Green Public Procurement

Street Lighting and Traffic Lights

Technical Background Report

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Table of Contents

Abbreviations

CELMA	Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union
CEN	European Committee for Standardization
CFL	Compact Fluorescent Lamp
CIE	International Commission on Illumination
CLRTAP	Convention on Long-range Transboundary Air Pollution
CO_2	Carbon Dioxide
EEE	Electrical and Electronic Equipment
EEI	Energy Efficiency Index
ELC	European Lamp Companies Federation
EMC	Electromagnetic Compatibility Directive
EU	European Union
EuP	Energy using Product
g	Gram
GHG	Greenhouse Gas
GJ	Gigajoule = 10^9 Joules
GPP	Green Public Procurement
Hg	Mercury
HID	High Intensity Discharge lamp
HPS	High-pressure Sodium lamp
HPM	High-pressure Mercury lamp
ILP	Institution of Lighting Professionals
i-Teq	International Toxic equivalent
kJ	Kilojoule = 10^3 Joules
kWh	Kilowatt hours
LCA	Life Cycle Assessment
LED(s)	Light Emitting Diode(s)
LLMF	Lamp Lumen Maintenance Factor
lm	Lumen
LMF	Luminaire Maintenance factor
LOR	Light Output Ratio of a luminaire
LPS	Low-pressure Sodium lamp
LPM	Low-pressure Mercury lamp
LSF	Lamp Survival Factor
MEEuP	Method for the Evaluation of Energy using Products
mg	Milligram = 10^{-3} Grams
MH	Metal Halide Lamp
ml	Millilitre = 10^{-3} Litres
ng	Nanogram = 10^{-9} Grams
PAH	Polycyclic Aromatic Hydrocarbons
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
pg	Picogram = 10^{-12} Grams

PM	Particulate Matter
PO_4	Phosphates
POP	Persistent Organic Pollutants
PWB	Printed Wiring Board
R-11	Trichlorofluoromethane
Ra	Colour Rendering Index
RoHS	Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Directive
SO_2	Sulphur Dioxide
TWh	Terawatt hours = 10^9 kWh
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultra Violet
VOC	Volatile Organic Compounds
W	Watt
WEEE	Waste Electrical and Electronic Equipment
µg	Microgram = 10^{-6} Grams

1 Introduction

The European Commission[1] has presented recommended GPP criteria for a range of different products and services. Green Public Procurement is a voluntary instrument.

This Technical Background Report provides background information on the environmental impact of street lighting and traffic signals based on the life cycle data and outlines the key relevant European legislation affecting this product group. It presents market availability of this product group, some cost considerations and public procurement needs. It outlines the rationale for the core and comprehensive environmental purchasing criteria that are being proposed. It then goes on to describe existing standards and ecolabels that cover the street lighting and traffic signals product group.

This report accompanies the associated **EU GPP criteria,** which contains the proposed purchasing criteria and ancillary information for green tender specifications, and as such they should be read alongside one another.

2 Definition, Scope and Background

2.1 Product Description

Street lighting and traffic signals are widespread and common elements in our towns and cities of what is sometimes referred to as street furniture. To put this into a general context, these are objects that exist on roads in the urban and suburban environment. Full definitions of street lighting and traffic signals relevant to this report are provided in the sections below.

[1] http://www.ec.europa.eu/environment/gpp

Both street lighting and traffic signals are made up of several component parts, including the lamp that provides the light, the housing that directs or filters the light, known as a luminaire, as well as the stands, poles and other mounting fixtures that hold it all in place. Likewise there are several technical terms that describe the characteristics of lighting. These are explained further here.

2.2 Lighting Terminology

This section defines terms that describe the characteristics and properties of lighting and how it performs. Box 1 provides a brief summary of these terms, taken from European Standard EN 12665.

Box 1. Definition of Lighting Terms[2]

Luminous flux [lm]
The luminous flux (light output) quantifies the total amount of light emitted by a light source. The unit lumen [lm] in which the luminous flux is measured is used to rate the output of lamps; typically the lumen output at 1000 hours life is quoted. For example:
- The flame of a candle generates about 12 lumen.
- A 150W high-pressure sodium (HPS) lamp is rated at 17500 lumen.
- A 250W metal halide (MH) lamp is rated at 21000 lumen.

Watt [W]
The electrical energy a light source consumes is measured in Watt [W]. Part of the power input is transformed into light (visible radiation), while the rest is considered as loss (heat). For example, high-pressure sodium (HPS) lamps transform up to 60% of the electric power input into light and the rest into infrared radiation (heat).

Luminous efficacy "lumen per watt" [lm/W]
Luminous efficacy describes light output in relation to power input and is expressed in lumen per Watt. The higher the efficacy value, the more energy-efficient lamps or lighting systems are. For example, the luminous efficacy of a metal halide (MH) lamp of 400W can reach 115 lm/W and of a high-pressure sodium (HPS) lamp of 400W can reach 140 lm/W. This figures are lamp efficacies only, excluding the power consumed by the ballast which is needed to run the discharge lamps (see below).

Luminaire efficacy [lm/W]
Luminaire efficacy is the light output of the entire luminaire (light fitting) divided by the total power consumed by the lamps and ballasts. It is equal to the lamp efficacy multiplied by the light output ratio of the luminaire (see below) and is measured in lumens per watt (lm/W).

Light output ratio (LOR)
The basic measure for the efficiency of a luminaire is the Light Output Ratio (LOR). This is the ratio of the light emitted by the luminaire to the light output of the lamps contained within it. The LOR depends on the quality of the materials used as well as the basic design of the luminaire. Luminaires for street lighting may typically have LOR values of between 0.6 and 0.9, for example.

[2] EN 12665 Light and lighting - Basic terms and criteria for specifying lighting requirements and EN 60598-2-3 Luminaires Part 2-3: particular requirements - luminaires for road and street lighting

Energy consumption [kWh]
The amount of electric energy consumed by a lamp over a certain period is expressed in kWh (kilowatt–hours). For example a 100W high-pressure sodium (HPS) lamp consumes 1 kWh in 10 hours (10 hours × 100W = 1000Wh or 1 kWh). The amount of electricity used for lighting is generally based on energy consumption per year (kWh per year).

Light Quality – Colour Rendering Index (Ra)
Colour rendering is the ability of a light source to show surface colours as they should be, usually in comparison to a tungsten or daylight source. This is measured on the colour rendering index (Ra) scale from 0 to 100: a value of 0 means it is impossible to discern colours at all, while a score of 100 means no colour distortion. The most common discharge lamps used for street lighting have Ra indexes of 15-65 (HPS lamps) and 60-95 (MH lamps).

The Lamp Lumen Maintenance Factor – LLMF
The output of a lamp tends to decrease with time. This is measured by the Lamp Lumen Maintenance Factor which is the ratio of the luminous flux emitted by the lamp at a given time in its life to the initial luminous flux.

The Lamp Survival Factor – LSF
This is the fraction of the total number of lamps, which continue to operate at a given time under defined conditions and switching frequency.

Although there are several types of lighting that are considered under the scope of street lighting and traffic signals, and their physical properties may differ, they all require the same generic components. Definitions of the components of street lighting and traffic lights are given in Box 2.

Box 2. EN 12665 Lighting System Component Definitions[3]

1. *Lamp*: a “source made in order to produce an optical radiation, usually visible”

2. *Ballast*: a “device connected between the supply and one or more discharge lamps which serves mainly to limit the current of the lamp(s) to the required value”

Note that a ballast[4] may also include means for transforming the supply voltage, correcting the power factor and, either alone or in combination with a starting device, provide the necessary conditions for starting the lamp(s)

3. *Luminaire*: an “apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting the lamps to the electric supply”

[3] EN 12665 Light and lighting - Basic terms and criteria for specifying lighting requirements and EN 60598-2-3 Luminaires Part 2-3: particular requirements - luminaires for road and street lighting
[4] Sometimes known as ‘control gear’

2.3 Street Lighting Components

Both the EuP Lot 9 Study on Street Lighting[5] and the European Lamp Companies Federation[6] consider that the most predominantly used lamps in street lighting are high-intensity discharge lamps (HID), examples of which include:

- High-pressure sodium lamps
- Metal halide lamps with quartz arc tube
- Metal halide lamps with ceramic arc tube
- Low-pressure sodium lamps
- High-pressure mercury lamps

Of these the mercury and sodium variants are the most commonly used in street lighting, although mercury lamps are generally less efficient in their energy use than sodium, or even metal halide lamps. Both metal halide (MH) and high-pressure sodium (HPS) lamps are used in street lighting, but for different kinds of applications, each with its own advantages. For example, metal halide lamps are best suited for clear white illumination, for example in city centre streets, where the light gives the true colours of objects around it. Whereas high-pressure sodium lamps are well suited to general street lighting, including in residential areas, with their yellow colour which has the advantage of attracting fewer insects and thereby requiring less maintenance and cleaning. They also have long operational times from three to six years[7].

These HID lamps are collectively classified under the heading of gas discharge lamps, along with other similar technologies including fluorescent lamps. They work by creating a beam of electrons, otherwise known as a discharge, inside the lamp when power is supplied to the lamp via the ballast. On their way from the cathode to the anode the electrons excite other gaseous atoms in the lamp, often containing mercury or another metal like sodium, by passing some of their energy on. These excited atoms then release their excess energy back as radiation, either ultra-violet (UV) in the case of mercury-containing lamps or visible radiation for others. As UV radiation is not visible, the inside of those lamps therefore have a phosphor coating which absorbs the UV, re-emitting it as visible light. Other lamps containing different metals such as sodium emit directly in the visible part of the electromagnetic radiation.

Following the eco-design requirements implemented by Regulation (EC) No 245/2009[8], less efficient HID lamps will be phased out in the following years. Standard HPS and lowest performing MH lamps (E27, E40 and PGZ12 base) will be banned from April 2012, HPM lamps (E27, E40 and PGZ12 base) and retrofit/plug-in HPS lamps (E27, E40 and PGZ12 base) designed to operate on HPM ballasts will be banned from April 2015, while MH lamps rated below 405 W and not meeting minimum requirements (E27, E40 and PGZ12 base) will be phased out from April 2017.

The other main components of street lighting include the ballast which regulates the flow of power and current to the lamp and can be either magnetic (older technology, generally less

[5] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 29-30. Available from http://www.eup4light.net
[6] European Lamp Companies Federation, http://www.elcfed.org/documents/-56-finelc_road_map_11_07.pdf
[7] European Lamp Companies Federation, 'Saving energy through lighting'. Available from http://buybright.elcfed.org/uploads/fmanager/saving_energy_through_lighting_jc.pdf
[8] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:EN:PDF

energy efficient) or electronic in design, and the luminaire which houses the lamp and circuitry as well as protecting the lamp from the weather and directing the light as necessary to its intended destination.

Specifically for street lighting, European Standard EN 13201 draws on the definitions of components as described in EN 12665 above and defines public street lighting equipment as:

> "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".

In addition to HID lamps, compact fluorescent lamps (CFL) do find some use for street lighting. However as stated above, HID lamps are considered to be the most predominately used lamp types in street lighting applications and CFLs are not used to the same levels as HID. Additional consideration of this is provided in Section 2.7 below. CFLs are more commonly used in domestic and office lighting applications. The Ecodesign measures for tertiary lighting also cover HID lamps used for street lighting, although their main focus is on fluorescent lighting, including CFLs, for office lighting applications.

Therefore CFLs have not been included in the scope of this GPP specification given the limited use of these lamp types in street lighting.

LEDs are another type of lamp that may be suitable for use in street lighting. LEDs are developing rapidly and improving in efficacy and colour while reducing in cost. Currently LEDs have lower luminous efficacy than HID lamps, but the directional nature of LEDs means that LED luminaires are generally more efficient and can in principle direct the light very precisely to where it is required. Retrofit LED street lighting solutions replacing HID lamps already exist on the market. Even if this does not cover all street lighting applications, it is often considered a valuable and cheaper alternative to replacing the full lighting system. A typical luminaire includes an array of LEDs so if one LED fails the area still remains lit. LEDs can also be dimmed readily.

Although the use of LEDs is increasing, there is a limited requirement for replacement lamps, partly because there are fewer LED systems but also because of the longer lifetime of LEDs. Therefore LEDs are not included within the scope for the GPP criteria for lamps for street lighting (LED fittings are included in the more general criteria on luminaires and street lighting power density). The development of criteria for LED street lights would be worth considering as part of future revisions to the GPP criteria as their use and reliable evidence base is developed. It is proposed to include an explanatory note in the accompanying product sheet, to ensure that LEDs are considered as part of the decision making in choosing which lighting system is best suited to a specific use. Where the use of HID lamps is proposed then the GPP criteria would be applicable.

In addition to the product based approach identified above, the wider installation aspects of street lighting are important in terms of key environmental aspects, such as energy consumption by the whole lighting system. Based on street lighting market research and system modelling, GPP criteria for new street lighting systems were developed taking into account reference values for energy efficiency introduced by other methodologies, for example the Dutch street lighting energy efficiency criterion (SLEEC)[9] developed on a whole system approach. Further information regarding the Dutch criteria is included in Appendix 1 of this Background Report.

The criteria for luminaires and lighting systems cover all types of lamps, including CFL and LED lamps as well as HID lamps.

Section 4.6 'Other Considerations' below gives more information on the design and installation aspects of street lighting.

2.4 Traffic Signal Components

The main component of traffic signals is the 'head', which contains the lamps. Traditionally these have been 50W incandescent (tungsten halogen) lamps[10]. As well as the head there needs to be the support arms and poles to hold it all up as well as the electric controller, which may receive input from a range of controls like traffic sensors or timers.

Other lighting technologies are used in traffic signals, namely light emitting diode (LED) lamps. These lamps have lower energy consumptions and invariably longer lifetimes compared to incandescent lamps for all the colours used in traffic signals.[11] As well as saving on direct energy costs by using LEDs instead of conventional incandescent filament lamps one also saves on less frequent maintenance operations for lamp replacement. LEDs can also have better light output than incandescent lamps providing a better contrast with the surrounding daylight and thus clearer visibility of the signals for road users. An LED signal consists of an array of LED sources, so if one LED does fail the rest remain lit, ensuring that the signal continues to operate.

A number of definitions in relation to traffic signals are available through the standards that exist. The European Standard EN 12368:2006 for Traffic Control Equipment – Signal Heads[12] describes the scope of traffic signals as follows:

> "This European Standard only applies to red, yellow and green signal lights for road traffic with 200mm and 300mm roundels. It defines the requirements for the visual, structural, environmental performances and testing of signal heads for pedestrian and road traffic use. Portable signal lights are specifically excluded from the scope of this European Standard."

It defines a signal head as:

[9] Energy Labeling Guide for Public Lighting, NSVV, March 2009. Available from: http://www.nsvv.nl/download/download.aspx?id=8c802b05-7ab5-4610-a90b-a1d40db54576

[10] Quick Hits, Traffic Signal, UK ERC, December 2006 http://www.ukerc.ac.uk/Downloads/PDF/06/0612_Traffic_Signals_QH.pdf

[11] MTP Briefing Note BNCL12: Light-emitting diodes - Innovation Briefing Note, version 1.0, 14/4/2008, www.mtprog.com

[12] 2006 Traffic Control Equipment - Signal Heads EN 12368:2006 and http://www.led2.org.pdf/Engelse versie Eisen Led2-lamp.pdf

a "device which comprises one or more optical units, including the housing(s), together with all the mounting brackets, fixings, hoods, visors, cowls and background screens, whose task is to convey a visual message to vehicle and pedestrian traffic".

This EN standard provides limited environmental requirements, which include the specification that signal heads should comply with one of the following classes for operational temperature ranges, indicating the variety of climatic conditions traffic signals may operate under.

- Class A +60^{o}C to -15^{o}C
- Class B +55^{o}C to -25^{o}C
- Class C +40^{o}C to -40^{o}C

Outside of Europe the US Energy Star specification for traffic signals provides a wider definition as follows:

A. Vehicular Traffic Signal: A power-operated illuminated traffic control device, other than a barricade warning light or a steady illuminated lamp, by which traffic is warned or directed to take some specific action.

B. Modules: Standard 8-inch (200 mm) or 12-inch (300 mm) round traffic signal indications (balls).
They consist of the light source and the lens (usually a sealed unit) that communicate movement messages (stop, caution or prepare to stop, and go) to drivers through red, yellow, and green colours.
Arrow modules in the same colours are used to indicate turning movements. Pedestrian modules are used to convey movement information to pedestrians.

C. Traffic Signal Head: The combination of the traffic signal housing, with the modules (red, yellow, and green) installed in it. The head typically contains three modules and the necessary wiring, although it may also include arrow modules.

D. LED Lamps or LEDs: The individual light-emitting diodes (LEDs), which can be set on a circuit board in any arrangement.

E. LED Traffic Signal: The generic term used to describe the combination of signal heads or modules that use LEDs as the source of light. The combination also incorporates the housing unit at an intersection along with any internal components and support structures.

Potentially the Energy Star scope and definition includes a wider range of traffic signals than the EN standard and could also include traffic signals such as motorway signs / information warning signs. The criteria included in the Energy Star relate to wattage specifications for red and green lights and also Combination Walking Man/Hand, Walking Man and Orange Hand. Further details regarding this are provided in Section 11.

This GPP specification focuses on traffic signals as defined by the EN standard above. Traffic signals under this definition are a key element of traffic signals generally and by using this scope will allow the criteria to be focused. Portable traffic signals are excluded, as these will not necessarily be of the same standard as fixed traffic signal installations.

For both street lighting and traffic signals the units themselves are considered with respect to life-cycle impacts. Poles, building mounts, catenary wire systems or any other type of support and the required fixing mounts are considered a separate product group (construction).

Both of these products are considered to be energy-using products by virtue of both containing energy using parts and being an energy consumer in itself, therefore it is included at 'part' and 'product' level.

2.5 Product Scope for Street Lighting

For the purpose of this report, a public street light will be defined[13] 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 is derived from EN 13201 and 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. As highlighted in Section 2.3 above, the following types of HID lamps are those mainly used in street lighting:

- High-pressure sodium lamps
- Metal halide lamps with quartz arc tube
- Metal halide lamps with ceramic arc tube
- Low-pressure sodium lamps
- High-pressure mercury lamps

Therefore for the purposes of replacement lamp specification, only high intensity discharge lamps for street lighting are considered. As outlined in Section 2.3, other types of lamps, which are used to a much lesser extent for street lighting, including low intensity lamps such as CFLs and other types including LEDs, are excluded from the scope of the replacement lamp specification.

2.6 Product Scope for Traffic Signals

For the purposes of this report traffic signals will be defined as:

> "Red, yellow and green signal lights for road traffic with 200mm and 300mm roundels (whose task is to convey a visual message to vehicle and pedestrian traffic). Portable signal lights are specifically excluded."

This in accordance with EN 12368 Traffic Control Equipment – Signal Heads.

[13] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 21. Available from http://www.eup4light.net

2.7 Road Classifications

The type of road and the volume of traffic it carries largely influence the required lighting levels and therefore the choice of street lighting. It is important to understand the different requirements for lighting conditions under these various circumstances. To this end road classifications are set out in EN 13201-2 along with guidance on how to apply these classes. A simplified classification system was used in the EuP Lot 9 preparatory study on Street Lighting and is summarised below with the equivalent European Norm classifications. The full correlation is provided in Appendix 2.

