirements for lamps.

The 'high' MEPS requirements (80+ lm/W) will mandate triphosphor lamps, whereas the other MEPS requirements (75 lm/W and lower) will allow halophosphate lamps. As can be seen in Annex J, the EU efficacy requirement for T8 linear fluorescent lamps is at the lower end of requirements for lower power lamps, and at the higher end for higher power lamps. Note however that EU MEPS is described in terms of rated values, rather than actual test values (this problem also discussed in section 4.1.2).

The EU MEPS requirements for T5 lamps (standard output) range from:

- 86 lm/W for 14W (2-foot) lamps
- 93 lm/W for 28W (4-foot) lamps, to
- 94 lm/W for 35W (6-foot) lamps.

For 4-foot T5 lamps this is higher than the US which requires 81 and 86 lm/W (>4500K and ≤4500K respectively).

The China minimum specification requires differing efficacy depending on colour temperature but has relatively low MEPS - for example, the 4-foot T8 requirement is 62 or 63 lm/W depending on colour temperature.

It is worth noting, in recent testing of 4-foot linear fluorescent lamps for a CLASP study [283], a US lower-power lamp (25W lamp to replace 32W lamp) recorded a tested efficacy of almost 100 lm/W (tested on 50Hz reference ballast). Thus, it may be worth considering not only increasing the efficacy requirement for fluorescent lamps, but placing a power ceiling on these lamps as well, in order to extract increased efficacy as lower power rather than more light.

Efficiency requirements for linear fluorescent lamps - key conclusion(s): The EU has higher efficacy requirements than other countries, although these are described in terms of rated values, rather than actual test values which does not align with most other economies.

Further, lamps available in the market appear to display higher efficacies than current EU requirements, which raises the opportunity of enhance efficacy levels and/or placing a power ceiling on fluorescent lamps, to extract increased efficacy as lower power rather than delivery of additional light.

HID lamps

The only known economies with MEPS for HID lamps are the EU and China although Korea and the US have requirements under consideration [284]. The US also indirect regulates mercury vapour lamps

EU MEPS for HID lamps covers high pressure sodium and metal halide lamps, with all HID lamp types (including mercury vapour) to be covered in 2015 - this will have the effect of prohibiting the sale of all mercury vapour lamps and prohibiting the sale of the less efficient varieties of high pressure sodium and metal halide lamps and ballasts.

Chinese MEPS covers high-pressure sodium lamps ranging from 50W-1000W and metal halide lamps ranging from 175W-1500W. However, even within this power range the EU efficacy requirements for HID lamps are higher than China.

[283] [TBW, study undergoing final review – reference to be inserted on publication]
[284] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/60

The US has no MEPS for HID lamps, but has banned the sale of new ballasts for use with mercury vapour lamps. Effectively this is phasing out mercury vapour lamps at the rate ballasts fail [285].

Efficiency requirements for HID lamps - key conclusion(s): The only known economies with MEPS for HID lamps are the EU and China, and the EU efficacy requirements are currently higher than China.

However, the US has is effectively phasing-out mercury vapour technology. There is value in highlighting the mechanism used by the US to phase-out mercury vapour lamps, i.e. through prohibiting sale of the ballast rather than the lamp itself. Should it be considered appropriate, the use such a proxy mechanisms (e.g. via an auxiliary product as in this case, but also potentially by specific performance requirements) may be an approach that could be used within EU to remove specific lamp types from the market while still maintaining technology neutral lamp requirements.

Linear fluorescent ballasts

The EU stage 1 requirement (2010) specifies that the minimum energy efficiency index class for linear fluorescent ballasts shall be:

- B2 for ballasts covered by table 17 in Annex III.2.2 (T8, T5, circular)
- A3 for the ballasts covered by table 18 (other ballasts)
- A1 for dimmable ballasts.

The EU stage 3 requirement (2017) ballasts for fluorescent lamps shall have the efficiency: ηballast ≥ EBbFL (where EBbFL is determined from rated lamp power and is defined in the EU legislation). However, this will effectively mandate electronic ballasts.

In the US, commencing in November 2014 the new metric will be Ballast Luminous Efficiency (BLE) defined as ballast input power divided by the lamp arc power of a lamp-and-ballast system. Calculations of specific BLEs for ballasts are listed in Annex J.