- Category F "fast traffic" with fast motorised traffic use only, having only luminance requirements (cd/m^2). These correspond to the road classifications ME1, ME2, ME3a and ME4a in EN 13201.
- Category M "mixed traffic" with motorised traffic, slow moving vehicles, and possibly cyclists and pedestrians with only luminance requirements (cd/m^2). These correspond to the road classifications ME2, ME3a and ME4a in EN 13201.
- Category S "slow traffic" for mainly urban and pedestrian areas, with illuminance requirements only (lx). These correspond to the road classifications CE2, CE3, CE4, S2, S4 and S6 in EN 13201.

As stated, High Intensity Discharge (HID) lamps have been identified as the main types of lamps used for street lighting and this is further emphasised by an assessment in the EuP study that considers the types of lamps used for different road categories. The typical breakdown of the lamp types used for different road categories is summarised below[14].

Road category F (fast traffic)
Here sodium lamps are the most commonly used with the typical wattages and lamp types being 150W, 250W High Pressure Sodium (HPS), 131W, 135W and 180W Low Pressure Sodium (LPS). 400W and 600W high-pressure sodium lamps, although widely available are less commonly used. The only EU Member States still with substantial shares of LPS luminaires in category F in their existing stock are Belgium, The Netherlands, Sweden, UK and Ireland. The trend is that these are being replaced by HPS.

Road category M (mixed traffic)
In this situation mainly sodium and high-pressure mercury (HPM) lamps are used. The typical wattages and lamps types used are 250W, 400W HPM and 100W, 150W, 250W HPS. There are still some LPS luminaires in use that use lamps with wattages of 90W, 131W and 135W however these are being gradually replaced with HPS lamps and luminaires.

Road category S (slow traffic)
For slower traffic areas sodium and mercury lamps are the most widely used and to a lesser extent compact fluorescent and metal halide lamps. Here, the typical wattages for HPM lamps are either 50 or 125W and 70W for HPS. For the metal halide variety they are generally 70W and for CFLs they come in at 36W. The use of LPS lamps represents a minor share of the current stock with 35W and 55W lamps being used. HPM are currently being replaced but still represent a substantial proportion of the installed stock.

[14] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 26. Available from http://www.eup4light.net

Some CFLs are used for slow road categories; however they are not used at all for medium and fast road categories. For the slow road category, CFL sales (including both new and replacement lamps) is calculated as 13%, which is minor compared to HID lamps, which make up the remaining sales and in particular sodium lamps which make up 53% of sales for slow road categories.

It is important that the contracting authority is aware of the road classifications, as this will influence the type of lighting required. The contracting authority should ensure they consult with the lighting designers to check the correct, most efficient street lighting system is purchased to meet the lighting needs of that road. When considering street lighting design and the purchase of lamps for specific circumstances it is important to take into account the EN standard and the guidelines contained within it. It provides performance requirements for road lighting, covering a range of different aspects for example road safety, engineering and factors relating to pedestrian crossings.

3 Market Availability

The EuP Lot 9 study gathered market data on street lighting by searching the Eurostat databases. They concluded that some data is available but it is often aggregated to total lighting product sales in the EU, rather than specifically for street lighting, or that matter or traffic signals. This would be due to the lack of data with enough detail, due either because data was not made available for reasons of commercial confidentiality or because the data had simply not been collated in the past. As such, data on HID lamps was made available for all uses of HID lamps, not just street lighting applications. Notwithstanding these issues, some information is presented below on the main market data for street lighting lamps and their component parts; luminaires and ballasts. The database categories used for the EuP Lot 9 study were extracted from Eurostat in order to obtain the latest data available over that in the report[15].

3.1 Lamps

In 2007 around 25.2 million mercury vapour discharge lamps were manufactured in the EU25 area. When imports and exports are taken into account the apparent sales of these lamps were 28.1million. Similarly for sodium discharge lamps the production statistics are 30.6 million with slightly more, 31.7 million being actually consumed in the EU after imports and exports have been factored in. These numbers are applicable to HID lamps for all uses, not just for street lighting.

Figures 1 and 2 below show the trends for mercury vapour and sodium discharge lamps over the period 2004 - 2007.

From other data[16] for 2004, mercury vapour lamps accounted for 27% of all sales of HID lamps in the EU25, sodium lamps accounted for 37% and metal halide lamps made up the remaining 36%. Furthermore, the trend since 1999 has been for fewer mercury lamps to be bought (these are generally less energy efficient than other HID technologies, see section 3)

[15] Last consulted April 2011
[16] Data from the ELC used in the Lot 9 EuP study

with their market share dropping from 38% to 27%, whilst on the other hand the market share for metal halides has risen from 24% to 36%.

Figure 1. Mercury vapour lamps for EU25 2004-2007

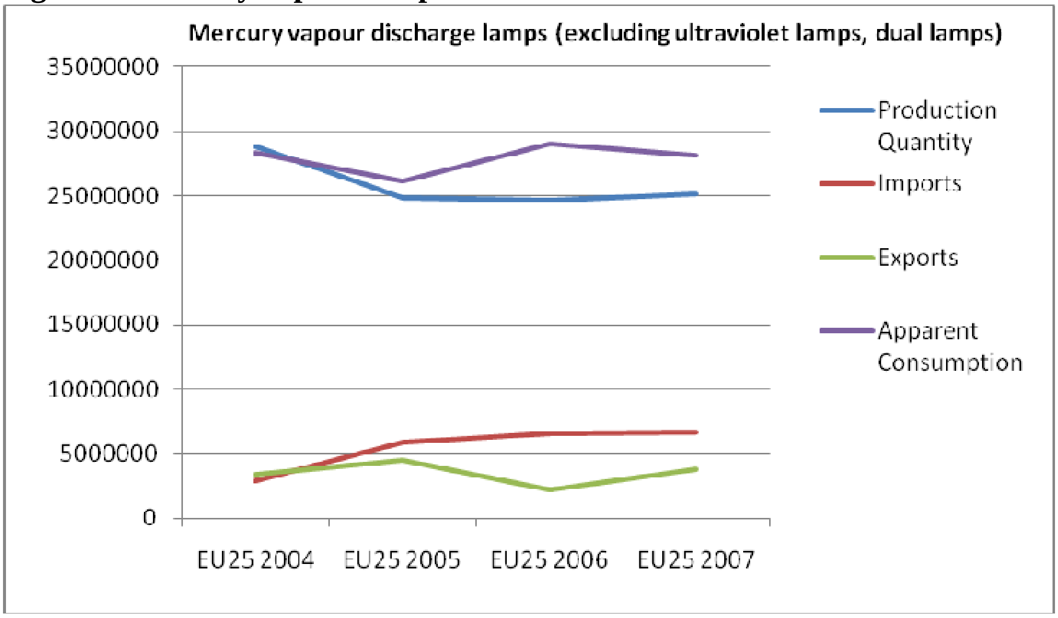
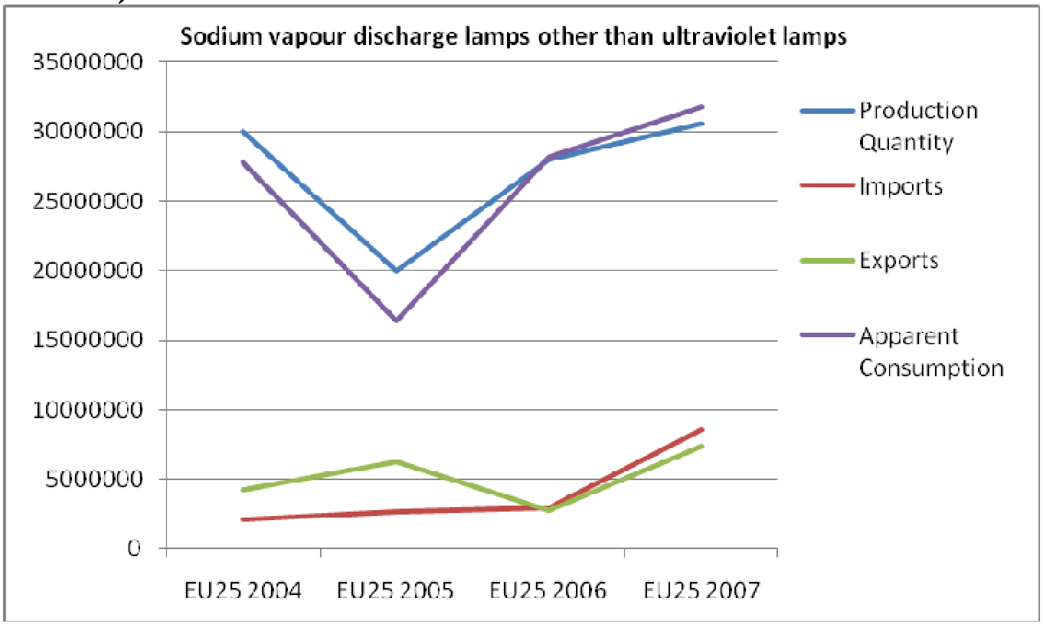


Figure 2. Sodium vapour lamps for EU25 2004-2007 (Production figures 2004-2006 rounded)



The EuP study estimated the numbers of lamps sold in the EU for street lighting in 2004, segregated by lamp technology. They sub-divided it by whether or not the lamps were bought as replacements or for new applications. The headline results were that 7 million mercury lamps were purchased for replacement works whereas 285,000 were bought for new systems. For sodium lamps nearly 9.6 million were bought for replacement and 562,000 were bought for new lighting systems.

Data from the European Lamp Company Federation (ELC) estimates that there were around 62.2 million street lamps installed in the EU25 in 2004, having an average lifetime of three years. There are variations in lamp technology used from Member State to Member State though. Whereas in Germany almost half of all lamps in place are mercury vapour they only make up a small fraction, 5%, in Belgium, where high-pressure sodium lamps predominate with over 50% of the share.

For the revision of the GPP criteria, comprehensive research has been carried out to identify lamp parameters and compliance with the Ecodesign requirements implemented for Stage 2 (2012) under the Ecodesign Directive (245/2009), as well as with the previous GPP criteria. A total number of 173 high-pressure sodium and metal halide lamps, produced by 5 manufacturers, were assessed and the results shown in Figures 3 to 6 below were split by lamp type and colour rendering properties. The values represent the number of lamps meeting minimum global requirements in terms of luminous efficacy, lumen maintenance, survival factor and mercury contents. The only Ecodesign requirements for metal halide lamps apply to lamps with Ra ≤ 60 and they only refer to minimum luminous efficacy. Requirements of minimum efficacy will come into force for the other metal halide lamps in 2015, while minimum values for lumen maintenance and survival factors will apply from 2017.

Figure 3. Compliance of HPS lamps Ra ≤ 60 with global requirements. The bars show the percentage of lamps from each manufacturer that meet the different criteria.

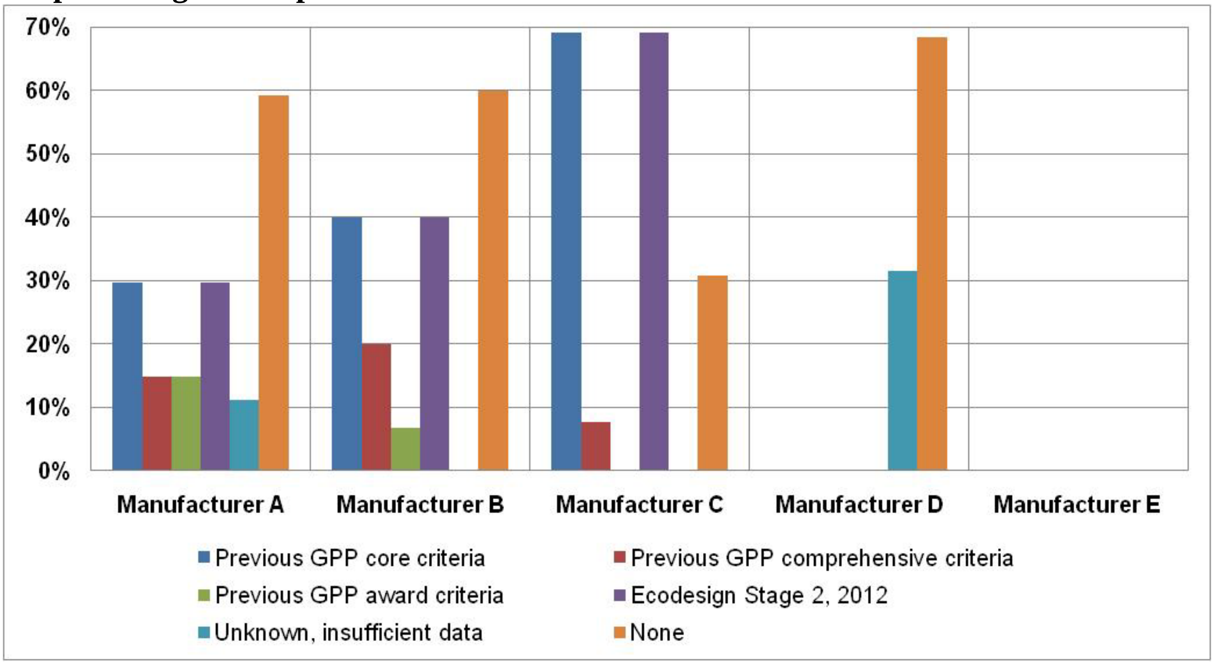


Figure 4. Compliance of HPS lamps Ra > 60 with global requirements. The bars show the percentage of lamps from each manufacturer that meet the different criteria.

Figure 5. Compliance of MH lamps Ra ≤ 80 with global requirements. The bars show the percentage of lamps from each manufacturer that meet the different criteria.

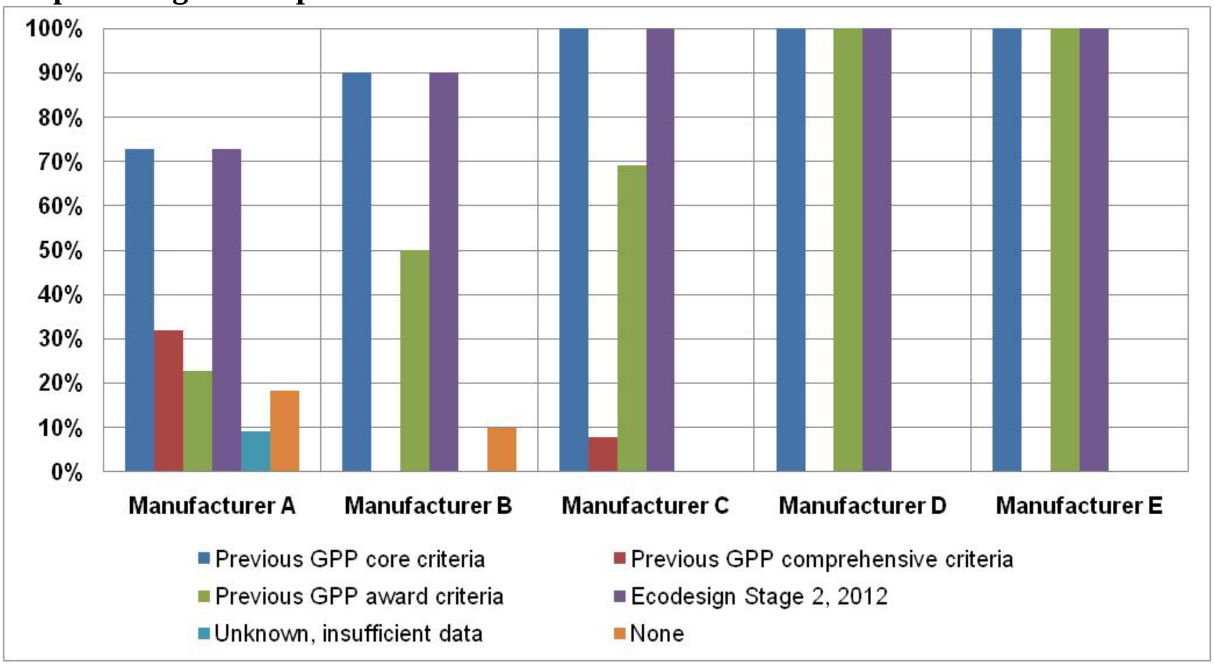
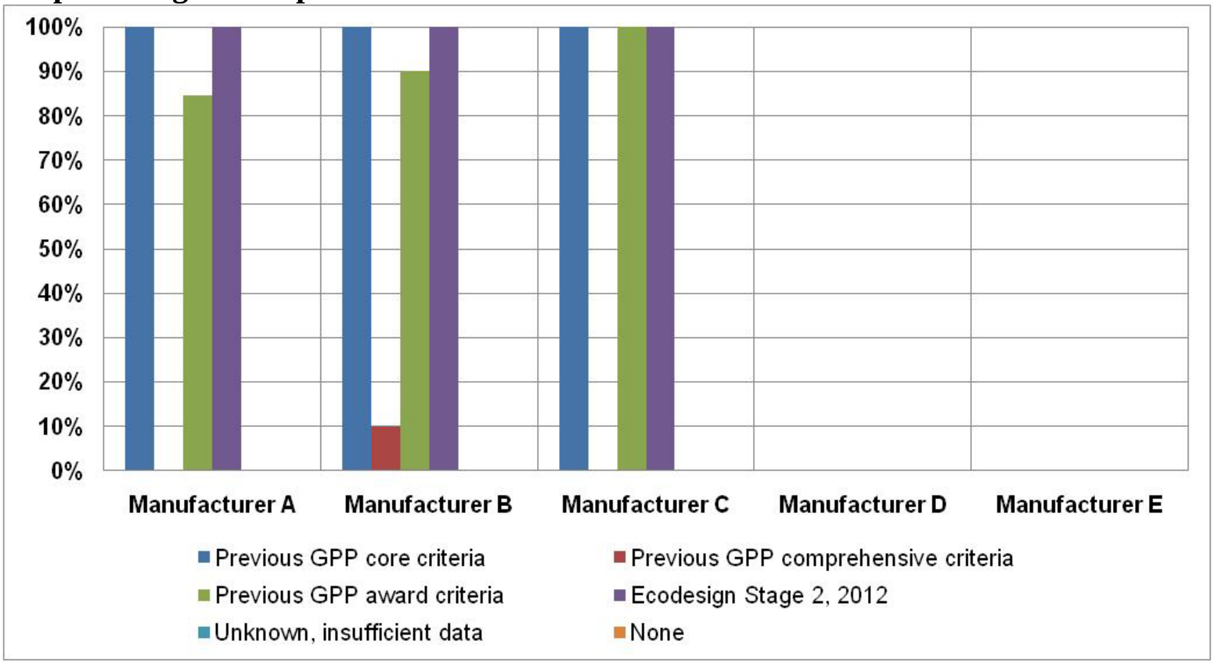


Figure 6. Compliance of MH lamps Ra > 80 with global requirements. The bars show the percentage of lamps from each manufacturer that meet the different criteria.



Because the existing GPP core criteria were essentially the same as the Stage 2 (2012) Ecodesign criteria, the proportions meeting the two sets of criteria were the same. A significant proportion of the high-pressure sodium lamps on sale did not meet either criteria. Under the Ecodesign provisions, these lamps will have to be withdrawn from the market from April 2012. Consequently the GPP criteria need to be updated, to ensure that they are more demanding than the Ecodesign provisions.