Comparing the EU (stage 3) and 2014 US requirements for a typical 4-foot T8 lamp, the EU will require ballast efficiency of 0.88 and the US will require ballast efficiency of 0.89. This is an A2 (electronic) ballast.

Australia sets a minimum ballast EEI of B2 (ferromagnetic ballast). China uses a ballast efficiency factor and also effectively requires minimum EEI of B2 (ferromagnetic ballast) however China requires that electronic ballasts are A3.

Efficiency requirements for linear fluorescent ballasts - key conclusion(s): Currently, the EU requirement mandates B2 (ferromagnetic ballast). In 2017, the EU will mandate electronic ballasts and this will be in line with the US 2014 requirement.

HID ballasts

The relative stringency of MEPS for HID ballasts for the EU, Canada and the US can be seen in the figure below. Note that the figure only graphs the required ballast efficiency for lamps up to 500W, although the scope of some countries' regulation extends beyond this size (refer to section 6.2.1).

From Figure 7 we can see that the current (2012) EU requirement for ballasts is relatively low (noting that EU covers all HID ballast and not just metal halide as in US/Canada). The 2017 EU requirement is more stringent than US/Canada at low wattages (≤150W) but is similar to US/Canada at higher wattages.

[285] http://www.superefficient.org/Resources/~/media/Files/CLASP%20Harmonization%20Study.pdf

The US has also banned the sale of all ballast for mercury vapour lamps.

Efficiency requirements for HID ballasts - key conclusion(s): The EU requirement for HID ballasts is currently lower than in many other countries, although this is corrected in stage 3 (2017) at which time the EU lower wattage requirements are the most stringent, and becoming similar to other countries at higher wattages (noting that EU covers all HID ballast and not just metal halide as in US/Canada).

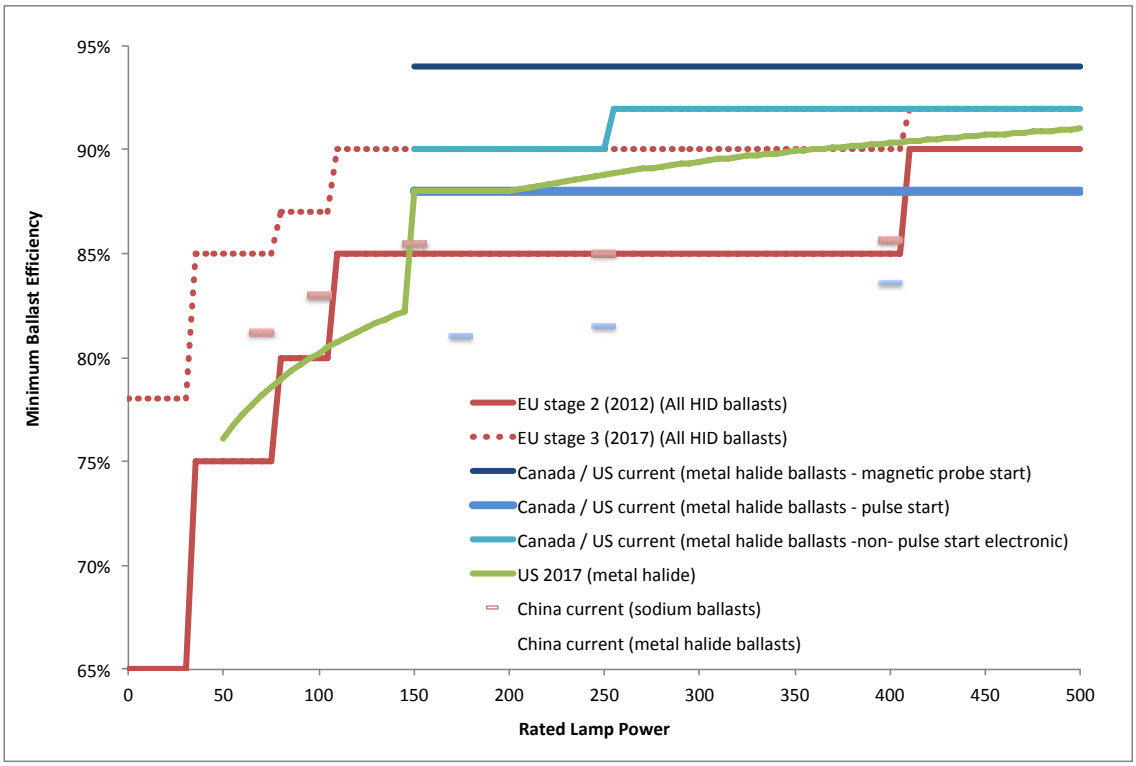

Figure 7 Comparison of MEPS for HID ballasts

Luminaires

The EU is the only known economy with MEPS for luminaires (linear fluorescent and HID). The regulation covers both fluorescent and HID luminaires, and is separated into three elements.