Based on this study, the proposed GPP criteria were derived by choosing targets more demanding than the Ecodesign requirements but which can still be met using a choice of lamps. Appendix 2 presents in more detail the results of the lamp survey, while values of the luminous efficacy, lamp lumen maintenance factor and lamp survival factors are discussed in Section 4.1 below.

3.2 Ballasts

The two most common types of ballast used in the EU are magnetic and electronic. According to the sales statistics collected by the industry the EU market for HID ballasts for all indoor and outdoor applications is roughly 20 million pieces (II/2007 + I/2008)[17]. In outdoor applications magnetic ballasts are the dominant technology, as electronic ballasts have just recently entered to market. In indoor and particularly in shop and office applications, where metal halide lamps are increasingly used, the electronic ballast has become a dominant technology in new systems. Unfortunately it is not possible from the information currently available to identify how many of the 20 million pieces are for street lighting.

[17] Personal communication with CELMA

3.3 Luminaires

The Eurostat database has categories for various types of street lighting luminaires but they hold no data. Data used in the EuP study was gathered from CELMA[18]. In 2005 there were 2.5 million luminaires sold in the EU at a cost of €388 million. In addition to this there were 18.3 million lamps replaced which cost €208 million. Electricity use cost €2,805 million while installation and maintenance cost €105 million. The installed stock of street lighting luminaires in the EU25 is estimated at some 56.2 million, which compares well with the 62.2 million lamps above[19].

3.4 Traffic Signals

As with street lighting there is no disaggregation of data specifically on traffic signals. No other data could be found on the levels of sales or consumption of LEDs for traffic signals.

4 Key Environmental Impacts

Lighting can have environmental impacts at a number of different stages in its life:

a. Production. This includes extraction of raw materials (resources) and manufacture of the lamps, luminaires and ballasts, which involves the use of hazardous substances.
b. Distribution. This covers emissions from transport, and the use of packaging.
c. Use. This is principally carbon emissions from the energy used by the lighting.
d. End of life. This could include release of chemicals such as mercury following disposal of lamps and waste management.

The different components of street lighting i.e. the lamp that provides the light, the ballast or control gear that regulates current and the luminaires that direct and shade the light, will have different environmental impacts at different stages of the life cycle. There have been a limited number of studies looking at the life-cycle impacts of street lighting and traffic signals. However, the final EuP Lot 9 report for street lighting uses the 'Method for the Evaluation of Energy using Products' (MEEuP) methodology to assess these impacts. This data, along with other sources, namely from trade federations, has been used in assessing the environmental impact of manufacturing, using and ultimately disposing of street lighting and traffic signals.

The EuP study mentioned above concluded that energy consumption in the use phase, predominantly by the lamps, but also by the ballasts and optical parts of the luminaires, is the main environmental impact, due to the associated greenhouse gas emissions[20]. Other impacts relate to the materials used in some types of lamps and the subsequent end-of-life disposal and treatment of these materials.

[18] The trade federation for national manufacturers associations for Luminaires and Electrotechnical components for luminaires, www.celma.org

[19] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 75. Available from http://www.eup4light.net

[20] This assumes conventional fossil fuel-derived power generation. Of course, if lighting is powered by renewable energy sources to a considerable extent then these global warming impacts can be reduced.

Table 1 below demonstrates the importance of the use phase in terms of energy consumption. This data is for the weighted average (based on share in sales) for the base case of lamp/ballast/luminaire configurations for category F, M and S roads.

Table 1. Energy consumption for street lighting in different life cycle phases[21].

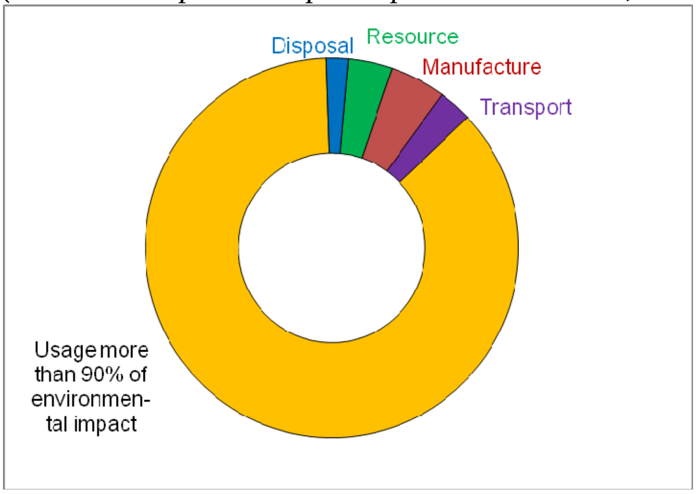
Road category	Energy consumption	Production	Distribution	Use	End of life	Total	Use as a % of total
F (fast traffic)	Total energy (GJ)	1.2	0.3	356.9	0.1	358.5	99.5
	Of which, electricity (GJ)	0.3	0.0	356.9	0.0	357.2	99.9
M (mixed traffic)	Total energy (GJ)	1.1	0.3	325.9	0.1	327.4	99.5
	Of which, electricity (GJ)	0.3	0.0	325.9	0.0	326.2	99.9
S (slow traffic)	Total energy (GJ)	1.0	0.3	126.1	0.1	127.5	98.9
	Of which, electricity (GJ)	0.2	0.0	126.1	0.0	126.3	99.8

Note: 1GJ = 1GW (per second)

The key impact from the use of lamps in lighting is the use phase, as depicted by Figure 7 below, from the European Lamp Companies Federation[22]. Applicable to all kinds of lighting, this shows that over 90% of the environmental impact is from energy consumption and associated GHG emissions whilst the lighting is being used. The environmental effect of energy consumption originates from the power generation, where fossil energy carriers like oil, natural gas or coal are converted into electricity.

Figure 7. Life cycle impacts of lamps

(source: European Lamp Companies Federation, 2005)



For luminaires, most of the environmental impacts occur in the production and end of life phases. The distribution of environmental impacts over the entire life cycle for an average luminaire is summarised in Table 2 below, which is representative of the lifecycle of a

[21] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007. Available from http://www.eup4light.net

[22] European Lamp Companies Federation, http://www.elcfed.org/1_health.html

'typical' luminaire. Luminaires of a higher efficiency will help increase the overall efficiency of the light through improved use of light and reduced losses as obtrusive light. The environmental impacts related to luminaires will be managed mainly in the production phase of the luminaire and at the end of life phase.

Table 2. Distribution of impacts over life cycle of a typical luminaire[23]

Life Cycle Phases	**Production**	**Distribution**	**Use**	**End of Life**
Other Resources & Waste				
Total Energy	74%	1%	16%	10%
of which, electricity	100%	1%	0%	-1%
Water (process)	100%	1%	0%	-1%
Water (cooling)	100%	1%	0%	-1%
Waste, non-hazardous / landfill	94%	1%	1%	4%
Waste, hazardous / incinerated	1%	0%	0%	99%
Emissions (Air)				
Greenhouse Gases	66%	1%	21%	13%
Acidification, emissions	82%	1%	12%	5%
Volatile Organic Compounds (VOC)	13%	0%	71%	16%
Persistent Organic Pollutants (POP)	82%	1%	2%	14%
Heavy Metals	42%	0%	8%	50%
PAH	97%	1%	2%	0%
Particulate Matter (PM, dust)	23%	0%	13%	63%
Emissions (Water)				
Heavy Metals	93%	1%	0%	6%
Eutrophication	86%	1%	0%	13%

The importance of the different impact categories, for example energy use or emissions in the production and end of life phases will vary depending on the materials used.

Other environmental effects of procurement of street lighting and traffic signals are relatively minor. There are some environmental costs associated with the transport and distribution of lighting equipment, but as the studies mentioned above show, these amount to less than 2% of all environmental impacts. They can be reduced by the choice of appropriate recyclable packaging to minimise breakage but also reduce additional weight and volume of transported items. Based on this, specific EU GPP criteria for packaging were introduced for procurement of lighting equipment and traffic signals. In order to minimize the environmental impacts of transportation, the contracting authorities may refer to the EU GPP for Transport[24].

The key environmental impacts are discussed below in more detail.

4.1 Production Phase

Many materials are used in lamps, luminaires and ballasts; glass, metals and plastics being chief among them. By weight, glass is the most important material in most types of lamps

[23] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 162. Available from http://www.eup4light.net

[24] http://ec.europa.eu/environment/gpp/pdf/toolkit/transport_GPP_background_report.pdf

(more than 90% of total weight), with the other contributors being brass for the cap and soldering metals (tin, lead). Ballasts on the other hand contain far more metal: steel sheet has more than 50% of total weight, followed by copper, and plastics. As for luminaires, they are on average almost half metal (largely aluminium, with some copper wire) and half plastics.

Although the use of certain materials and substances is essential to maintain optimal life cycle performance and maximum energy efficiency of lamps, the use of substances having a significant environmental impact in all types of lamps is regulated by the RoHS Directive (2002/95/EC). Over the past few decades lamp manufacturers have put considerable effort into manufacturing lamps with optimal performance and minimal use of harmful substances.

The substance that is most relevant in terms of environmental impact is considered to be the mercury used in gas discharge lamps. Technical advancements in the production process and materials applied have enabled the amount of mercury to be reduced without compromising light output or lamp life span. The mercury content in high intensity discharge (HID) lamps can vary significantly depending on the type of lamp. Typical mercury content is 1-5mg in ceramic MH lamps and 12-30mg in HPS lamps.

Annex V of the Ecodesign measure for tertiary lighting provides, for information only, that the energy efficient HID lamps with the lowest mercury content include not more than 12mg of mercury. It is not appropriate to use this limit in the GPP criteria, as it is not clear to which types of HID lamps the 12mg is relevant. In addition, the Decision 2010/571/EU amending the Annex to Directive 2002/95/EC includes limitations of mercury contents after 31 December 2011 for HID sodium lamps, and the values are given in Table 3 below. There are currently no limitations for the mercury contents of metal halide lamps.

Table 3. Mercury content limitations introduced by Decision 2010/571/EU[25]

Lamp Wattage	Low-pressure sodium lamps	High-pressure sodium lamps, Ra > 60	High-pressure sodium lamps, Ra ≤ 60
P < 155 W	15 mg	30 mg	25 mg
155W < P < 405W		40 mg	30 mg
P > 405 W		40 mg	40 mg

The EuP study on street lighting identifies certain materials that can impact specific stages of the life cycle in different ways[26]. For example, environmental impact categories where materials can have a large effect include PAH release due to aluminium production, particulate matter from the incineration of polyester housing and eutrophication from the production of the luminaire polyester housing. For example, in the case of luminaires the production phase and materials contribute most to environmental impacts over the life cycle of the product. This is in contrast to the use phase for lamps being the most important due to electricity consumption.

The use of different materials for luminaires, such as a mix of aluminium and glass fibre reinforced polyester or all aluminium, and whether the front cover is made from glass or polycarbonate will influence the overall weight of the luminaire and therefore the relative life cycle environmental impacts.

[25] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:251:0028:0034:EN:PDF
[26] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 162. Available from http://www.eup4light.net

The use of different materials for luminaires will influence which of the different impact categories are most important, in the production and end of life phases. For example luminaires can be made of all aluminium or be a mixture of aluminium and glass fibre reinforced polyester. In addition the front cover material can differ, for example it may be glass or polycarbonate.

LCA studies on sustainable material use in traffic management systems have shown that there is no advantage to be found for any particular material type. The main environmental gains are in recycling and reusing the materials, in particular poles and mounts.

4.2 Use Phase

4.2.1 Street Lighting

System lifespan is difficult to assess if you consider the variety of components, for example lighting columns may last more than 40 years, luminaires 20 years, control gear 10 to 15 years and lamps 2 to 6 years. However, on average lighting units are on for 4,000 hours a year[27] and have a lifespan of around 30 years, meaning there is potential for a range of energy efficiency measures to be implemented including technology changes and improved management and control.

The estimated energy consumption in 2005 for street lighting was 35 TWh[28] for the EU25 representing approximately 1.3% of the final energy consumption of electricity in the EU25[29].

The estimated 30-year lifespan of these products means there is likely to be a large number of older, less efficient systems in the EU. Although refitting and replacement of street lighting units will require capital investment, the annual maintenance and running costs are significantly reduced through the product's life. By replacing currently used older technologies with highly efficient new technologies, the energy consumption of electricity for street lighting can be reduced by approximately 60% and additional significant savings on maintenance costs can be achieved[30]. The Institution of Lighting Engineers (ILE) and the UK Lighting Board in consultation with the County Surveyors' Society (CSS) published advice on the reduction or removal of street lighting without compromising safety as part of their Invest to Save research[31].

In addition to the types of lamps used, the energy efficiency of street lighting is also influenced by the ballast used. Older ballasts can also significantly increase energy consumption of street lighting. Directive 2000/55/EC on energy efficiency requirements for ballasts aimed to improve the efficiency of the lighting systems by limiting the ballast losses.

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[27] EN 12665 Light and lighting - Basic terms and criteria for specifying lighting requirements and EN 60598-2-3 Luminaires Part 2-3: particular requirements - luminaires for road and street lighting
[28] Terawatthours = 1,000,000,000 kWh
[29] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 17. Available from http://www.eup4light.net
[30] Huenges Wajer B. et al. 'Energy labels and LED solutions change public lighting' ECEEE 2009. Available from: http://eceee.torped.se/conference_proceedings/eceee/2009/Panel_2/2.325/
[31] http://ile.org.uk/uploads/File/Technical/Street%20Lighting%20-%20Invest%20to%20Save.pdf

For this purpose, CELMA developed a classification system that takes both the lamp and the ballast into account and divides ballasts into 7 classes of efficiency according to their Energy Efficiency Index (EEI). The Energy Efficiency Index (EEI) of the ballast-lamp combination is defined as the corrected total input power of the lamp-ballast circuit and the classes of efficiency are A1, A2, A3, B1, B2, C and D, where A1 ballasts are the most efficient.

The use of more efficient lamps and ballasts / control gear will reduce the energy consumption of the street lighting, thereby reducing CO_2 emissions from fuel combustion required to generate the electricity in the first instance. In addition there will also be reduced impacts in the life cycle of the fuel, included reduced emissions from exploration, extraction, refining, processing, transportation and storage. Similarly, there will be less maintenance required for more efficient, longer lasting lamps and luminaires and hence reduced impacts from these operations.

The light output from a lamp is measured in lumens. Lamps are available with a range of lumen output to meet different requirements. In order to achieve this, lamps will likewise have a range of power consumptions.

The efficiency by which a lamp uses the electricity supplied to it to create the lumen output is denoted as the lamp's luminous efficacy; typical ranges are presented in Figure 8. It is the number of lumens provided per watt of power consumed, lm/W. This measure enables the efficiency of different lamps to be compared.

Lamp efficacy varies between the different types of lamps. Figure 8 below clearly shows that sodium lamps (high and low-pressure) as well as metal halide lamps are far more efficient with their energy consumption than more conventional high-pressure mercury lamps. This means that they provide more light for a given power consumption, or conversely, they consume less power in providing a set light output.

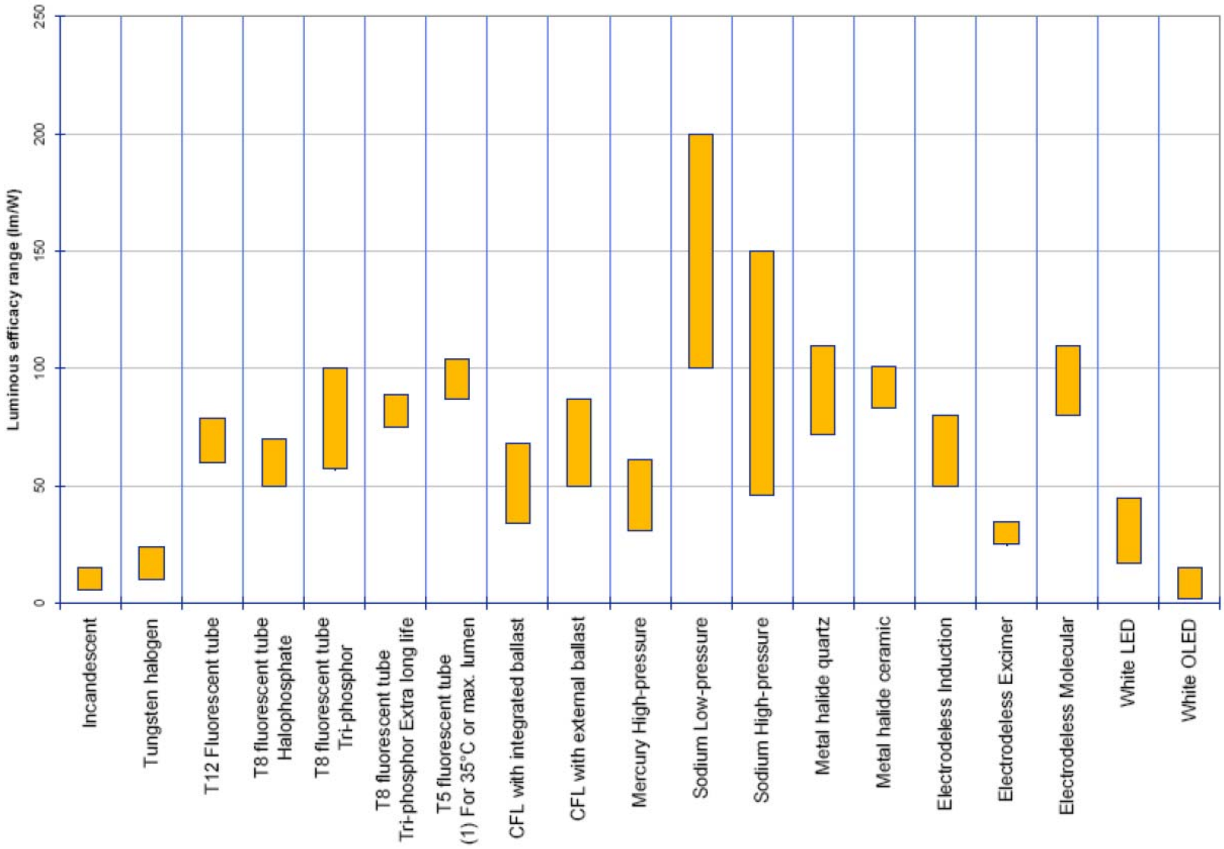
Setting limits in relation to lamp efficacy will encourage the use of the most efficient lamp types. The level of lamp efficacy varies between different types of lamps. Metal halide and high-pressure sodium lamps are considered the best available technology for modern street lighting[32].

As part of the Buy Bright Initiative[33] a procurement guide for efficient lighting highlighted the need for procurement criteria for lighting to enable energy savings[34]. This initiative recommended lamp efficacy for metal halide lamps and high-pressure sodium lamps and excluded the less efficacious mercury vapour lamps.

Limits to lamp efficacy, for example those in the Ecodesign requirements, have encouraged the use of the most efficient lamp types. An example is the implementing measure[35] for tertiary sector lighting products under the Ecodesign Directive (245/2009).