- Power consumption of fluorescent luminaires shall not exceed the sum of the power consumption of the incorporated ballasts when the lamps they are normally operating do not emit any light.
- Fluorescent and HID luminaires shall be compatible with ballasts complying with the third stage requirements, except luminaires with ingress protection grade at least IP4X. Power consumption of HID luminaires shall not exceed the sum of the power consumption of the incorporated ballasts when the lamps they are normally operating do not emit any light.
- Fluorescent and HID luminaires shall be compatible with ballasts complying with the third stage requirements.

However, these requirements are not onerous and relate primarily to no-load power and compatibility with ballasts.

Canada and the US do have MEPS in place for HID luminaires, however this primarily affects only the ballast installed in the luminaire.

Efficiency requirements for Luminaires - key conclusion(s): The EU is currently the only country to regulate luminaires in any extensive way, and the associated requirements are not onerous.

6.2.3. Comparison of key functionality requirements

Lamp functionality requirements are a critical element of EU legislation. Below these requirements are assessed in comparison to those of other major countries and trading partners where functionality is also mandated.

Non-directional incandescent and tungsten halogen lamps

The key mandated functionality requirements, for a range of countries, for non-directional incandescent and tungsten halogen lamps are shown in Table 5.

Country	Minimum Lifetime	Minimum Lumen Maintenance	Minimum CRI
EU	2000 hrs	85% at 75% of life	-
USA	1000 hrs	-	80
Canada	1000 hrs	-	80
Australia	2000 hrs	80% at 75% of life	-
China	-	-	--

Table 5 Key mandated functionality requirements, for a range of countries, for non-directional incandescent and tungsten halogen lamps

Note that there is a strong relationship between lamp efficacy and lamp life - increasing a lamp's efficacy can involve a sacrifice in lamp life.

Non-directional incandescent and tungsten halogen lamps - key conclusion(s): Currently, the EU requirements are broadly in line with other countries, although the EU does not require a minimum CRI as required in the USA and Canada. The addition of such a requirement is unlikely to be onerous, but given the concerns regarding CRI as a functional measurement (detailed in section 3.1), the addition of this requirement may be inappropriate.

Compact fluorescent lamps with integrated ballast (CFLi)

The key CFLi MEPS functionality requirements for a range of countries are shown in Table 6.

For lifetime, the EU requires a survival rate or at least 0.7 at 6000 hours. Typically, the IEC/EN standards define lifetime as the time to which at least 50% of lamps survive (and the soon to be adopted IEC 60969 for CFLs further softens this requirement). Hence, as the failure of most lamps does not follow a normal distribution, the reported value is not the average lifetime of the lamp. Rather this performance requirement provides the *median* life of a sample of lamps. Hence, as a claimed 'lamp lifetime value', this is potentially misleading to consumers as it represents neither the average life of the lamp, nor accounts for premature failure (the failure of a lamp before a certain minimum number of hours operation has been reached).

Key functionality requirements for CFLi - key conclusion(s): Currently, the EU requirements are typically more stringent than with other countries, with the exception of rapid cycle switching. The EU

legislation treats lamp life differently to IEC performance standards, which is an appropriate approach to maintain.

Country	Lifetime	Lumen maintenance	CRI	Start time	Warm up time	Premature failure rate	Rapid cycle switching
EU	Lamp survival factor ≥ 0.70 at 6000h	≥88% at 2000h. (≥83% for lamps with 2nd envelope). ≥70% at 6000h.	≥80	<1.5s if P<10 W <1.0s if P≥10 W	<40s <100s for amalgam lamps	≤ 2.0% at 400h	≥ rated life in hours. ≥ 30000 if start time > 0.3 s
USA	≥6000h	≥90% at 1000h ≥80% at 40% life	-	-	-	-	≥2 x rated life in hours
Australia	≥6000h	≥88% at 2000h ≥80% at 5000h	≥80	<=2s	≤ 60s	≤ 10% at 30% life	≥3000
China	≥6000h	≥0.85 v 2000h	-	-	-	-	-

Table 6 Key CFLi MEPS functionality requirements for a range of countries

LED

Very few countries have MEPS in place for LEDs (endorsement labelling is more popular). MEPS for LEDs do exist in the EU and China. Japan's Top Runner program is a de facto MEPS, and countries such as Taiwan are known to be developing MEPS for LEDs. The EU currently has significantly more stringent functionality requirements for LEDs than other countries.

Key functionality requirements for LED - key conclusion(s): The EU currently has significantly more stringent functionality requirements for LEDs than other countries.

Fluorescent lamps (linear and single capped)

The EU legislation requires fluorescent lamps to adhere to a CRI of at least 80. Lamps must also meet limits for lamp lumen maintenance and lamp survival factor. Australia requires a minimum CRI of 79 for linear fluorescent lamps. The US and Canada (newly proposed Canadian requirements to harmonise with the US) do not appear to have functionality requirements. This is also the case with China.

Key functionality requirements for fluorescent lamps - key conclusion(s): The EU currently has significantly more stringent functionality requirements for fluorescent lamps than other countries.

HID lamps

The only known economies with MEPS for HID lamps are the EU and China. The EU legislation requires high-pressure sodium lamps to meet limits for lamp lumen maintenance factor and lamp survival factor. In 2017, metal halide lamps in the EU will also be required to meet limits on lamp lumen maintenance and lamp survival. The Chinese MEPS do not place limits on HID lamp functionality.

Key functionality requirements for HID lamps - key conclusion(s): The EU currently has significantly more stringent functionality requirements for HID lamps than other countries.

6.2.4. Comparison of labelling legislation

There are a myriad of lamp and ballast labelling schemes in operation around the world. Energy labelling schemes can be either 'comparative' or 'endorsement'. 'Comparative' labels allow consumers to form a judgement about the energy efficiency (or energy consumption) and relative ranking across the products that carry a label. The comparative labelling programs for appliances and equipment in OECD countries are primarily mandatory; however, some comparative programs in other countries are voluntary. Endorsement and comparative labels can coexist, and do so in many countries.

The most commonly used comparative labels use a scale with defined efficiency categories or thresholds. This type of label allows consumers to easily assess the comparative efficiency of a product by means of a simple numerical or ranking system. The concept is that it is much easier for a consumer to remember and compare a simple ranking scale (such as 1, 2, 3 or 1 star, 2 stars, 3 stars or A, B, C) for a range of different products than to remember and compare energy consumption values and sizes of individual products of interest. Numbers as a ranking system are often used in preference to Western letters where a country's language and culture is not based on these letters.

Endorsement labels indicate that products belong to the 'most energy efficient' class of products or meet a predetermined standard or eligibility criteria. Products generally display a logo or mark which identifies they have met the standard or product class and endorsement labels generally contains little or no comparative energy efficiency information. This type of label merely informs the consumer that the product meets a required standard or benchmark. Endorsement labelling programs are mostly in voluntary nature. An Endorsement label may be specifically for energy efficiency or it may be an 'eco' label. Eco label programs endorse products that have low impact across a wide range of environmental factors, with energy consumption levels often having a high priority (but not always).

The figure below highlights a selection of lamp and ballast labelling currently in place.

From the figure, we can see that mandatory comparative labels are very prevalent, especially for the most common lamp types. Voluntary endorsement labels are also very popular, such as US Energy Star labelling. Labelling for ballasts is also common, although often this is for a technical audience, e.g. energy efficiency index (EEI) labelling such as is used in Europe and other IEC-centric countries.