[32] http://buybright.elcfed.org/uploads/fmanager/saving_energy_through_lighting_jc.pdf
[33] http://buybright.elcfed.org/index.php?page=21
[34] http://buybright.elcfed.org/uploads/fmanager/061016_sse_05_054_buy_bright_report.pdf
[35] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:EN:PDF

Figure 8. Luminous efficacy range of lamp technology
(source: Laborelec, from EuP 8 Lot Study on Office Lighting, 2007)



Note: Although the luminous efficacy of the individual lamps will remain constant regardless of application, it should be noted that the type of system will affect how 'efficiently' this light is used.

Furthermore, the type of ballast used and its efficiency will also impact the overall energy efficiency of street lighting. The Ecodesign measures include minimum energy efficiency standards for ballasts, and these have therefore been used in the development of GPP criteria. The core criteria for ballasts are based on the second stage Ecodesign measures, which will not be mandatory requirements until 2012, but following a ballast market survey, targets were raised for ballasts operating lamps of wattages below 105W. Similarly the comprehensive criteria are based on the third stage Ecodesign requirements, which will not be mandatory requirements until 2017. The use of the Ecodesign implementation measure is considered suitable as they will not be mandatory straight away and allow differentiation between products. As above for lamps, the GPP criteria based on these measures were reviewed, as market transformation takes place and an increasing number of products meet these requirements and standards are developed further.

In addition ballasts that can dim lighting further reduce energy consumption. This ability has been incorporated in the criteria where appropriate as there are a number of factors that will influence where the use of variable control ballasts are suitable, including the location of the street lighting, levels of ambient lighting, traffic intensity and security considerations.

In a typical lighting system there is a combination of light losses due to light being trapped in the luminaire, light absorption on surrounding surfaces and light being directed to areas where it is not particularly needed. There is a very large range of luminaires available commercially and these can have significantly different optical properties, which have a large impact on the efficiency of the lighting system. Inefficient luminaires may produce half as much light as highly efficient ones with the same lamps. Initial proposals[36] for including luminaire efficiency in the Ecodesign requirements were not included in the final implementing measure for tertiary lighting. Thus there remains considerable scope for promoting energy efficiency by including luminaires in GPP criteria, either directly or indirectly.

In order to avoid wasted light and therefore improve energy efficiency and reduce other impacts such as obtrusive light, discussed in section 4.4, the luminaires should be designed and installed in order to limit the proportion of light going above the horizon. This is an important feature to reduce unwanted light but is considered to be secondary, in terms of overall environmental impacts, to the primary luminous efficacy (energy efficiency) of the lamps being used. Therefore it has been included in the criteria after lamp efficacies and lifetimes.

There are only very few European countries that have provisions addressing the energy efficiency of the whole street lighting system. Spanish codes introduce the energy efficiency for street lighting, measured in $m^2 \cdot lux/W$, for different road types and average service illuminances[37]. In the Netherlands an energy efficiency A-G label has been developed for street lighting systems, based on the street lighting energy efficiency criterion (SLEEC), which is a whole system indicator taking into account efficiency of the lamp, ballast and luminaire[38]. It is used in the European lighting standard EN 13201-5 and takes into account aspects like lighting quality and dimming. GPP criteria for the energy efficiency of street lighting systems have been developed based on the SLEEC values and Appendix 1 describes how the criteria were derived.

Depending on the specific location characteristic e.g. climate and available systems, it may be possible to use technology that allows street lights to generate and store electricity during the day, for example by using photovoltaic (PV) panel systems, to power themselves, at least in part during the night. The contracting authority may wish to consider such systems, but would need to ensure road safety issues were addressed to ensure the street lighting would not fail. Criteria are not included as part of this product group in relation to this, and separate GPP criteria are available that promote the use of renewable energy.

4.2.2 Traffic Signals

For traffic signals, LEDs offer improved energy efficiency compared to incandescent lamps. The use of LEDs is considered the best available technology (BAT) for traffic signals and can

[36] Working document on possible ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, for ballasts and luminaires used with these lamps, and on the conditions for the indication of suitability of lighting products for office lighting' VITO, 2007.
[37] Technical Instruction ITC-EA-01, BOE no. 279, 2008. Available from: http://www.boe.es/boe/dias/2008/11/19/pdfs/A45988-46057.pdf
[38] Energy Labelling Guide for Public Lighting, NSVV, March 2009. Available from: http://www.nsvv.nl/download/download.aspx?id=8c802b05-7ab5-4610-a90b-a1d40db54576

reduce energy consumption by at least a factor of three or four with currently available technology[39].

In the UK for example, it was estimated that converting all traffic signals to LED lights would have saved 57,000 tonnes of CO_2 per year in 2010[40]. It was also estimated that upgrading all traffic signals in London by the use of LEDs would reduce CO_2 emissions by up to 10,000 tonnes per year[41]. The energy consumption for LED traffic signals can be around 8-12W bright and 5-7W dim, compared to 50W bright and 25W dim for ordinary incandescent signals. This alone offers significant savings in energy consumption without detracting from the performance of the lighting system, and also requires less maintenance.

In more remote areas where grid electricity can be difficult to connect to, further greenhouse gas emissions savings can be made through the use of photovoltaic (PV) cells to power traffic signals. Obviously this will be dependent on factors such as climate, availability of sunlight to the right degree, aspect and location of the traffic signals, performance criteria and planning controls.

4.2.3 Night-time Dimming

The use of light-sensors or photocell sensors can be used to dim both street lighting and traffic signals relative to the ambient light levels. This provides a level of control meaning lights are not simply on or off but are illuminated to the levels required at the time. The amount of reflected light on the road surface is also reduced so that glare and light pollution is also reduced. This can be applied to both street lights and traffic signal provided the minimum health and safety standards are met and as such will save energy and costs.

The savings potential is greater for roads with a high lighting class, for example motorways. Variable control could be linked to the traffic density, meaning lighting on these roads could be reduced at times of low traffic volume.

LED traffic signals can also be dimmed at night, which reduces the energy consumption further; typically in the UK voltage is reduced from 240V to 160V.

4.3 Product Durability – Lifetimes

4.3.1 Lamp Survival and Lamp Lumen Maintenance Factors

In addition to the key aspect of increased lamp efficacy and reduced energy consumption, there are a number of other benefits linked with the use of certain types of high intensity discharge lamps for street lighting and LEDs for traffic signals. These are primarily how long

[39] Policy Brief: Improving the energy performance of street lighting and traffic signals, DEFRA, July 2008. Available from: http://www.mtprog.com/spm/files/download/byname/file/2006-07-10%20Policy_Brief_street_lighting%20fin.pdf
[40] Quick Hits, Traffic Signals, UK ERC, December 2006. Available from: http://ukerc.rl.ac.uk/UCAT/cgi-bin/ucat_query.pl?GoButton=Year&YWant=2006
[41] News centre: Energy-busting LED traffic signal installation, Transport for London, May 2010. Available from: http://www.tfl.gov.uk/corporate/media/newscentre/archive/15647.aspx

the lamps last for, the lamp survival factor (LSF) and how well they maintain their light output, the lamp lumen maintenance factor (LLMF).

The following graph demonstrates that the high-pressure sodium and metal halide technologies also in general have longer lifetimes than the high-pressure mercury alternatives. The benefits of this are two-fold: lamps last for longer before needing to be replaced so fewer of them need to be made and so less material is used in manufacture, furthermore fewer maintenance operations are required in replacing lamps. In addition to lasting longer these lamps maintain their lumen output such that they remain near to the original output when they were first installed and the need to over-light on initial installation to maintain sufficient illumination later in the lifetime is avoided. This reduces the need to replace older lamps that, whilst they still work, have dimmed beyond the necessary, useful and safe level of light required.

Figure 9. Typical lifespan of lamp technology
(source: Laborelec, from EuP 8 Lot Study on Office Lighting, VITO et al., 2007)

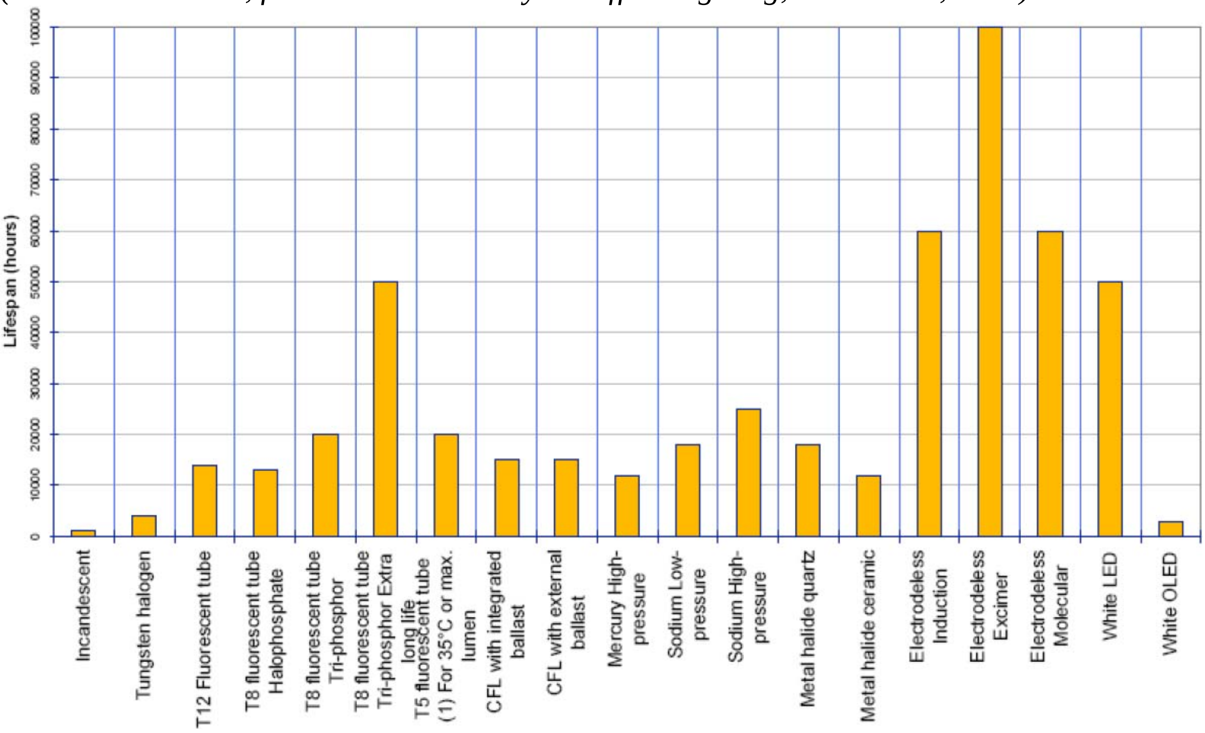


Table 4 below shows the average values of LLMF and LSF for the two main street lighting types. For example it can be seen that 78% of high-pressure sodium lamps survive to 20,000 hours of operation, whilst maintaining 91% of their original lumen output. On the other hand for high-pressure mercury lamps only 74% of them survive to 16,000 hours of operation, whilst maintaining 80% of their original lumen output.

It should be noted that high efficiency lamps and ballasts, with increased efficiencies and life spans, for example the 'cosmo' lamp, are available and economies of scale are reducing the cost of these.

Table 4. LLMF and LSF data for the two main street lighting technologies

Lamp type	Factor	Burning hours				
		4,000	*8,000*	*12,000*	*16,000*	*20,000*
Metal halide (MH)	LLMF	0.89	0.85	0.81	0.80	-
	LSF	1.00	0.99	0.91	0.74	-
High pressure sodium (HPS)	LLMF	0.95	0.93	0.93	0.92	0.91
	LSF	0.99	0.97	0.94	0.87	0.78

This information can be translated into common average lifetimes of these lamps, which indicate the usual length of time they will last both in elapsed time, years, and number of hours of burning. The results are given in Table 5 below.

Table 5. Average lifetimes of street lighting lamps by lamp technology

Lamp type	Lifetime	
	Years	*Hours*
High-pressure Sodium	6.25	25,000
Metal Halide (quartz)	4.5	18,000
Metal Halide (ceramic)	3	12,000

To ensure lamps with a sufficient life span are purchased for street lighting, it is proposed to include criteria in the GPP specification, which relate to the lamp survival factor. To reiterate, the lamp survival factor is a measure/indication of the fraction of the total number of lamps, which continue to operate at a given time under defined conditions and switching frequency.

4.3.2 Ballasts and Luminaires

Depending on the type of ballast, manufacturers' data suggests that ballasts can last anywhere between 40,000 to 60,000 hours of use, equating to ten to fifteen years. According to the relevant standards magnetic ballasts shall have minimum life of ten years continuous operation. However in practice this can be exceeded and field experience has shown that lifetimes of thirty or even fifty years can be achieved.

The life of ballasts will be affected by conditions such as the working temperature of the lighting system; if it is too hot then the lifetime can be decreased. The types of ballast used will also be important, for example magnetic versus electronic ballasts. Whilst experience has shown that magnetic ballasts have a long lifetime, there is currently not the same field evidence available for electronic ballasts used outside. However the experience from indoor applications show that the failure rate is clearly higher, that the life time is clearly shorter compared to magnetic ballasts and it will be expected that electronic ballasts would need to be replaced during the life time of the luminaire, though it should be noted the ability of the luminaire to resist dust and moisture ingress will affect the life of the lamp and ballast.

Luminaires are normally only affected by climatic conditions of wind and rain as well as vibrations and pollution due to the passing traffic. Depending on their location they can remain in situ for anywhere between ten and thirty years[42].

[42] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 75. Available from http://www.eup4light.net

Due to the relatively long life span of luminaires and ballasts in comparison to most lamps, depending on how they are configured, lamps can be viewed as replacement parts for luminaires. Procurement decisions will need to bear this in mind when commissioning street lighting systems. Luminaires should be compatible with various existing and potential future types of lamps as well as ballasts where appropriate. Furthermore, it is imperative that local conditions of climate, geography as well as national legislation are taken into account in any procurement decision, as these will affect the design, installation and operation parameters.

At present there is insufficient information available to develop objective criteria for luminaires, for example with regard to their minimum efficiencies. This is a result of the decision to postpone the detailed luminaire ecodesign efficiency requirements under the Ecodesign Regulation for tertiary sector lighting products.

This aspect should be considered in the future once an evidence base is available on which to base the development of GPP criteria for the efficiency of luminaries.

4.3.3 Luminaire Maintenance Factor (LMF)

The lifetime of a luminaire and the length that it gives out good quality light can be extended through its design and maintenance to reduce the amount of dirt and water getting inside as well as their resistance to heat. This is known as ingress protection (IP rating) in the lighting industry and describes how well the luminaire performs against these environmental factors, including when they are repeatedly opened for lamp or control gear replacement. More recent developments include self-cleaning luminaires that function with UV light activating the coating on the luminaire to degrade the dirt on it such that it can be washed off more easily by rain.

During the life of a lighting system, the available light progressively decreases. The reduction rates are a function of time and environmental and operating conditions. Lighting design takes this into account by the use of a maintenance factor, and a suitable maintenance schedule to limit the decay should be planned. The International Commission on Illumination's guide CIE 33-1977[43] along with British Standard 5489:2003 provides information on suggested maintenance factors and the selection of suitable equipment. It describes the parameters influencing the depreciation process and develops the procedure for estimating the economic maintenance cycles for outdoor electric lighting systems and gives advice on servicing techniques.

4.3.4 LED traffic signals

The same benefits are also realised when using LED traffic signals, which last much longer compared to incandescent bulbs, which in the UK are typically replaced every six – twelve months[44]. This replacement frequency is required to ensure the lamps are working, as incandescent bulbs will burn out quickly. This is in contrast to LEDs, which gradually loose brightness over time. This loss can be monitored and LEDs replaced when required.

[43] International Commission on Illuminating, www.cie.co.at

[44] Policy Brief: Improving the energy performance of street lighting and traffic signals, DEFRA, July 2008. Available from http://www.mtprog.com/spm/files/download/byname/file/2006-07-10%20Policy_Brief_street_lighting%20fin.pdf

4.4 Obtrusive Light

Another important environmental impact is what is known to the lighting industry as *obtrusive light*, or more commonly known as *light pollution*. Obtrusive light, or light pollution, is defined as: *"Spill light which, because of the quantitative, directional or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information"*[45]. It affects people (and animals) in three main ways: upward light pollution known as sky glow, light trespass, and disorientation from glare and clutter.

Sky glow occurs when light is shed upwards, either directly by light sources such as street lamps or floodlights, or reflected from the ground or other surfaces. Dust and water vapour in the air scatter the light to give an orange glow above our towns and cities which obscures stars in the night sky. The orange colour is derived from the sodium lamps that comprise most street lighting.

Light trespass is a more localised issue, which occurs where artificial light sources are visible beyond the areas they are supposed to light. Often associated with poorly aimed floodlights or over-lighting of areas, light trespass can disturb and annoy people, who may find their bedrooms lit to the extent that they can't sleep.

Glare occurs when a source of artificial light is so much brighter than the area around it that it causes discomfort and inability to see, something which is very dangerous to road users. A common example is the effect of main beam headlights on an oncoming car when driving along a dark road, but it can also be caused by fixed lighting systems, such as a floodlight which directly faces an observer.

Visual clutter occurs where important lights such as traffic signals are viewed against a competing background which reduces their visual impact. The effect is worse if the competing lights are coloured.

Excessive light into the local environment can disturb the natural night-time biorhythms of human activity and other plant and animal ecosystems. There is limited research available to allow obtrusive light to be quantified, however there are indications that it affects the natural bio-rhythms of terrestrial and aquatic ecosystems and is considered an important factor for street lighting[46].

Artificial light can extend the length of the day, affecting insect populations, nocturnal mammal species, and nesting and roosting birds. Night flying insects such as moths can either cease flying and settle when exposed to high levels of general illumination, or fly in spirals where they are misled by an individual light. Some entomologists believe that increased street lighting is a significant factor in the reduction of moth species in urban areas.

Bright light is likely to deter nocturnal mammals from using established foraging sites. If the population is already threatened this represents an additional risk factor, particularly if the

[45] CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations', Vienna, 2003

[46] Ecological Consequences of Artificial Night Lighting, Edited by Catherine Rich and Travis Longcore, Published 2005

lighting is along important areas like river corridors. Conversely, if road lighting deters animals from crossing the carriageways it may have a positive effect. Fast flying bat species can benefit from the insects attracted to street lights, but slower-flying species, which include most of those considered particularly vulnerable in Europe, do not experience the same benefits[47].

The behaviour of birds is strongly affected by light. Artificial increases in day length can induce hormonal, physiological and behavioural changes in birds, initiating breeding[48]. Very bright lights can also attract and disorient birds. Nocturnal species are particularly likely to be disturbed. Some short-day plants will not flower if the night is shorter than the critical length. Others will flower prematurely.

The industry sets standards on obtrusive light for their manufacturing members with limits provided by CELMA in the *Guide on obtrusive light*[49]. Similarly, national associations provide guidance on reducing obtrusive light, such as the Institution of Lighting Professionals in the UK[50] and the French Lighting Association (l'Association Française de l'Eclairage) with their 2006 guide which includes methods endorsed by CELMA to optimise the luminous flux towards the sky[51]. The International Lighting Commission (CIE) has given guidance in its documents[52] CIE 150:2003 *Guide on the limitation of the effects of obtrusive light from outdoor lighting installations* and document CIE 126:1997 *Guidelines for minimizing sky glow*. Additional guidance on obtrusive lighting from areas specific to road lighting is contained in EN 13201-2, while EN 12464-2 contains numerical guidance on suitable lighting levels to limit obtrusive light for various outdoor work premises.

The guidance centres on avoiding over lighting areas and directing the light as best as possible to the area where it is intended through a combination of the correct luminaire, installation and the correct light (lumen) output. This will not only reduce obtrusive light but can improve energy efficiency by requiring less energy to light the desired area.

The explanatory note for the Commission's draft Regulation for the ecodesign measures for tertiary lighting indicates that methods for assessing the environmental impact of light pollution are still under development. However, obtrusive light is identified as an important environmental impact and therefore specific comprehensive GPP criteria are included to reduce the proportion of light going above the horizon[53] and thus to reduce the levels of obtrusive light.

[47] Royal Commission on Environmental Pollution, 'Artificial light in the environment', Norwich, TSO, 2009
[48] Department of Environment/Countryside Commission, 'Lighting in the countryside: towards good practice', HMSO, 1997. Available from www.communities.gov.uk
[49] Guide on Obtrusive Light' – 1st Edition, CELMA, June 2007. Available from http://www.celma.org/archives/temp/First_edition_Celma_Guide_on_obtrusive_light.pdf
[50] Guidance Notes for the Reduction of Obtrusive Light', ILP, 2005. Available from http://www.ile.org.uk/uploads///File/02_lightreduction.pdf
[51] 'Les nuisances dues à la lumière', AFE, 2006. Available from http://www.lux-editions.fr/recommandations_guides.asp?acc=A
[52] International Commission on Illuminating, www.cie.co.at
[53] That is, light going up and above the luminaire

4.5 End of Life and Waste Management

The end of life management of street lights and traffic signals is mainly regulated by the requirements of the WEEE Directive, which is outlined in Section 10 of this report. As such, units have to be collected for proper disassembly, treatment and recycling of parts. Much of the components of street lights and traffic signals can be recycled with a minimum of treatment, for example glass, plastics and metals. This should be undertaken at the end of use phase.

It is important that lamps are dealt with correctly at the end of their life. This is generally covered by the requirements of the WEEE Directive. Mercury can be recovered from lamps using specialist plant and this should be undertaken wherever possible. A key issue in the end of life management of lamps is mercury and the release of mercury vapour. Lamps should be sent to facilities that have the required technology to dismantle the lamps and recover the mercury appropriately.

In addition to mercury, other substances are contained in lamps, depending on their types, for example sodium and lead. It is important that potential environmental impacts of these substances e.g. ecotoxicity are managed, and in particular at the end of life phase.

4.6 Other Considerations

It must be remembered though that lamps are chosen primarily for the amount of light they provide in order to meet the needs of a given application, such as lighting a given road length to a suitable extent for the safe passage of vehicles and pedestrians. Contracting authorities will also procure lamps for a number of different scenarios, including the replacement of lamps, retrofitting of lamps and installing completely new lighting systems. Aesthetics will play a part too, in the colour and brightness of the lamp, as well as its shape.

It is therefore important in the design and installation phases that the correct lighting system is chosen for the intended application. Care must be taken to define the procurement needs in terms of the required lighting output for the given area, in terms of the lumen output from the lamps and associated ballasts as well as characteristics of the luminaires to direct the light. This is the role of the contracting authority working closely with suppliers and designers. This will maximise the use of natural ground and other surface reflections, ambient light and local surroundings and environment in maximising energy efficiency. Not only choosing components with the right light output but also those with long and good quality lifetimes will reduce the need for failed component replacement and other more general maintenance, such as cleaning.

It is important to remember that not all street light systems can be retrofitted with more efficient lamp types, as they are not always compatible. HID lamps need an appropriate ballast and so in many cases this will require replacement of whole systems; luminaire, lamp and ballast. Some older and worse performing technology is still available and installed today. The replacement of the existing street lighting stock that is still in good working order (albeit older and potentially less energy efficient) with newer more efficient street lighting will be a major capital investment in most cases and would depend on the policies of the relevant contracting authority. It is important that GPP criteria should not be too difficult or costly to implement, otherwise they may deter public authorities in investing in new, more efficient equipment.

Street lighting is generally chosen with regard to the requirements for light output and the specific application. As shown above this will be influenced by several factors, such as road category. A comparison of the environmental impacts of lamp/ballast combinations per lamp lumen output is shown in Table 6; the EuP report concluded that for the same road category the environmental impact is comparable for different types of lamp/ballast combinations. This therefore demonstrates that the key consideration for contracting authorities is the specific application of the street lighting. Section 2.7 outlines the key types of lamps used for specific road categories; mainly HID lamps.

Table 6. Life cycle impact per base case lamp/ballast, expressed per lamp lumen output over 30 years[54].

LAMP + GEAR, ***time period 30 year***		Road category A		Road category B		Road category C			
		131W LPS	250W HPS	150W HPS	400W HPM	125W HPM	70W HPS	70W MH	36W CFL
PER LUMEN									
Other Resources & Waste									
Total Energy	kJ	57.9	32.8	53.4	54.9	160.0	124.0	203.0	217.0
of which, electricity	kJ	10.0	6.3	8.7	7.2	10.5	13.4	14.9	7.0
Water (process)	ml	6.7	2.1	3.4	1.5	1.8	7.5	8.7	4.5
Water (cooling)	ml	1.3	3.2	4.3	2.8	4.1	6.5	7.5	0.1
Waste, non-haz./landfill	g	0.8	0.6	0.8	0.8	1.6	1.3	1.6	0.3
Waste, hazardous/incinerated	g	0.02	0.02	0.03	0.00	0.01	0.08	0.09	0.00
Emissions (Air)									
Greenhouse Gases in GWP100	g CO2 eq.	4.3	2.4	4.0	4.2	13.0	9.6	16.3	18.6
Ozone Depletion, emissions	mg R-11 eq.	0	0	0	0	0	0	0	0
Acidification, emissions	mg SO2 eq.	19.4	13.5	20.2	20.1	48.7	41.1	61.4	50.3
Volatile Organic Compounds (VOC)	mg SO2 eq.	0.13	0.08	0.13	0.13	0.39	0.31	0.49	0.21
Persistent Organic Pollutants (POP)	pg i-Teq	4.4	3.7	5.0	5.5	11.5	8.6	11.2	1.5
Heavy Metals	µg Ni eq.	6.7	27.6	35.1	25.4	34.2	40.0	49.3	11.1
PAHs	µg Ni eq.	2.1	1.5	2.5	2.2	7.5	6.1	10.9	11.9
Particulate Matter (PM, dust)	mg	5.5	2.4	3.7	4.0	10.1	8.1	12.6	3.8
Emissions (Water)									
Heavy Metals	µg Hg/20	3.1	2.2	3.4	1.1	2.5	7.6	9.4	1.1
Eutrophication	mg PO4	0.06	0.15	0.19	0.12	0.16	0.24	0.29	0.01
Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	0	0	0	0

5 Cost Considerations

5.1 Street Lighting

When purchasing HID lamps, it is important to not only consider the initial cost of the lamps, but also the lamp efficacy. Although HPM lamps may appear to be cheaper, it must be remembered that these types of lamps have a lower luminous efficacy; therefore they will require more watts to give the same lumen output as an HPS lamp or MH lamp.

[54] EuP Lot 9 Study: Public Street Lighting, VITO, January 2007, pg. 158. Available from http://www.eup4light.net

This will provide energy savings, and therefore cost savings, as HPS lamps and MH lamps will use less power (watts) than a HPM lamp to provide the same lumen output. These benefits will however depend on other factors, for example, are the sockets the same and will the light distribution change therefore requiring other changes to the street light system e.g. a different luminaire/ballast. On a replacement only basis, a long payback would be expected due to the cost of the whole fitting i.e. lamp, ballast and luminaire e.g. greater than ten years[55].

Therefore to ensure street lighting is economic it is important in terms of cost considerations for the contracting authority to consider this GPP specification and the best available fittings for new lighting systems and refurbishment of existing systems, for example upgrading ballasts. Obviously where fittings allow, more efficient lamps should be used depending on the location and specific light use requirements.

Some contracting authorities do not meter electricity consumption for street lighting, and the cost of electricity is calculated based on the number of units and their nominal wattage. Where street lighting is upgraded to improve energy efficiency, the contracting authority would normally renegotiate the electricity charges.

Good street lighting design may be able to reduce costs by the resulting increase in distance between the streetlights and lower lamp power. However this will need to be balanced against requirements, for example local health and safety requirements regarding spacing and lighting requirements for specific uses.

Furthermore, using lamps that have longer lifetimes and better lumen maintenance will result in longer maintenance times, therefore reducing costs. This will also reduce the indirect impacts incurred through replacement and maintenance, such as vehicular emissions and the associated impacts from manufacturing and distributing more components, mainly lamps.

It should be noted that limited information and data is available regarding the costs considerations for street lighting.

5.2 Traffic Signals

There are a number of cost considerations that the contracting authority will need to taken into account when purchasing traffic signals.

The cost of light-emitting diode (LED) traffic signals has been a barrier to the wider implementation of these types of traffic signals over the years, although some countries such as USA and Germany have implemented replacement programmes to upgrade traffic signals to LEDs.

[55] Policy Brief: Improving the energy performance of street lighting and traffic signals, DEFRA, July 2008 http://www.mtprog.com/spm/files/download/byname/file/2006-07-10%20Policy_Brief_street_lighting%20fin.pdf

The costs[56] for a standard (incandescent) red-amber-green head is currently around €187.5 compared to over €750 for an equivalent LED model however LED prices are falling rapidly. Therefore, although the initial up-front costs are more for LEDs, overall lifetime costs are lower thanks to a reduction in energy used and far lower maintenance costs[57]. Other designs allow the use of LEDs with common traffic controllers and reduce replacement costs to €250 – €375 per head[58].

Although the initial capital costs for installation of LED traffic signals is more than conventional (incandescent) versions, the payback following the installation of LED traffic signals has proved to be relatively short as a result of reduced electricity charges and maintenance costs, as the examples below demonstrate. The benefits will be further increased if the price of energy keeps on increasing, as has been the trend over recent times.

A European example of replacing conventional traffic signals with LED traffic signals is provided by the city of Freiburg in Germany. Here 53 traffic signals were replaced in 2006 with projected annual savings of €155,000 as a result of lower maintenance costs and a reduction of 350,000 kilowatts in power consumption, equating to a reduction in emissions of CO_2 of 240 tonnes. The financing of this project is over 15 years, with annual repayments of €140,000, which is less than the total savings per year[59].

In the USA for example, the California Energy Commission has estimated that a city converting all traffic signals at an intersection (cross-roads) with LEDs will reduce energy use by an estimated 70%, resulting in a simple payback of three to five years. In the city of Portland, Oregon nearly all red and green incandescent traffic lights were replaced in 2001 with LEDs. This resulted in net payback in less than three years due to energy and maintenance savings totalling $400,000, approximately[60] €284,000.

6 Public Procurement Needs

Almost all municipalities require street lighting and traffic lights. Public procurement activities may cover one or more of the following areas:

a. Lighting for a new outdoor public traffic area (road or pathway).
b. Lighting for an outdoor public traffic area that is being completely refurbished.
c. Replacement luminaires within an outdoor public traffic area, while keeping wiring and lighting controls.
d. Retrofit lighting controls, while keeping luminaires.
e. Replacement lamps.

Replacement lamps form the majority of regular procurement. However there is limited scope for using procurement policies on replacement lamps to save energy. Partly this is because the Ecodesign requirements set high minimum standards of efficacy for most lamps anyway, and

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56 Costs have been converted from Pounds Sterling to Euros using an exchange rate of €1.25 to £1
57 http://www.reuk.co.uk/UK-Traffic-Lights-57000-Tonnes-Of-CO2.htm
58 Policy Brief: Improving the energy performance of street lighting and traffic signals, DEFRA, July 2008 http://www.mtprog.com/spm/files/download/byname/file/2006-07-10%20Policy_Brief_street_lighting%20fin.pdf
59 http://www.siemens.de/staedte/referenzprojekte/Seiten/stadt-freiburg.aspx
60 Savings have been converted from US Dollars to Euros using an exchange rate of €0.71 to $1

partly it is because installed lighting often requires particular types of lamps and using a more efficient lamp means replacing the luminaires.

The purchase of new lighting happens less frequently, but has a big influence on energy consumption. This is because a new lighting system may often remain in place for 40 years or more, consuming energy throughout that time.

Procurement of new lighting may occur in a number of ways. Design of a new system may be carried out by a contracting authority's in house staff, or by street lighting contractor or an independent lighting designer. The installation work is usually carried out by a contractor.

Alternatively where a new development is planned which incorporates roadways or pathways, the developer may supply lighting to the standards of the local authority. This lighting is then adopted by the authority which then maintains it.

7 Conclusions and Summary

A number of different types of lamps can be used for street lighting, however the main type is high intensity discharge lamps, as outlined by the EuP Study and the European Lamp Companies Federation (ELC), which include metal halide lamps and high-pressure sodium lamps. The GPP criteria for replacement lamps used for street lighting therefore focus on these types of lamps. The scope of street lighting for this GPP specification is consistent with that used in the EuP study, albeit focussing on HID lamps. HID lamps are used across all types of road categories (Fast, Medium and Slow), whereas other types of lamps, for example CFLs are only used for the slow road category with a limited percentage of sales. Other lamp types, along with CFLs are also excluded, such as linear fluorescent lamps, as they are predominantly used in domestic or office applications, and not street lighting.

Depending on the specific location characteristic e.g. climate and available systems, it may be possible to use localised renewable energies such as photovoltaic panels or wind turbines to power the lighting. The contracting authority may wish to consider such systems, but would need to ensure road safety issues were addressed to ensure the street lighting would not fail. Criteria for technologies that allows street lights and traffic signals to generate and store electricity during the day to power themselves, for example photovoltaic (PV) systems, are not included as part of this product group, and separate GPP criteria are available that promote the use of renewable energy.

There are no ecolabel criteria available for HID lamps, however the GPP criteria focus on the key environmental impact of energy use and include lamp efficacy, lamp survival and lamp lumen maintenance. This is consistent with the key areas considered by existing standards for other types of lighting, for example the EU Ecolabel for light bulbs. Following on from these key areas in relation to the HID lamps, other criteria consider additional elements of the street lighting system, including the luminaire and energy used by the whole system (these latter criteria are relevant to all lamp types, not just HID lamps).

The specific limits for replacement lamps included in the criteria are derived from the Ecodesign measures for tertiary lighting (including HID lamps, and ballasts and luminaires for use with these types of lamps) and are based on a detailed survey of the lamp market.

Targets more demanding than the Ecodesign requirements were chosen, which can still be met using a choice of lamps.

The core criteria for ballasts are derived from the second stage Ecodesign requirements which will be mandatory from 2012, and targets are raised for ballasts operating lamps of wattages below 105W, based on a ballast market survey. The comprehensive criteria for ballasts are based on the third stage Ecodesign requirements, which will not be mandatory requirements until 2017, slightly increased based on the ballast market survey.

Where new lighting systems are being provided for outdoor public traffic areas, GPP criteria for the energy efficiency of street lighting systems were developed based on a detailed system modelling and on the street lighting energy efficiency criterion (SLEEC), which is a whole system indicator taking into account efficiency of the lamp, ballast and luminaire. It is used in the European lighting standard EN 13201-5 and takes into account aspects like lighting quality and dimming.

Mercury content of lamps is identified as a key issue. Relevant limits for mercury content are dealt with through the RoHS Directive and its amendments, and are potentially subject to change. The mercury content of HID lamps in the GPP specification is addressed through setting maximum contents based on the RoHS Directive and a detailed survey of various lamps currently available on the market.

In addition to the recommended core and comprehensive technical specifications (which are criteria that have to be met by all products offered for purchase), award criteria are proposed for street lighting to promote the purchase of lamps with further efficiency measures by using dimming ballasts and additional reductions in the proportion of light emitted above the horizon. These are additional criteria on which the contracting authority will base its award decision. Award criteria are not pass/fall criteria, meaning that offers of products that do not comply with the criteria may still be withheld for the final decision, depending on their score on the other award criteria, including the price. To stimulate further market uptake of ever improved environmental products, award criteria should be considered depending on the specific circumstances of each case.

There is a lack of existing standards and detailed studies relating to traffic signals, however the scope used for this GPP specification is consistent with the EN 12368 standard. Traffic signals are a smaller element of this product group in terms of their overall energy consumption compared to street lighting. Nonetheless the main focus in recent years has been the development of LEDs for use in traffic signals to improve energy efficiency and lifetime. The criteria for traffic signals therefore focus on this aspect, with the aim of promoting the use of LED traffic signals by contracting authorities. They include wattage specifications for green and red lights.

Finally, it is important to note that these GPP criteria are applicable to the purchase of retrofitting or replacement lamps as required for existing lighting systems, as well as for new lighting systems. It does not however specify that retrofitting and replacements should be undertaken and that lamps that meet the specification outlined in the GPP criteria should only be purchased where the existing lighting system allows the use of such lamps. It would not be expected to have to replace the lighting system to be able to purchase lamps that meet the specified criteria. This wider change will be driven through the implementation of the

Ecodesign measures and the other policies at EU and Member State level for a gradual reduction in stock of certain lamp types as these measures take place. Obviously, given the lengthy life span of lighting systems it is important that the contracting authority considers this when purchasing new lighting systems and aims for the best available technology.

8 Recommended Core and Comprehensive GPP Criteria

It is proposed to set core and comprehensive criteria for street lighting and traffic signals. The proposed GPP criteria are designed to reflect the key environmental risks. This approach is summarised in the following table:

Key Environmental Impacts	GPP Approach
• Energy consumption, in all phases, but especially the use phase of street lighting and traffic signals • High energy consumption from the use of incandescent bulbs in traffic signals • Use of natural resources and materials and generation of waste (hazardous and non-hazardous) • Potential pollution of air, land and water due to the use of hazardous materials e.g. mercury • Light pollution from street lighting	• Purchase lamps with high lamp efficacy • Purchase efficient ballasts • Promote the purchase of lighting systems with a low energy consumption for the light provided • Promote the use of LEDs in traffic signals • Encourage the use of dimmable ballasts where circumstances allow • Promote lamps with a lower mercury content • Promote the use of luminaires that limit light emitted above the horizon

Please note that the order of impacts does not necessarily translate to the order of their importance.

As already outlined in this report, there is a lack of ecolabel standards available for street lighting, specifically HID lamps and traffic signals. The street lighting criteria are based on a detailed survey of the lamp market and on the Ecodesign requirements for HID lamps and associated ballasts, introduced by the Regulation (EC) No. 245/2009. The criteria for traffic signals are based on recent developments in relation to LEDs in traffic signals, to promote their wider use.

The core criteria focus on the key environmental impact of energy consumption in the use phase. The criteria use lamp efficacy standards for HID lamps, in particular high-pressure sodium lamp and metal halide lamps, to ensure only lamps with acceptable efficacy levels are purchased. Core criteria for ballast efficiency are also included for different lamp wattages. The core criteria also require lamp product information to be provided on a range of other parameters, which will inform the contracting authority about the product and allow them to compare different products.

The comprehensive criteria develop the lamp efficacy criteria further by using parameter values met by the best available products at the present time. Again these are for two types of

HID lamps, metal halide lamps and high-pressure sodium lamps. These criteria are more challenging than the core criteria and provide scope for contracting authorities to go beyond the minimum standards.