	Incandescent / Tungsten Halogen Lamps		CFLi Lamps		LED Lamps		Fluorescent Lamps		HID Lamps		Fluorescent Ballasts	
	Comp.	End.	Comp.	End.	Comp.	End.	Comp.	End.	Comp.	End.	Comp.	End.
Argentina	Mand		Mand	Vol								
Australia											Mand	
Brazil	Mand		Mand				Mand	Mand			Mand	Mand
Canada	Mand	Vol	Mand	Vol		Vol	Vol	Vol				Vol
Chile							Mand				Mand	
China				Vol		Vol	Mand	Vol				Vol
EU	Mand		Mand	Vol	Mand	Vol	Mand	Vol	Mand		Mand	Vol
Hong Kong			Mand				Vol				Vol	
India			Vol				Mand	Vol			Vol	
Indonesia			Mand				Mand				Prop	
Japan			-				Mand	Vol				
Korea	Mand							Vol			Mand	Vol
Malaysia												
Mexico				Vol			Mand	Vol			Mand	Vol
Philippines			Mand					Prop			Mand	
Russia	Vol		Prop				Vol					
Singapore												
South Africa	Prop		Prop	Mand							Prop	
Taiwan			Mand	Vol		Vol		Vol				
Thailand			Vol	Vol			Vol	Vol			Vol	Vol
USA	Mand		Mand	Vol	Mand	Vol	Mand	Vol			Mand	Vol
Vietnam				Vol				Vol				Vol

Note: Comp = comparison label, End = endorsement label, Mand = mandatory, Vol = voluntary, Prop = proposed

Figure 8 Selection of lamp and ballast labelling currently in place

The following is a description of labelling of lighting products in a range of economies including the EU.

In Europe, comparison labelling for lamps is mandatory across a very wide range of lamps -filament lamps, fluorescent lamps, HID lamps, LED lamps and LED modules. The EU lamp label is presented in the figure below - it uses an alphabetic energy efficiency rating scale including A+ and A++.

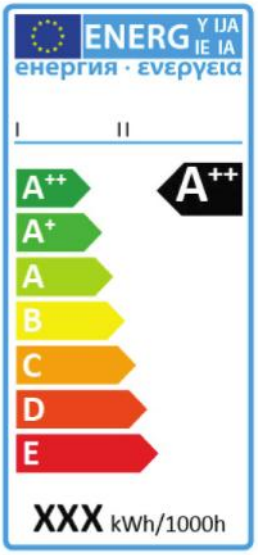

Figure 9 EU label for lamps

The EU regulation also establishes requirements for labelling of luminaires designed to operate such lamps. The purpose of the label is to demonstrate with which types of lamps the luminaire is compatible, and with which type of lamp it is supplied (see figures below).

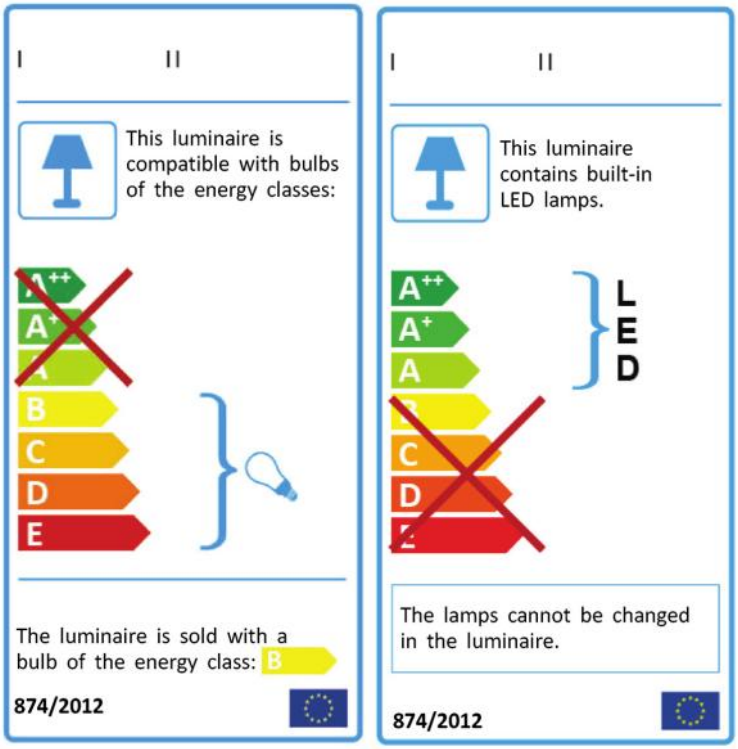

Figure 10 EU label for luminaires

Note that the EU (MEPS) regulations also require lamps and ballast to carry a range of other information, for example, non-directional lamps must carry information regarding the following parameters:

- Luminous flux
- Lifetime
- Switching cycles
- Colour temperature
- Warm-up time
- A warning if lamp cannot be dimmed
- Use in non-standard conditions (such as temperature)
- Dimensions
- Equivalence (if stated must comply)
- Restriction on use of the term 'energy saving lamp' or similar
- Mercury content and instructions on clean up if broken.