Ballast efficiency criteria are included in the comprehensive criteria, based upon the third stage requirements, which are due to come into effect in 2017.

Criteria are also included in relation to lamp survival rate and lamp lumen maintenance. By setting these at relatively high levels, it will ensure maintenance requirements for street lighting will be kept to a minimum, and will not need to be undertaken as frequently.

Where new lighting systems are being provided for outdoor public traffic areas, new GPP criteria for the energy efficiency of street lighting systems were developed based on detailed system modelling and on the street lighting energy efficiency criterion (SLEEC), which is a whole system indicator taking into account efficiency of the lamp, ballast and luminaire. It is used in the European lighting standard EN 13201-5 and takes into account aspects like lighting quality and dimming. These criteria allow for all aspects of the lighting system to be taken into account, including lamps, ballasts, luminaires, lighting control (dimming) and the design of the system to ensure that the light is directed to where it is required. Appendix 1 to this Report explains how the criteria were derived.

Additional comprehensive criteria relate to ballasts and luminaires. This includes product information, ballast efficiency and proportion of light emitted above the horizon. Again these will contribute towards a reduction in energy consumption, and will also affect other environmental impact, such as light pollution.

The previous GPP criteria included requirements for product information to be supplied with lamps, luminaires and ballasts. These are Ecodesign requirements from April 2012, and have therefore been removed from the GPP criteria because manufacturers will have to supply this information anyway. Some of the core and comprehensive criteria are derived from Eco-design measures, coming into effect in 2012 and 2017, and based on the lamp market analysis, more demanding targets are set in order to enable public procurers to signal to the market that they want to be striving for higher product performance credentials. Once the market has caught up, then the GPP criteria can be re-cast and revised to keep them forward looking ahead of regulatory measures. Comprehensive criteria are set at current best practice levels in the market, for those who want to buy at this higher level.

Relevant limits for mercury content are dealt with through the RoHS Directive and its amendments, and are potentially subject to change. The mercury content of HID lamps in the GPP specification is addressed through setting maximum contents based on the RoHS Directive and a detailed survey of various lamps currently available on the market.

A periodic review of GPP criteria would be expected in any case as the market and products will naturally develop over time, as technological advances are made. This will be the case for other product groups that are based on Ecolabel criteria, which are reviewed and revised on a regular basis.

The award criteria focus on promoting energy efficiency further, with criteria relating to the use of dimming ballasts and further reductions in the proportion of light emitted above the horizon.

For traffic signals the core and comprehensive criteria both focus on the key area of promoting the use of LEDs in traffic signals, which significantly reduce energy consumption and also reduce maintenance frequencies. Both the core and the comprehensive criteria require 100% of traffic signals purchased to be LEDs. This is based on the fact that whilst being far more energy efficient than traditional incandescent lamps, LEDs purchase price is decreasing on their continuously expanding market. To ensure energy consumption is minimised, both the core and comprehensive criteria for traffic signals include maximum nominal wattages for red, amber and green balls/arrows, for the same size balls/arrows as required under the scope from EN 12368:2006. These are based on a survey of the signals currently available on the market.

Full details of the proposed purchasing criteria are provided in the associated EU GPP criteria for this product group.

9 Verification Issues

An advantage of the proposed criteria is that verification would be fairly straightforward.

For new lighting systems, the lighting designer should provide a calculation showing the total and the average power consumed by the lighting system, including lamps, ballasts, sensors and controls, divided by the required road surface luminance or horizontal illuminance (depending on the road class) and the total area to be lit (including the roadway and, where relevant, footway). Where lighting can be dimmed, the average system power is the mean power consumed by the system averaged for periods with different consumptions. By dimming, the average system power was considered to be 80% of the installed system power.

The lighting designer should also show that the lighting meets the relevant performance standards in EN 13201, equivalent national standards or best practice guides, or those set by the public authority. Depending on the type of road and its requirements, these may include luminance or illuminance, uniformity, control of glare and lighting of surroundings.

The luminous efficacy and the lumen maintenance and survival factors for lamps are easy to verify because manufacturers are required to provide this information within their technical specifications or as a written declaration to demonstrate criteria are met. The same verification procedure applies to ballast efficiency and to the proportion of light emitted by luminaires above the horizon and the ingress protection rating of luminaires.

The selection criterion for lighting controls is easy to verify because the contracting authority can just check that the controls are present. The award criterion, for dimmable lighting, is more difficult to apply, as it requires a calculation based on data that would have to be obtained from the luminaire manufacturer.

Substitution can be an issue in lighting procurement. Sometimes installers can substitute lower quality luminaires which either produce less light or use more energy, even if they are claimed to be 'equivalent'. A contract performance clause has therefore been developed to require the installer to provide lighting equipment exactly as specified in the original design. Where substitution is inevitable because the originally specified products are unavailable, the contractor would have to show that the system would still meet the relative design criteria. The contracting authority needs to be aware of this and ensure that inferior products are not substituted.

10 Relevant European Legislation and Policies

This section details EU legislation that is relevant to street lighting and traffic lights, which is important in setting the background context in which standards and labels have been developed. Contracting Authorities should also be aware of and take into account any additional local, regional or national legislation pertinent to their situation with respect to a particular product or service. It should be noted that this list is complete as of May 2011.

10.1 Regulation (EC) No 245/2009 with regard to eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, repealing Directive 2000/55/EC, and Regulation 347/2010

This ongoing regulation implements Directive 2005/32/EC of the European Parliament and of the Council[61]. The original Directive (2005/32/EC) on the eco-design of energy using products was adopted in July 2005. This Directive has subsequently been repealed by Directive 2009/125/EC[62], which is a recast and increases the scope from energy using products to energy related products.

It provides clear EU wide rules for eco-design, aimed at avoiding disparities in regulation amongst individual Member States, which could impede the free movement of products within the internal market.

Implemented in three main and two intermediate stages, this directive gives details on the energy requirements related to the eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps. Table 7 below shows the eco-design requirements and the affected lighting products for HID lighting solutions.

This Regulation repeals the Directive on energy efficiency requirements for ballasts for fluorescent lighting 2000/55/EC.

[61] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:EN:PDF
[62] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:093:0003:0010:EN:PDF

Table 7. Overview of eco-design requirements and phased out lighting products *(source: CELMA and European Lamps Companies Federation[63])*

Stage	Product	HID lighting solutions
Stage 1 from 13 April 10	Lamps	Obligation to provide technical information on websites and in technical documentation
	Ballasts	
	Luminaires	
Intermediate stage from 13 October 10	Lamps	
	Ballasts	
	Luminaires	
Stage 2 from 13 April 12	Lamps	Standard HPS and lowest performing MH lamps (E27, E40 and PGZ12 base)
	Ballasts	Introduction of efficiency limit values for HID ballasts The energy efficiency of all HID ballasts must be indicated Marking on the ballasts with EEI = A3
	Luminaires	Technical information must be provided on websites and in documentation for luminaires above 2,000 lm
Intermediate stage from 13 April 15	Lamps	HPM lamps (E27, E40 and PGZ12) Retrofit/plug in HPS lamps (E27, E40 and PGZ12) designed to operate on HPM ballasts
	Ballasts	
	Luminaires	
Stage 3 from 13 April 17	Lamps	MH lamps not meeting minimum requirements ≤ 405 W (E27, E40 and PGZ12)
	Ballasts	Higher limit values than in stage 2, as a function of lamp wattage The energy efficiency of all HID ballasts must be indicated Marking on the ballasts with A2
	Luminaires	All luminaires must be compatible with stage 3 ballasts

[63] http://www.celma.org/archives/temp/CELMA_EcoDesign_(SM)258_CELMA_ELC_Tertiary_Lighting_Guide_2nd_Edition_FINAL_December2010.pdf

Regulation 245/2009/EC has subsequently been revised by Regulation 347/2010[64], dated 21st April 2010. The purpose of this amendment is to ensure unidentified impacts on the availability and performance of the products covered by Regulation 245/2009 are avoided and improve coherence regarding the product information requirements between this Regulation and Regulation 244/2009, which covers non directional household lamps.

10.2 Directive 2006/32/EC on energy end-use efficiency and energy services

The aim of this Directive[65] is to enhance the cost-effective improvement of energy end-use efficiency across Europe. It provides the necessary indicative targets and mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections that impede the efficient end use of energy, and creates the conditions for the development and promotion of a market for energy services and for the delivery of other energy efficiency improvement measures to final consumers.

Member States will be required to save at least an additional 1% of their final energy consumption each year from 2008 for nine years. Within these targets are savings targets for the public sector of 1.5%[66] as it is expected that a particular contribution will have to be made by this sector, a large part of which will be as a result of public procurement.

The Directive in particular promotes energy efficient public procurement, and street lighting is specifically mentioned in Annex V of the Directive.

On 8 March 2011, the European Commission has adopted the Communication "Energy Efficiency Plan 2011", which aims at closing the gap in reaching the EU's 20% energy saving target as well as at helping to realise the 2050 vision of a resource efficient and low carbon economy[67]. It also aims at increasing energy independence and security of supply. Fully implementing this plan should deliver important energy savings: it is estimated that the actions of the public sector and the new minimum efficiency requirements for appliances should yield savings of up to 100 Mtoe and that comparable savings can also be expected from measures in the transport sector and from energy savings for consumers from their energy suppliers.

Directive 2006/32/EC will be repealed by a new Directive on energy efficiency[68], which was proposed by the European Commission on 22 June 2011, as a new set of measures for increased energy efficiency aimed at stepping up Member States' efforts to use energy more efficiently at all stages of the energy chain – from the generation of energy and its distribution to its final consumption. The new Directive establishes a common framework for the promotion of energy efficiency within the Union in order to ensure the achievement of the Union's target of 20% primary energy savings by 2020 and to pave the way for further energy

[64] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:104:0020:0028:EN:PDF
[65] OJ L 114, 27.4.2006, p. 64–85 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0085:EN:PDF
[66] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/03/1687&format=HTML&aged=0&language=EN&guiLanguage=en
[67] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52011DC0109:EN:HTML:NOT
[68] http://ec.europa.eu/energy/efficiency/eed/doc/2011_directive/com_2011_0370_en.pdf

efficiency improvements beyond that date. It lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of national energy efficiency targets for 2020.

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

The WEEE Directive[69] aims to control the increasing amount of waste electrical and electronic equipment generated in Europe, reducing the environmental burden on conventional disposal routes and improving recycling rates. The RoHS Directive[70], discussed below, is also relevant here.

The Directive requires electrical and electronic equipment to be taken to a suitable authorised treatment facility at the end of its life so that it can be treated/dismantled and materials recovered for recycling where possible. The Directive outlines minimum requirements for the treatment and recovery of WEEE.

The WEEE Directive also requires products to be labelled, in order to identify them as EEE, with the aim of minimising the wrong disposal of WEEE. Where it is not feasible to put the label on the actual product it should be included in the documentation accompanying the product.

This Directive therefore deals with many of the end-of-life environmental impacts of electrical and electronic equipment, with some exemptions listed in annexes.

In December 2008, the European Commission proposed to revise the directives on electrical and electronic equipment in order to set a new binding target for the collection of electrical and electronic equipment. The Commission proposes to differentiate the targets by setting mandatory collection targets equal to 65% of the average weight of electrical and electronic equipment placed on the market over the two previous years in each Member State. The recycling and recovery targets of such equipment now include the re-use of whole appliances, and weight-base targets will increase by 5%[71].

The Council reached Political Agreement on 14 March 2011 and more information regarding the latest status and schedule of this recast can be found on the European Parliaments website[72].

[69] OJ L 37, 13.2.2003, p. 24–39 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:EN:HTML
[70] OJ L 37, 13.2.2003, p. 19–23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML
[71] http://ec.europa.eu/environment/waste/weee/index_en.htm
[72] http://www.europarl.europa.eu/oeil/file.jsp?id=5723502

10.4 Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

The RoHS Directive[73] prevents the use of certain hazardous materials in new electrical and electronic equipment (EEE) placed on the market from 1 July 2006 onwards. This will limit the impact of the EEE at the end of its life and it also ensures harmonisation of legislation on the use of hazardous materials in EEE across all Member States.

Electrical and Electronic Equipment must not contain the following substances; lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). There are some exemptions and limit values listed in the Annex to the Directive for some equipment where it is understood that one or more these substances is required for their functioning and no economically viable alternatives exist in sufficient quantity at present. Therefore, some of these substances may still be found in some electrical and electronic equipment.

The Annex to this Directive has been replaced by the Annex to the Decision 2010/571/EU[74], altering the list of exclusions and limit values. A number of these exemptions relate to lamps, and in particular Exemptions 1 to 4 allow the use of mercury in fluorescent and discharge lamps, whereas Exemption 5 allows the use of lead in glass of lamp tubes. These exemptions are required, as the use of substances such as mercury is needed for the product to operate effectively.

In May 2011, the Council revised the RoHS Directive to extend protection from dangerous chemicals to more electrical appliances and improve the safety of products such as mobile phones, refrigerators and electronic toys[75]. The review extends the scope of the ban to more products, while harmonising it across the EU: the ban will now in principle apply to all electrical and electronic equipment as well as to cables and spare parts. The revised Directive also obliges the Commission to regularly review and adapt the list of restricted substances according to a number of criteria, which means that further substances in electrical and electronic equipment may be banned in future. Energy-saving light bulbs are temporarily exempted from the directive.

Information regarding the latest status and schedule of this recast can be found on the European Parliament's website[76].

10.5 The CLP Regulation (EC) No 1272/2008

The Regulation of 16 December 2008[77] on classification, labelling and packaging of substances and mixtures entered into force on 20 January 2009 and will ultimately replace the current rules on classification, labelling and packaging of substances (Directive 67/548/EEC)

[73] OJ L 37, 13.2.2003, p. 19–23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML
[74] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:251:0028:0034:EN:PDF
[75] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/envir/122249.pdf
[76] http://www.europarl.europa.eu/oeil/FindByProcnum.do?lang=en&procnum=COD/2008/0240
[77] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF

and preparations (Directive 1999/45/EC). Substance classification and labelling must all be consistent with the new rules by 1 December 2010 and for mixtures 1 June 2015.

The Regulation aims to ensure a high level of protection of human health and the environment, as well as the free movement of chemical substances, mixtures and certain specific articles, whilst enhancing competitiveness and innovation. This should be achieved by ensuring that the same hazards will be described and labelled in the same way all around the world.

10.6 Regulation (EC) 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency

This Regulation[78] aims to protect human health and the environment, by controlling hazardous chemicals.

The REACH Regulation came into force on 1 June 2007 and provides an improved and streamlined legislative framework for chemicals in the EU. It places the responsibility for assessing and managing the risks posed by chemicals and providing safety information to users in industry instead of public authorities, promotes competition across the internal market and innovation. Manufacturers are required to register the details of the properties of their chemical substances on 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 develop.

10.7 Directive 2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC

The Electromagnetic Compatibility Directive was adopted on 15 December 2004 and repealed Directive 89/336/EEC as from 20 July 2007. This Directive[79] regulates the electromagnetic compatibility of equipment. It aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility and not to interfere with or be disturbed by other electrical equipment.

Before equipment is placed on the market (including both apparatus and fixed installations) they must be shown to meet the requirements set out in the EMC Directive.

[78] OJ L 396, 30.12.2006, p. 1–849 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF
[79] OJ L 390, 31.12.2004, p. 24–37 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024:0037:EN:PDF

10.8 Low Voltage Directive (LVD) 2006/95/EC on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits

This Directive[80] covers electrical equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current (AC) and between 75 and 1500 V for direct current (DC). These voltages refer to the input or output voltage and not to those found inside the equipment.

The Directive's main objectives are to ensure a high level of protection for the European public and that these products enjoy a single market within the EU. For electrical equipment within its scope, the Directive covers all health and safety risks, thus ensuring that electrical equipment is safe in its intended use.

10.9 UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP)

The Convention[81] aims to reduce and prevent air pollution. Of particular interest in relation to HID lamps is the Protocol on Heavy Metals (1998), which entered into force on 29th December 2003. This protocol targets mercury, cadmium and lead. It introduces measures to reduce emissions of these heavy metals, for example management measures for mercury containing products, such as electrical components.

10.10 The EU Climate and Energy Package

In March 2007 the EU's leaders endorsed an integrated approach to climate and energy policy that aims to combat climate change and increase the EU's energy security while strengthening its competitiveness. They committed Europe to transforming itself into a highly energy-efficient, low carbon economy.

To kick-start this process, the EU Heads of State and Government set a series of demanding climate and energy targets to be met by 2020, collectively known as the 20-20-20 targets[82]. These are:

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

[80] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:en:PDF
[81] http://www.unece.org/env/lrtap/
[82] http://ec.europa.eu/environment/climat/climate_action.htm

10.11 Directive 89/106/EEC on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products

The Construction Products Directive[83] aims to create a single market for construction products, through the use of CE Marking. It defines the Essential Requirements of construction works (buildings, civil engineering works) which indirectly determines the requirements for construction products (in function of the works design and the climatic and geological conditions in the place where the construction works are situated).

Manufacturers of construction products must declare their mechanical strength and stability, fire safety, health and environment effects, safety of use, sound nuisance and energy economy, if EU or national regulatory requirements exist. Under the Directive, the Commission may give a mandate to standardisation organisations such as CEN to develop standards in consultation with industry. A list of the adopted standards can be found on the European Commission's website[84]. Where harmonised standards are not available, existing national standards apply.

Directive 93/68/EEC[85] amended the Construction Products Directive 89/106/EEC on the approximation of laws, regulations and administrative provisions of the Member States relating to Construction Products.

The Commission has adopted a proposal to replace Council Directive 89/106/EEC by a Regulation with the aim to better define the objectives of Community legislation and make its implementation easier[86]. It now includes a specific extra essential requirement related to the sustainable use of natural resources, stating that:

"The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and ensure the following:

(a) Recyclability of the construction works, their materials and parts after demolition.
(b) Durability of the construction works.
(c) Use of environmentally compatible raw and secondary materials in the construction works."

10.12 Directive 2010/30/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products

On 19 May 2010, the European Commission adopted this Directive[87], which establishes a framework for the harmonisation of national measures on end-user information, particularly by means of labelling and standard product information, on the consumption of energy and

83 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0106:en:HTML
84 http://ec.europa.eu/enterprise/newapproach/standardization/harmstds/reflist/construc.html
85 OJ L 220, 30.8.1993, p. 1–22 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0068:EN:HTML
86 http://ec.europa.eu/enterprise/construction/index_en.htm
87 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0001:0012:EN:PDF

where relevant of other essential resources during use, and supplementary information concerning energy-related products, thereby allowing end-users to choose more efficient products. This Directive applies to energy-related products which have a significant direct or indirect impact on the consumption of energy and, where relevant, on other essential resources during use.

Directive 98/11/EC[88] currently refers to the energy labelling scheme for general lighting products and applies to household electric lamps supplied directly from the mains (filament and integral compact fluorescent lamps), and to household fluorescent lamps (including linear, and non-integral compact fluorescent lamps), even when marketed for non-household use. It is not applicable to most forms of street lighting. It implements the requirements of the previous Council Directive 92/75/EEC[89] on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances. The label introduced by Directive 98/11/EC includes specific information, such as the energy efficiency class of the lamp, the luminous flux of the lamp in lumens, the input wattage of the lamp and the average rated life of the lamp in hours. The Directive also sets out how the energy efficiency class of a lamp will be determined.

A new Commission Regulation (EU) is planned to repeal Directive 98/11/EC and to implement Directive 2010/30/EU with regard to energy labelling of general lighting lamps and household luminaires[90]. The new Regulation extends the existing label to all professional lamps, including LEDs and high-intensity discharge (HID) lamps.

11 Ecolabels & Existing Standards and Other Information Sources

11.1 Ecolabels for Street Lighting

There are no specific Ecolabels at present for street lighting or their lamps although several countries have labels and/or minimum energy performance standards for various components of street lighting, focussing mainly on the ballasts. The Ecolabels that do exist are by far and away applicable to fluorescent tubes and compact fluorescent lamps, and not HID lamps.

There are various Ecolabels covering LED lamps as well, but these however do not fall within the product scope of the current GPP background report for street lighting.

The HID lamps used for street lighting are currently affected by eco-design requirements only, implemented through Regulation (EC) No. 245/2009 as described in detail in section 10.1 above.

[88] OJ L 71, 10.3.1998, p. 1–8 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:071:0001:0008:EN:PDF

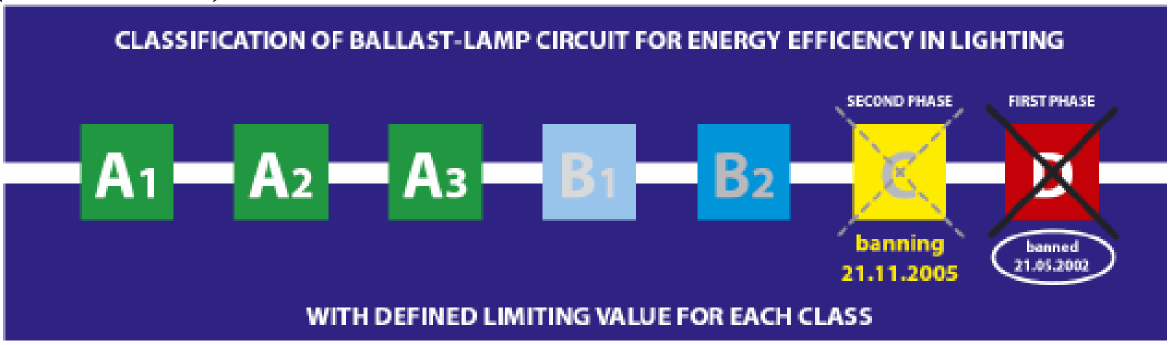
[89] OJ L 297, 13.10.1992, p. 16–19 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0075:EN:HTML

[90] http://ec.europa.eu/energy/lumen/professional/legislation/index_en.htm

11.1.1 Energy Efficiency Index for Ballasts – CELMA, Europe

CELMA, the European lighting trade body, have developed an Energy Efficiency Index (EEI) for ballast-lamp combinations[91] in accordance with Directive 2000/55/EC on energy efficiency requirements for ballasts for fluorescent lighting. This Directive is related to the eco-design directive and demonstrates the kind of labelling available for lighting products. The Index indicates how efficient the output is from a ballast-lamp combination for fluorescent lighting normally used in office situations. It is defined as the corrected total input power of the ballast-lamp circuit. There are seven classes from A1 to D, of which classes C and D have already been phased out, as pictured below in Figure 10.

Figure 10. CELMA Ballast-lamp energy efficiency classes
(source: CELMA)



The classification is independent of technology but classes A1, A2 and A3 relate to electronic ballasts which are more energy efficient than magnetic ballasts, which currently typically fall into classes B1 and B2 (classes D and C were phased out in 2002 and 2005 by the Directive 2000/55/EC). Category A1 is intended for dimmable ballasts and lamps to operate at lower powers.

11.1.2 Korea Ecolabel - Ballasts for Sodium Lamps or Metal Halide Lamps

Ballasts can consume a significant amount of electricity over and above the lamp's consumption. The Korean ecolabel[92] applies to magnetic ballasts for sodium lamps or metal halide lamps with both rated input voltage and rated second voltage of 1000 V or less.

The energy consumption criteria are highlighted in Table 8 below.

In order to extend product life, it shall have the structure to replace some parts (including an igniter at least). The power-factor of the product shall be 90% or higher.

[91] CELMA Ballast Guide, www.celma.org/archives/temp/CELMA_Ballast_Guide.pdf
[92] http://el.keiti.re.kr/eng/index.do

Table 8. Energy Consumption Criteria in the Korean Ecolabel for Ballasts

Class	Electric consumption rate for ballast itself (%)	Change rate of lamp power (%)	
		90% of rated input voltage	110% of rated input voltage
Ballasts for sodium lamps	≤10 (≤15, in case of current transformer type)	≤87	≤113
Ballasts for metal halide lamps	≤8 (≤15, in case of current transformer type)	≤87	≤113

11.1.3 General Lighting Products

There are a number of Ecolabels that are applicable to types of lighting outside the scope of this GPP product group. In particular these cover general lighting products for use in domestic and small commercial situations and focus mainly on compact fluorescent lamps. Examples of these Ecolabels are given here for context:

- EU Ecolabel for light bulbs implemented by Decision 2011/331/EU[93]
- German Blue Angel eco-label for lamps[94]
- German Blue Angel eco-label for electronic ballasts for fluorescent lamps[95]
- US Energy Star labels for compact fluorescent lamps[96] and for LED light bulbs[97]
- US Energy Star labels for light fixtures (luminaires)[98]

These Ecolabels focus on key environmental aspects that are also identified in Section 4 of this report, including lamp efficacy, lifetime and materials. The proposed GPP criteria are consistent with the approach taken by these Ecolabels by including criteria that cover the same key environmental aspects.

11.2 Ecolabels for Traffic Signals

11.2.1 Energy Star for Traffic Signals

The Energy Star Traffic Signal[99] specifications are based on the characteristics of low energy consuming LED lamps, although other technologies that meet the requirements are not excluded. The US Congress passed a minimum federal efficiency standard in 2005 on that all traffic signals must meet the same standards as the Energy Star. As such all new traffic signals manufactured after 1st January 2006 have to meet these criteria and as a consequence the Energy Star Traffic Signal Specification was suspended on 1 May 1, 2007. Table 9 gives the Energy Star criteria for traffic signals.

[93] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:148:0013:0019:EN:PDF
[94] http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=560
[95] http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=42
[96] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LB
[97] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=ILB
[98] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LF
[99] http://www.energystar.gov/ia/partners/product_specs/eligibility/traffic_elig.pdf

The sizes of signals to which these relate i.e. 200mm and 300mm is consistent with the product scope for traffic signals taken from EN 12368, and detailed in Section 2.4. The wattage requirements for the Combination Walking Man/Hand, Walking Man and Orange Hand are not included as these are more specific to the USA market and not Europe.

Amber LED modules are not included in the Energy Star requirements as at the time of publication available amber LED modules were not Institute of Transportation compliant (see Point 6 in the Energy Star Specifications). The subsequent federal efficiency standard, which replaced the Energy Star requirement, does not include standards for amber modules either.

Table 9. Energy-efficiency criteria for Energy Star qualified traffic signal modules

Module Type	Maximum Wattage (74ºC)	Nominal wattage (at 25ºC)
12” Red Ball (300mm)	17	11
8” Red Ball (200mm)	13	8
12” Red Arrow (300mm)	12	9
12” Green Ball (300mm)	15	15
8” Green Ball (200mm)	12	12
12” Green Arrow (300mm)	11	11
Combination Walking Man/Hand	16	13
Walking Man	12	9
Orange Hand	16	13

Criteria are given for operation at 74°C as well as 25°C. For the GPP criteria for Europe it is proposed not to include requirements for performance at 74°C. This is because in the milder European climates traffic signals will not normally be operating at such a high temperature, and no European standards require this test.

Whilst the Energy Star requirements are now mandatory in the USA, there are two key aspects in relation to the development of GPP criteria for traffic signals in Europe. Firstly that LED traffic signals that meet an acceptable standard are purchased, and secondly the promotion of LED traffic signals instead of incandescent lamps. This will be achieved by setting a requirement to purchase 100% LED traffic signals as part of the GPP criteria.

The use of the Energy Star requirements as guidance allows a quantitative aspect to be included in the GPP criteria. In addition the cost of LED traffic signals needs to be considered when developing GPP criteria. As Section 5 in this report shows, LED traffic signals are initially more expensive than incandescent lamps.

A market survey helped to increase efficiency targets for LED traffic signals and furthermore to include specific GPP efficiency criteria for amber modules. More details can be found in the document providing the EU GPP Criteria for Street Lighting & Traffic Signals.

11.2.2 Netherlands GPP Criteria for Traffic Management Installations

Recent developments in the Netherlands have seen the development of criteria for traffic management installations, which encompasses traffic lights/signals, traffic information systems and street and ship signage.

Development of the criteria by SenterNovem[100] started in June 2007, with the final criteria published in August 2008 after a period of consultation. The criteria are concerned with energy efficiency (such as energy efficient and dimmable lighting in lit systems for example), material use, as well as sustainable design and traffic management systems. For example they state that ‘class II’ energy efficient light sources must be installed in new systems, including LED lamps. Class II equates to a maximum of 15 watts power. This ties in with the Energy Star values above, although the Energy Star criteria have more flexibility on size and colour of lamp as well as temperature and are therefore considered to have wider application. In addition to Class II light sources, the less efficient Class I light sources have a maximum of 50 Watts power. Class III light sources, which will be more efficient than both Class I and Class II, are currently under development.

The SenterNovem criteria state for sustainable material use that there is no advantage to be found in LCA studies for any particular material type. The main environmental gains to be had are in recycling and reusing the materials, in particular poles and mounts. Sustainable material use is handled through a qualitative award criterion asking for a weighted approach to reducing the use of raw materials, energy use in manufacture, and maximising product lifetime, durability and recyclability. The more energy that is saved and the lower the environmental impact, the more points are awarded to the product.

Other criteria that were proposed included, for example, standardising components and limiting the light given out to the local surroundings, but these were rejected during the consultation phase as being unsuitable for various reasons, such as maintaining suitable levels of light for health and safety reasons.

11.3 Slovene Light Pollution Law

In 2007 Slovenia adopted a law aimed at tackling light pollution. The law requires that 0% of the output of a luminaire should shine above the horizon (90°).

There are a few exceptions where other conditions are met, for example for some security lighting, cultural lighting, for decorative illumination between 10th December and 15th January and transport signalling. With regards to street lighting, the law means that all luminaires must not emit any light above the horizontal plane. This requires the use of cut-off luminaires. The law also requires that for public roads and highways the yearly consumption per head of population shall not exceed 5.5kWh.

[100] http://www.senternovem.nl/duurzaaminkopen/Criteria/gww/verkeersregelinstallaties.asp

11.4 European Standards

There are a number of standards, listed in Appendix 3, which are relevant to the procurement and installation of street lighting and traffic signals. These do not necessarily cover environmental issues, for example they include safety aspects and product specifications, however it is useful to be aware of their existence. Manufacturers and contractors will apply these where necessary in the design, production and installation of these products.

Contracting authorities should check to ensure that when implementing the GPP criteria, all other requirements, including legislative or within European standards are met as required.

11.5 Studies and Other Sources of Information

- European Commission's GPP Training Toolkit:
  http://www.ec.europa.eu/environment/gpp

- European Lamp Companies Federation:
  www.elcfed.org

- The Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires (CELMA):
  www.celma.org

- The International Commission on Illumination (CIE):
  www.cie.co.at

- Institution of Lighting Professionals:
  www.theilp.org.uk

- Buy Bright Initiative:
  http://buybright.elcfed.org/index.php?page=21

- UK Energy Research Centre:
  www.ukerc.ac.uk

- Quick Hits, Traffic Signal, UK ERC, December 2006
  http://www.ukerc.ac.uk/Downloads/PDF/06/0612_Traffic_Signals_QH.pdf

- Ecological Consequences of Artificial Night Lighting, Edited by Catherine Rich and Travis Longcore, Published 2005

- Guidance Notes for the Reduction of Obtrusive Light:
  http://www.ile.org.uk/uploads///File/02_lightreduction.pdf

- Information on renewable raw materials and bio-based products
  http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative/biobased-products/index_en.htm

Appendices

Appendix 1 - Setting target values for energy efficiency

This appendix describes how the criteria for the energy efficiency of new street lighting systems were derived.

The approach adopted was based on the street lighting energy efficiency criterion (SLEEC) as a whole system indicator taking into account efficiency of the lamp, ballast and luminaire[101]. The formula for the SLEEC indicator depends on the photometric measure used in the calculation of the street lighting system for specific road classes.

For illuminance-based road classes, the SLEEC indicator is given by

$SE = P / (E_{h,av} \cdot A)$ $\qquad$ $W/(lux \cdot m^2)$

where P is the system power consumed by the entire lighting system, including lamps, ballasts, sensors and controls, $E_{h,av}$ is the average horizontal illuminance and A is the road surface.

For luminance-based road classes, the SLEEC indicator is given by

$SL = P / (L_{av} \cdot A)$ $\qquad$ $W/(cd/m^2 \cdot m^2)$

where P is the system power consumed by the entire lighting system, including lamps, ballasts, sensors and controls, L_{av} is the average road surface luminance and A is the road surface.

An energy label using the SLEEC indicator and the standard EU A-G energy label format was developed in the Netherlands. Using the SLEEC values can encourage dimming and punish oversizing. For example, by not using the real average illuminance or luminance values, but the lower limit of the lighting class that is used to design the system, norm-SLEEC formulas are created. In the design any oversizing of the scheme then results in a higher value of SE or SL and lower label.

[101] Energy Labeling Guide for Public Lighting, NSVV, March 2009. Available from: http://www.nsvv.nl/download/download.aspx?id=8c802b05-7ab5-4610-a90b-a1d40db54576

The energy label categories A to G with target ranges for the SLEEC are given in the table below.

Label	SE in W/(lux·m^2)	SL in W/(cd/m^2·m^2)
A	0.000 - 0.014	0.075 - 0.224
B	0.015 - 0.024	0.225 - 0.374
C	0.025 - 0.034	0.375 - 0.524
D	0.035 - 0.044	0.525 - 0.674
E	0.045 - 0.054	0.675 - 0.824
F	0.055 - 0.064	0.825 - 0.974
G	0.065 - 0.074	0.975 - 1.124

The following step of the approach was to build models of multiple street lighting arrangements using multiple road classes and highly efficient HID lamps of various wattages. For each wattage, lamps with the highest luminous efficacies were chosen in order to compare the results with the SLEEC-based energy efficiency labels. ME/MEW and CE road classes were considered in the calculations based on luminance and illuminance, respectively. Models of optimized street lighting arrangements were developed by the use of the specialized Dialux software for a conventional double carriageway with two standard 3.5m wide lanes per way. For each lamp wattage, double row opposing poles arrangements were considered in order to achieve the luminous parameters required by the minimum and maximum road class which could be met by the street lighting arrangement.

The average system power was calculated as the mean power consumed by the system averaged for periods with different consumptions. By dimming, the average system power was considered to be 80% of the installed system power. The SLEEC and norm-SLEEC indicators, along with the SLEEC labels, were determined for each street lighting arrangement and the results of the study are summarised in the following two tables.

Luminance-based calculation: ME/MEW classes

Lamp type and wattage	Average luminance (cd/m^2)	Target		SL W/(cd/m^2·m^2)	SLEEC Label	Norm SL W/(cd/m^2·m^2)	Norm SLEEC Label
		Class	Luminance				
MH 45W	0.89	ME4a	0.75	0.551	D	0.523	C
MH 45W	1.34	ME3a	1	0.549	D	0.589	D
MH 60W	0.84	ME4a	0.75	0.456	C	0.408	C
MH 60W	2.11	ME1	2	0.454	C	0.383	C
MH 90W	0.86	ME4a	0.75	0.470	C	0.431	C
MH 90W	2.07	ME1	2	0.455	C	0.377	C
MH 140W	0.98	ME4a	0.75	0.496	C	0.518	C
MH 140W	2.46	ME1	2	0.444	C	0.437	C
HPS 50W	0.83	ME4a	0.75	0.525	C	0.465	C
HPS 50W	1.64	ME2	1.5	0.531	D	0.465	C

HPS 70W	0.83	ME4a	0.75	0.459	C	0.406	C
HPS 70W	2.5	ME1	2	0.457	C	0.457	C
HPS 100W	0.88	ME4a	0.75	0.411	C	0.386	C
HPS 100W	2	ME1	2	0.407	C	0.326	B
HPS 150W	1.37	ME3b	1	0.392	C	0.429	C
HPS 150W	2.12	ME1	2	0.380	C	0.322	B
HPS 250W	2.38	ME3b	1	0.331	B	0.631	D
HPS 250W	4.95	ME1	2	0.319	B	0.631	D
HPS 400W	4.62	ME3b	1	0.298	B	1.100	G
HPS 400W	5.2	ME1	2	0.297	B	0.619	D

Illuminance-based calculation: CE classes

Lamp type and wattage	Average illuminance (lux)	Target		SE W/(lux·m^2)	SLEEC Label	Norm SE W/(lux·m^2)	Norm SLEEC Label
		Class	Illuminance				
MH 45W	38	CE1	30	0.028	C	0.028	C
MH 45W	7.5	CE5	7.5	0.034	C	0.027	C
MH 60W	30	CE1	30	0.029	C	0.023	B
MH 60W	8	CE5	7.5	0.029	C	0.025	C
MH 90W	33	CE1	30	0.029	C	0.025	C
MH 90W	7.7	CE5	7.5	0.035	C	0.028	C
MH 140W	32	CE1	30	0.033	C	0.028	C
MH 140W	8.7	CE5	7.5	0.040	D	0.037	D
HPS 50W	32	CE1	30	0.034	C	0.029	C
HPS 50W	7.6	CE5	7.5	0.038	D	0.031	C
HPS 70W	32	CE1	30	0.030	C	0.025	C
HPS 70W	7.5	CE5	7.5	0.035	D	0.028	C
HPS 100W	32	CE1	30	0.027	C	0.023	B
HPS 100W	10.3	CE5	7.5	0.030	C	0.033	C
HPS 150W	36	CE1	30	0.027	C	0.026	C
HPS 150W	9.4	CE5	7.5	0.036	D	0.036	D
HPS 250W	33	CE1	30	0.031	C	0.027	C
HPS 250W	11	CE5	7.5	0.038	D	0.044	D
HPS 400W	49	CE1	30	0.025	B	0.032	C
HPS 400W	13.7	CE5	7.5	0.037	D	0.054	E

Based on the results of the study above, GPP criteria were derived for each road class by choosing targets which can still be met using a choice of lamps.

Where a new lighting system is being provided for a traffic route (classes ME or MEW in EN 13201-1), the maximum energy efficiency indicator, given by the average system power divided by the required road surface luminance and the area to be lit, must not exceed the following values:

Lamp Wattage (W)	Maximum energy efficiency indicator in W/(cd/m^2·m^2)
W ≤ 55	0.824
55 < W ≤ 155	0.674
155 < W	0.524

Where a new lighting system is being provided for a conflict area such as a road intersection or shopping street, or a residential road, pathway or cycle track (classes CE or S in EN 13201-1), the maximum energy efficiency indicator, given by the average system power divided by the required horizontal illuminance and the area to be lit, must not exceed the following values:

Required illuminance (lux)	Maximum energy efficiency indicator in W/(lux·m^2)
E ≤ 15 lux	0.044
E > 15 lux	0.034

Appendix 2 – Overview of lamp survey results

This appendix presents the survey results of the two main types of lamps used for street lighting and of LED traffic lights. A total number of 173 high-pressure sodium and metal halide lamps produced by 5 different manufacturers and having different wattages between 35W and 400W. The results are divided by lamp category according to the classification introduced in the Regulation (EC) No. 245/2009.