The EU lamp labelling scheme is probably the broadest in the world, for example, it is one of the few to require HID lamps to carry a label. The EU Regulation (245/2009) also requires fluorescents ballasts to carry an energy efficiency index (EEI) class, and HID ballasts to disclose their ballast efficiency.

In the US, there are three labels applicable to lamps. The mandatory Lighting Facts Label requires lamps to carry the label and include information such as light output, estimated energy cost, lifetime, colour temperature and wattage. An example of this information displayed using the Lighting Facts label is shown in the figure below (left). On the right is the LED Lighting Facts label is a voluntary program allowing LEDs to carry a label, which carries significantly more information than the mandatory Lighting Facts Label.

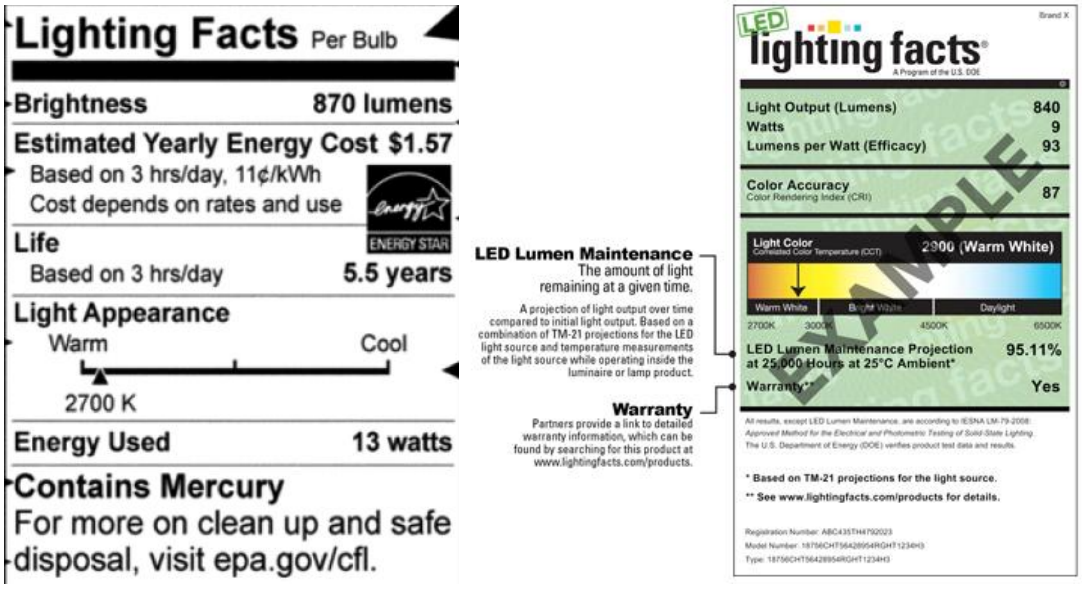

Figure 11 Example of the mandatory Lighting Facts Label (left) and the voluntary LED Lighting Facts Label (right) from the US

The third US label is the Energy Star label (see figure below) which is an endorsement label for complying LED lamps, CFLs and luminaires. Note that the Energy Star label is not applicable to commercial lighting lamps or ballasts such as linear fluorescent and HID.

Figure 12 Energy Star label

In China, an endorsement labelling program operates for almost all types of lamps and ballasts (excluding incandescent and tungsten halogen). The CQC Energy Conservation Certification program is implemented by the China Quality Certification Centre and complying products can carry the CQC energy conservation certification label (see figure below - left). The scope, test method, and evaluation of the CQC certification program are very similar to the mandatory MEPS program. Requirements for CQC certification are the same as the 'tier 2' requirements set in the mandatory MEPS program. China also operates a 3-tier comparative label for CFLi and this is shown in the figure below (right).

Figure 13 China Quality Certification Centre energy conservation certification label (left) and China's 3-tier comparative label for CFLi (right).

In Canada, basic labelling is required for general service incandescent non-reflector and reflector lamps and CFLi. The label is shown in the figure below.

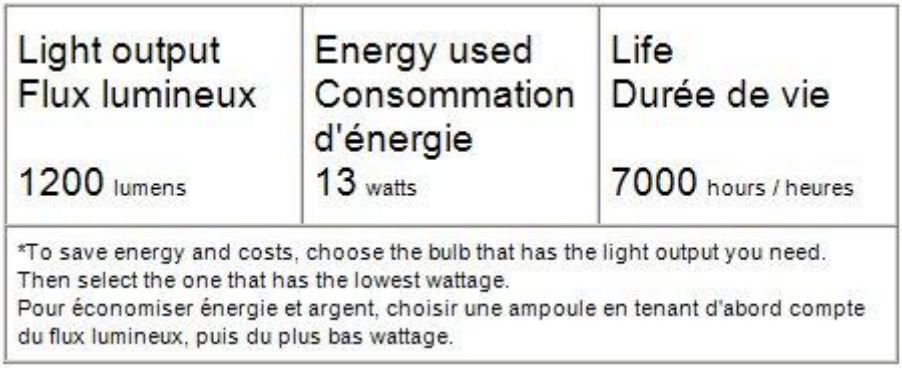

Figure 14 Basic labelling for general service incandescent non-reflector and reflector lamps and CFLi (Canada)

Korea has a range of mandatory and voluntary comparison and endorsement labels for lamps and ballast. However, of particular note is the recent addition of annual CO_2 emission to a number of their labels as illustrated below.

Figure 15 Addition of annual CO_2 emission on lamp labels from Korea

Labelling legislation - key conclusion(s): For mandatory energy labelling of lamps and ballasts, the EU currently covers significantly more lamp types than other countries. When the "graphical" lamp label and the 'disclosure' display requirements of the EU legislation are taken into account, the EU labelling/information requirements are, in comparison to most countries, very comprehensive. However, the US voluntary LED Lighting Facts label also presents graphical information about LED colour temperature, as well as other information about LED lumen maintenance and colour accuracy, the addition of which may assist EU consumers in selecting appropriate replacement products, particularly where multiple lamps are in the same fitting.

REFERENCES

See footnotes in text

LIST OF FIGURES MAIN REPORT

LIST OF TABLES MAIN REPORT

ACRONYMS

a	Annum, year
ANSI	American National Standards Institute
BAT	Best Available Technology
BAU	Business As Usual
BEF	Ballast Efficacy Rating
BGF	Ballast Gain Factor (due to dimming)
BLE	Ballast Luminous Efficiency
BMF	Ballast Maintenance Factor
bn / bln	Billion (10^9)
BNAT	Best Non-Available Technology
BOM	Bill Of Materials
CCFL	Cold-Cathode Fluorescent Lamp
CCT	Correlated Colour Temperature
cd	candela
CDR	Commission Delegated Regulation
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CIE	International Commission on Illumination
CFL	Compact fluorescent lamps
CFLi	CFL with integrated ballast
CFLni	CFL without integrated ballast
CISPR	Comité International Spécial des Perturbations Radioélectriques
CN / CN8	Combined Nomenclature (coding)
cor	corrected
CRI	Colour Rendering Index
DLS	Directional light sources
DEFRA	UK Department for Environment, Food and Rural Affairs
E14, E27	Screw-type lamp caps for general purpose lamp
EC	European Commission
ECEEE	European Council for an Energy Efficient Economy
ECG	Electronic Control Gear
ECO	Scenario considering ecodesign or energy labelling measures
ED	Ecodesign / Ecodesign Directive
EEI	Energy Efficiency Index
ELC	European association of lighting manufacturers, now part of Lighting Europe
ELD	Energy Labelling Directive
ELV	Extra Low Voltage
EMC	Electro-Magnetic Compatibility
EoL	End of Life
ErP	Energy related Product