High-pressure sodium (HPS) lamps, Ra ≤ 60 – total number 74 lamps					
Lamp Wattage	Bulb type	Colour rendering index (Ra)	Lamp efficacy (lm/W)	Lifespan (hours)	Mercury content (mg)
35W	Clear	21-22	64-66	16,000-24,000	31.9
	Coated	22	60	16,000	n/c
50W	Clear	22-25	75-83	24,000-40,000	12-21.2
	Coated		68-74		
70W	Clear	15-25	90-93	24,000-50,000	12-21.2
	Coated	16-25	79-83		
100W	Clear	20-25	90-107	24,000-60,000	0-26.6
	Coated	22-25	88-107		16-26.6
150W	Clear	18-25	100-117	24,000-60,000	0-26.6
	Coated		96-114	24,000-50,000	0-32.9
200W	Clear	22	110	24,000	n/c
250W	Clear	22-25	110-130	24,000-55,000	0-46.4
	Coated		104-121		0-32.9
310W	Clear	22	120	24,000	n/c
400W	Clear	22-26	120-140	24,000-55,000	0-38.3
	Coated	22-25	117-136.5		0-31.7
68W*	Coated	25	68	28,000	16.1
110W*	Coated	24-25	76-113	14,000-28,000	19.8-22
150W*	Coated	20	79	24,000	n/c
220W*	Coated	20-25	87-93	14,000-26,000	19.9-41
350W*	Coated	20-25	87-101	14,000-26,000	19.9-41

* Retrofit lamps designed to operate on HPM ballast
n/c = not communicated by the manufacturer

High-pressure sodium (HPS) lamps, Ra > 60 – total number 9 lamps					
Lamp Wattage	Bulb type	Colour rendering index (Ra)	Lamp efficacy (lm/W)	Lifespan (hours)	Mercury content (mg)
70W	Clear	60	64.3	8,600	32.7
100W	Clear	60	80	15,000	32.7
150W	Clear	65	80-87	15,000-24,000	19-32.7
	Coated		81	24,000	19
250W	Clear	65	80-93	15,000-24,000	38-40.9
	Coated		88	24,000	38
400W	Clear	65	90-95	15,000-24,000	38-40.9
	Coated		90	24,000	38

Metal halide (MH) lamps, Ra ≤ 80 – total number 61 lamps					
Lamp Wattage	Bulb type	Colour rendering index (Ra)	Lamp efficacy (lm/W)	Lifespan (hours)	Mercury content (mg)
45W	Clear	60	96	12,000-18,000	2
50W	Clear	70	100	16,000	1.1
60W	Clear	70	113-115	12,000-18,000	2
70W	Clear	70-77	75-105	6,000-16,000	2-8
	Coated	74	64	9,000	12
90W	Clear	65-70	116	12,000-30,000	1.6
100W	Clear	70	109	16,000	3.5
	Coated	73	79	9,000	11.2
140W	Clear	70	118	12,000-30,000	2.83
150W	Clear	70-75	86-111	9,000-16,000	4-16.3
	Coated	76	77	9,000	16.3
200W	Clear	65-68	105	15,000	n/c
	Coated	70	100		
250W	Clear	65-70	84-100	9,000-20,000	29.4-36
	Coated	66-70	104-121		28-47
350W	Clear	65-68	106	20,000	n/c
	Coated	70	100-101		
400W	Clear	58-70	84-118	9,000-20,000	27-55.2
	Coated	68-70	78-113		48.5-70
50W*	Coated	75	78	18,000	4.8
70W*	Coated	78	79	18,000	5.1

* Retrofit lamps designed to operate on HPS ballast
n/c = not communicated by the manufacturer

Metal halide (MH) lamps, Ra > 80 – total number 29 lamps					
Lamp Wattage	Bulb type	Colour rendering index (Ra)	Lamp efficacy (lm/W)	Lifespan (hours)	Mercury content (mg)
35W	Clear	83-90	92-95	15,000	3-5
50W	Clear	80	111	18,000	8

70W	Clear	82-94	93-100	15,000-20,000	5.8-7
	Coated	82	81	15,000	5
90W	Clear	80	n/c	n/c	1.4
100W	Clear	82-85	84-104	6,000-18,000	7-8.5
	Coated	83	87	15,000	7.3
140W	Clear	80	n/c	n/c	2
150W	Clear	80-96	99-106	15,000-20,000	12-17.2
	Coated	95	81	15,000	12
250W	Clear	81-91	97-104	12,000-24,000	19
	Coated	80	90	24,000	
400W	Clear	80-95	100-103	12,000-20,000	30-38.7
	Coated	80	97	20,000	30
50W*	Clear	80	78	18,000	4.8
70W*	Clear	83-90	85-88	18,000	4.58-6.1
	Coated	81	82		4.58
70W**	Clear	80	70	14,000	0
100W*	Clear	83	91	20,000	10.4
	Coated	80	87	20,000	10.4
110W**	Clear	80	70	10,000	0
150W*	Clear	85-90	83-95	20,000	12-16
	Coated	82-85	86-91		15-16
250W*	Clear	85	82-92	12,000-20,000	3.4-30
400W*	Clear	85	87	20,000	4.8

* Retrofit lamps designed to operate on HPS ballast
** Retrofit lamps designed to operate on HPM ballast
n/c = not communicated by the manufacturer

Lamp parameters were then compared to the previous GPP criteria and to the EU eco-design requirements for Stage 2, 2012. The following tables show the number of lamps meeting the different requirements for each lamp category according to the classification introduced in the Regulation (EC) No. 245/2009. Results were divided into meeting all global requirements, luminous efficacy requirements, lamp lumen maintenance requirements, lamp survival requirements and mercury contents requirements, where applicable. There are no mercury content requirements for metal halide (MH) lamps.

High-pressure sodium (HPS) lamps, Ra ≤ 60							
		No. of lamps meeting all requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	8	6	9	0	0	**23**
	Comprehensive	4	3	1	0	0	**8**
	Award	4	1	0	0	0	**5**
Eco-design requirements Stage2, 2012		8	6	9	0	0	**23**
Unknown, insufficient data		3	0	0	6	0	**9**
None		16	9	4	13	0	**42**
Total		**27**	**15**	**13**	**19**	**0**	**74**

High-pressure sodium (HPS) lamps, Ra ≤ 60							
		No. of lamps meeting luminous efficacy requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	12	9	9	6	0	**36**
	Comprehensive	7	3	2	0	0	**12**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		12	9	9	6	0	**36**
Unknown, insufficient data		0	0	0	0	0	**0**
None		15	6	4	13	0	**38**
Total		**27**	**15**	**13**	**19**	**0**	**74**

High-pressure sodium (HPS) lamps, Ra ≤ 60							
		No. of lamps meeting lamp lumen maintenance requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	21	13	13	0	0	**47**
	Comprehensive	21	13	13	0	0	**47**
	Award	13	2	0	0	0	**15**
Eco-design requirements Stage2, 2012		21	13	13	0	0	**47**
Unknown, insufficient data		6	2	0	19	0	**27**
None		0	0	0	0	0	**0**
Total		**27**	**15**	**13**	**19**	**0**	**74**

High-pressure sodium (HPS) lamps, Ra ≤ 60							
		No. of lamps meeting lamp survival requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	21	9	13	0	0	**43**
	Comprehensive	17	7	12	0	0	**36**
	Award	17	6	0	0	0	**23**
Eco-design requirements Stage2, 2012		21	9	13	0	0	**43**
Unknown, insufficient data		6	2	0	19	0	**27**
None		0	4	0	0	0	**4**
Total		**27**	**15**	**13**	**19**	**0**	**74**

High-pressure sodium (HPS) lamps, Ra ≤ 60							
		No. of lamps meeting mercury content requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	n/a					
	Comprehensive						
	Award						
Eco-design requirements Stage2, 2012		22	15	5	0	0	**42**
Unknown, insufficient data		0	0	0	19	0	**19**
None		5	0	8	0	0	**13**
Total		**27**	**15**	**13**	**19**	**0**	**74**

High-pressure sodium (HPS) lamps, Ra > 60							
		No. of lamps meeting all requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	6	0	0	0	0	**6**
	Comprehensive	0	0	0	0	0	**0**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		6	0	0	0	0	**6**
Unknown, insufficient data		0	0	0	0	0	**0**
None		3	0	0	0	0	**3**
Total		**9**	**0**	**0**	**0**	**0**	**9**

High-pressure sodium (HPS) lamps, Ra > 60							
		No. of lamps meeting luminous efficacy requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	9	0	0	0	0	**9**
	Comprehensive	0	0	0	0	0	**0**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		9	0	0	0	0	**9**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**9**	**0**	**0**	**0**	**0**	**9**

High-pressure sodium (HPS) lamps, Ra > 60							
		No. of lamps meeting lamp lumen maintenance requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	6	0	0	0	0	**6**
	Comprehensive	6	0	0	0	0	**6**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		6	0	0	0	0	**6**
Unknown, insufficient data		3	0	0	0	0	**3**
None		0	0	0	0	0	**0**
Total		**9**	**0**	**0**	**0**	**0**	**9**

High-pressure sodium (HPS) lamps, Ra > 60							
		No. of lamps meeting lamp survival requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	6	0	0	0	0	**6**
	Comprehensive	0	0	0	0	0	**0**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		6	0	0	0	0	**6**
Unknown, insufficient data		3	0	0	0	0	**3**
None		0	0	0	0	0	**0**
Total		**9**	**0**	**0**	**0**	**0**	**9**

High-pressure sodium (HPS) lamps, Ra > 60							
		No. of lamps meeting mercury content requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	n/a					
	Comprehensive						
	Award						
Eco-design requirements Stage2, 2012		6	0	0	0	0	**6**
Unknown, insufficient data		0	0	0	0	0	**0**
None		3	0	0	0	0	**3**
Total		**9**	**0**	**0**	**0**	**0**	**9**
Metal halide (MH) lamps, Ra ≤ 80							
		No. of lamps meeting all requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	16	9	13	8	8	**54**
	Comprehensive	7	0	1	0	0	**8**
	Award	5	5	9	8	8	**35**
Eco-design requirements Stage2, 2012		16	9	13	8	8	**54**
Unknown, insufficient data		2	0	0	0	0	**2**
None		4	1	0	0	0	**5**
Total		**22**	**10**	**13**	**8**	**8**	**61**

Metal halide (MH) lamps, Ra ≤ 80							
		No. of lamps meeting luminous efficacy requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	16	9	13	8	8	**54**
	Comprehensive	9	1	2	0	0	**12**
	Award	14	5	9	8	8	**44**
Eco-design requirements Stage2, 2012		16	9	13	8	8	**54**
Unknown, insufficient data		2	0	0	0	0	**2**
None		4	1	0	0	0	**5**
Total		**22**	**10**	**13**	**8**	**8**	**61**

Metal halide (MH) lamps, Ra ≤ 80							
		No. of lamps meeting lamp lumen maintenance requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	22	10	13	8	8	**61**
	Comprehensive	8	0	5	0	0	**13**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		22	10	13	8	8	**61**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**22**	**10**	**13**	**8**	**8**	**61**

Metal halide (MH) lamps, Ra ≤ 80							
		No. of lamps meeting lamp survival requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	22	10	13	8	8	**61**
	Comprehensive	12	0	8	0	0	**20**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		22	10	13	8	8	**61**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**22**	**10**	**13**	**8**	**8**	**61**

Metal halide (MH) lamps, Ra > 80							
		No. of lamps meeting all requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	13	10	6	0	0	**29**
	Comprehensive	0	1	0	0	0	**1**
	Award	11	9	6	0	0	**26**
Eco-design requirements Stage2, 2012		13	10	6	0	0	**29**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**13**	**10**	**6**	**0**	**0**	**29**

Metal halide (MH) lamps, Ra > 80							
		No. of lamps meeting luminous efficacy requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	13	10	6	0	0	**29**
	Comprehensive	1	7	2	0	0	**10**
	Award	11	9	6	0	0	**26**
Eco-design requirements Stage2, 2012		13	10	6	0	0	**29**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**13**	**10**	**6**	**0**	**0**	**29**

Metal halide (MH) lamps, Ra > 80							
		No. of lamps meeting lamp lumen maintenance requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	13	10	6	0	0	**29**
	Comprehensive	0	1	1	0	0	**2**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		13	10	6	0	0	**29**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**13**	**10**	**6**	**0**	**0**	**29**

Metal halide (MH) lamps, Ra > 80							
		No. of lamps meeting lamp survival requirements					
Manufacturer		**A**	**B**	**C**	**D**	**E**	**Total**
Previous GPP criteria	Core	13	10	6	0	0	**29**
	Comprehensive	10	1	2	0	0	**13**
	Award	0	0	0	0	0	**0**
Eco-design requirements Stage2, 2012		13	10	6	0	0	**29**
Unknown, insufficient data		0	0	0	0	0	**0**
None		0	0	0	0	0	**0**
Total		**13**	**10**	**6**	**0**	**0**	**29**

The table below shows the nominal wattages of various LED traffic lights surveyed, for the three colours and three types of signals. The origin country of the manufacturer was included for reference.

Nominal Wattage of LED Traffic Lights (W)										
Manufacturer and origin		**200mm Ball**			**300mm Ball**			**300mm Arrow**		
		Red	**Amber**	**Green**	**Red**	**Amber**	**Green**	**Red**	**Amber**	**Green**
A	Global	7.5	8.5	8.5	7.5	8.5	8.5	-	-	-
B	China	8	8	9	11	11	13	8	8	9
C	China	7	7	7	10	10	10	12	12	12
D	China	9	10	9	12	12	12	-	-	-
E	USA	4	7.7	-	15	15	15	-	-	-
F	Korea	6.2	6.3	6.7	-	-	-	-	-	-
G	China	8	8	8	8	8	8	8	8	7
H	Turkey	8	8	8	10	10	12	6	6	6
I	China	-	-	-	10	10	10	-	-	-
J	UK	-	-	-	10	9.5	13	-	-	-
K	Korea	-	-	-	10	7.5	9.3	4.8	4.8	4.8

Appendix 3 – Road classifications according to EN 13201

The tables below, reproduced from the EuP Lot 9 study, show the correlation between the EN 13201-1 road classification and the performance requirements introduced by EN 13201-2 for street lighting systems.

Simplified version of selection according to EN/TR 13201-1 guideline and standard EN 13201-2 performance classes						
		Luminance concept (objective = vision of road surface)				
Road type	**typical situation**	**EN 13201 class**	**Lavg** Cd/m²	U_O	U_l	**TI** %
category **'F'** fast traffic only (e.g. motorways,..)	busy and fast	ME1	2	0,4	0,7	10
	busy and normal speed	ME2	1,5	0,4	0,7	10
	not busy and rain	ME3a	1	0,4	0,7	15
	few traffic	ME4a	0,75	0,4	0,6	15
category **'M'** mixed traffic	busy	ME2	1,5	0,4	0,7	10
	normal	ME3a	1	0,4	0,7	15
	few traffic	ME4a	0,75	0,4	0,6	15

Simplified version of selection according to EN/TR 13201-1 guideline and standard EN 13201-2 performance classes					
		Illuminance concept (objective = light levels to see persons and cars)			
Road type	**typical situation**	**EN 13201 class**	**Eavg illuminance (Avg) lx**	**Umin Uniformity**	**Emin Illuminance(min)**
category **'S'** slow traffic	busy	CE2	20	0,4	
	normal	CE3	15	0,4	
	few traffic	CE4	10	0,4	
	busy	S2	10		3
	normal	S4	5		1
	few traffic	S6	2		0,6

Appendix 4 – European standards and guidance

- EN 12368: Traffic control equipment - Signal heads
- EN 12665: Light and lighting - Basic terms and criteria for specifying lighting requirements
- EN 13201-1: Road lighting - Selection of lighting classes
- EN 13201-2: Road lighting - Performance requirements
- EN 13201-3: Road lighting - Calculation of performance
- EN 13201-4: Road lighting - Methods of measuring lighting performance
- EN 50102: Degrees of Protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
- EN 50294: Measurement method of total input power of ballast-lamp circuits
- EN 60529: Degrees of protection provided by enclosures (IP code)
- EN 60598-1: Luminaires - Part1: General requirements and tests
- EN 60598-2-3: Luminaires - Part 2 -3: Particular requirements - Luminaires for road and street lighting
- EN 60662: High-pressure sodium vapour lamps
- EN 60923: Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps) - Performance requirements
- EN 60927: Auxiliaries for lamps - Starting devices (other than glow starters) - Performance requirements
- EN 61048: Auxiliaries for Lamps - capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
- EN 61049: Capacitors for use in tubular fluorescent and other discharge lamp circuits - Performance requirements
- EN 61167: Metal halide lamps - Performance
- EN 62035: Discharge lamps (excluding fluorescent lamps) - Safety specifications
- SO 16508:1999(E) / CIE S 006.1/E-1999: Joint ISO/CIE Standard: Road traffic lights - photometric properties of 200 mm roundel signals
- CIE 1-1980: Guide lines for minimizing urban sky glow near astronomical observatories (Joint publication IAU/CIE)
- CIE 17.4-1987: International lighting vocabulary, 4th ed. (Joint publication IEC/CIE)
- CIE 23-1973: International recommendations for motorway lighting
- CIE 31-1976: Glare and uniformity in road lighting installations
- CIE 32-1977: Lighting in situations requiring special treatment (in road lighting)
- CIE 33-1977: Depreciation of installation and their maintenance (in road lighting)

- CIE 34-1977: Road lighting lantern and installation data: photometrics, classification and performance
- CIE 47-1979: Road lighting for wet conditions
- CIE 66-1984: Road surfaces and lighting (joint technical report CIE/PIARC)
- CIE 79-1988: A guide for the design of road traffic lights
- CIE 84-1989: Measurement of luminous flux
- CIE 93-1992: Road lighting as an accident countermeasure
- CIE 100-1992: Fundamentals of the visual task of night driving
- CIE 115-2010 (2nd edition): Recommendations for the lighting of roads for motor and pedestrian traffic
- CIE 121-1996: The photometry and goniophotometry of luminaires
- CIE 126-1997: Guidelines for minimizing sky glow
- CIE 129-1998: Guide for lighting exterior work areas
- CIE 132-1999: Design methods for lighting of roads
- CIE 136-2000: Guide to the lighting of urban areas
- CIE 140-2000: Road lighting calculations
- CIE 144-2001: Road surface and road marking reflection characteristics
- CIE 150-2003: Guide on the limitation of the effects of obtrusive light from outdoor lighting installations
- CIE 153-2003: Report on an intercomparison of measurements of the luminous flux of high-pressure sodium lamps
- CIE 154-2003: Maintenance of outdoor lighting systems
- CIE 194-2011: On site measurement of the photometric properties of road and tunnel lighting