ESL	Electron Stimulated Luminescence
ESO	European Standardisation Organisation
EU	European Union
FIPEL	Field-Induced Polymer Electroluminescent Lighting
FU	Functional Unit
G4, GY6.35	Low voltage halogen lamp types, 2 pin cap, single ended
G9	Mains voltage halogen lamp, 2-pin cap, single ended
GLS	General Lighting Service (a.k.a. incandescent lamp)
h	Hour
HF	High Frequency
Hg	Mercury
HID	High-Intensity Discharge
HL	Halogen
HPM	High-Pressure Mercury
HPS	High-Pressure Sodium
HS	Harmonised System (coding)
HW	High Wattage
Hz	Hertz
IEC	International Electrotechnical Commission
IES / IESNA	Illuminating Engineering Society (of North America)
ILCOS	International Lamp COding System
ILV	International Lighting Vocabulary
IR, IRC	Infrared, Infrared coating
IR	Incandescent Reflector Lamp
ISA	International Solid State Lighting Alliance
ISO	International Organization for Standardisation
LBS	Lampen-Bezeichnungs-System
LCC	Life Cycle Cost
LE	LightingEurope (lighting manufacturers association)
LED	Light Emitting Diode
LENI	Lighting Energy Numerical Indicator
LER	Luminaire Efficacy Rating
LFL	Linear Fluorescent Lamp
LLCC	Least Life Cycle Cost
LLE	LED Light Engine
LLMF	Lamp Lumen Maintenance Factor
lm, Φ	Lumen, unit of luminous flux Φ
LMF	Luminaire Maintenance Factor
LOR	Light Output Ratio
LPD	Lighting Power Density [W/(m².lx)] (Pr EN 13201-5)
LV	Low Voltage (typical 12V)
LW	Low Wattage
max	maximum

MEErP	Methodology for Ecodesign of Energy-related Products
MEPS	Minimum Efficacy Performance Standard
MH	Metal Halide
min	minimum
mn / mln	Million (10^6)
MOCVD	Metal Oxide Chemical Vapour Deposition
Mt	Mega tonnes (10^9 kg)
Mtoe	Million Tonnes of Oil Equivalent
MV	Mains Voltage (typical 230V)
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne (coding)
NDLS	Non-directional light sources
nec	Not elsewhere classified
NEMA	National Electrical Manufacturers Association
OJ	Official Journal of the European Union
OLED	Organic Light Emitting Diode
P	Rated power
par	paragraph
ProdCom	PRODuction COMmunautaire (coding)
-R	Reflector
R	Electrical Resistance
R7s	Mains voltage linear halogen lamp, double ended
Ra	Colour rendering index, unit
ref	reference
RGB	Red Green Blue
s	Second (as unit for time)
SCHER	Scientific Committee on Health and Environmental Risks
SCENHIR	Scientific Committee on Emerging and Newly Identified Health Risks
SPL	Special Purpose Lamp
SPP	Special Purpose Product
sr	steradian
SSL	Solid State Lighting
TBC	To Be Confirmed
TBW	To Be Written / To Be Worked
TC	Technical Committee
TWh	Tera Watt hour (10^12)
UF	Utilisation Factor
UK	United Kingdom
ULOR	Upward Light Output Ratio
US(A)	United States of America
UV	Ultraviolet (subtypes UVA, UVB, UVC)
UVA	near UV-Black Light, 315-400 nm

UVB	middle UV-Erythemal, 280-315 nm
UVC	far UV-Germicidal, 100-280 nm
V	Volt
VHK	Van Holsteijn en Kemna
VITO	Vlaamse Instelling voor Technologisch Onderzoek
W	Watt
yr	year

Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19').

Final Report, Task 1

ANNEXES

Scope, Standards, Legislation

See separate document for the contents of the Annexes

Annex A. STATEMENT OF CONTRACTOR ON RIGHT TO DELIVERED RESULT

Annex B. DEFINITIONS

B.1 Definitions for types of lighting
B.2 Definitions for types of lighting products
B.3 Definitions for types of lamps (other than LED)
B.4 Definitions for LEDs
B.5 Definitions for lamp parameters
B.6 Definitions for ballasts / control gears
B.7 Definitions for control devices
B.8 Definitions for luminaires
B.9 Other definitions

Annex C. SELECTED LAMP SOCKET/CAP TYPES

Annex D. SPECIAL PURPOSE LAMPS

D.1 Why Special Purpose

D.1.1 Spectrum
D.1.2 Radiance
D.1.3 Safety