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Revision of the EU Green Public Procurement Criteria for Road Lighting

Technical report and criteria proposal (2nd draft)

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1 Glossary

AC – Award Criteria
AECI – Annual Energy Consumption Indicator
AHWG – Ad Hoc Working Group
ALARA – As Low As Reasonably Achievable
CCT – Correlated Colour Temperature
CFL – Compact Fluorescent Lamp
CLO – Constant Light Output
CPO – Virtual Power Output
CPC – Contract Performance Clause
CRI – Colour Rendering Index
EIR – Edge Illumination Ratio
ENEC+ - European Norms Electrical Certification
HID – High Intensity Discharge
HPM – High Pressure Mercury
HPS – High Pressure Sodium
IP – Ingress Protection
IPEA – Parameterized Energy Index for Luminaires
IPEI – Parameterized Energy Index for Lighting Systems
ITT – Invitation To Tender
LCA – Life Cycle Assessment
LCC – Life Cycle Cost
LED – Light Emitting Diode
LPS – Low Pressure Sodium
LLMF/F_{LLM} – Lamp Lumen Maintenance Factor
LMF/F_{LM} – Luminaire Maintenance Factor
LSF/F_{LS} – Lamp Survival Factor
MH – Metal Halide
PDI – Power Density Index
RW – Road Width
SC – Selection Criteria
TR – Technical Report
TS – Technical Specification
ULOR/R_{ULO} – Upward Light Output Ratio

2 Introduction

Public authorities' expenditures in the purchase of goods, services and works (excluding utilities and defence) constitute approximately 14% of the overall Gross Domestic Product (GDP) in Europe, accounting for roughly EUR 1.8 trillion annually (Buying Green, 2016)[1].

Thus, public procurement has the potential to provide significant leverage in seeking to influence the market and to achieve environmental improvements in the public sector. This effect can be particularly significant for goods, services and works (referred to collectively as products) that account for a high share of public purchasing combined with the substantial improvement potential for environmental performance.

Green Public Procurement (GPP) is defined in the Commission's Communication "COM (2008) 400 - Public procurement for a better environment" as "*...a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured.*"

Therefore, by choosing to purchase products with lower environmental impacts, public authorities can make an important contribution to reducing the direct environmental impact resulting from their activities. Moreover, by promoting and using GPP, public authorities can provide industry with real incentives for developing green technologies and products. In some sectors, public purchasers command a large share of the market (e.g. public transport and construction, health services and education) and so their decisions have considerable impact. In fact, COM (2008) 400 mentions that public procurement has the capability to shape production and consumption trends, increase demand for "greener" products and services and provide incentives for companies to develop environmental friendly technologies is clearly emphasised. Many examples of what is being done with GPP can be found online[2,3].

GPP is a voluntary instrument, meaning that Member States and public authorities can determine the extent to which they implement it.

The development of EU GPP criteria aims to help public authorities ensure that the goods, services and works they require are procured and executed in a way that reduces their associated environmental impacts. The criteria are thus formulated in such a way that they can be, if deemed appropriate by the individual authority, integrated into its tender documents with minimal editing.

GPP criteria are to be understood as being part of the procurement process and must conform to its standard format and rules as laid out by Public Procurement Directive 2014/24/EU (public works, supply and service contracts). Hence, EU GPP criteria must comply with the guiding principles of: Free movement of goods and services and freedom of establishment; Non-discrimination and equal treatment; Transparency; Proportionality and Mutual recognition. GPP criteria must be verifiable and it should be formulated either as Selection criteria,

[1] Buying green, 2016. Buying green! A handbook on green public procurement, 3rd edition, 2016. http://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf
[2] Green ProcA – Green Public Procurement in Action - http://gpp-proca.eu

[3] GPP2020 Procurement for a low-carbon economy http://www.gpp2020.eu

Technical specifications, Award criteria or Contract performance clauses, which can be understood as follows:

Selection Criteria (SC): Selection criteria refer to the tenderer, i.e., the company tendering for the contract, and not to the product being procured. It may relate to suitability to pursue the professional activity, economic and financial standing and technical and professional ability and may- for services and works contracts - ask specifically about their ability to apply environmental management measures when carrying out the contract.

Technical Specifications (TS): Technical specifications constitute minimum compliance requirements that must be met by all tenders. It must be linked to the contract's subject matter (the ‘subject matter’ of a contract is about what good, service or work is intended to be procured. It can consist in a description of the product, but can also take the form of a functional or performance based definition.) and must not concern general corporate practices but only characteristics specific to the product being procured. Link to the subject matter can concern any stage of the product's life-cycle, including its supply-chain, even if not obvious in the final product, i.e., not part of the material substance of the product. Offers not complying with the technical specifications must be rejected. Technical specifications are not scored for award purposes; they are strictly pass/fail requirements.

Award Criteria (AC): At the award stage, the contracting authority evaluates the quality of the tenders and compares costs. Contracts are awarded on the basis of most economically advantageous tender (MEAT). MEAT includes a cost element and a wide range of other factors that may influence the value of a tender from the point of view of the contracting authority including environmental aspects (refer to the Buying Green guide for further details[4]). Everything that is evaluated and scored for award purposes is an award criterion. These may refer to characteristics of goods or to the way in which services or works will be performed (in this case they cannot be verified at the award stage since they refer to future events. Therefore, in this case, the criteria are to be understood as commitments to carry out services or works in a specific way and should be monitored/verified during the execution of the contract via a contract performance clause). As technical specifications, also award criteria must be linked to the contract's subject matter and must not concern general corporate practices but only characteristics specific to the product being procured. Link to the subject matter can concern any stage of the product's life-cycle, including its supply-chain, even if not obvious in the final product, i.e., not part of the material substance of the product. Award criteria can be used to stimulate additional environmental performance without being mandatory and, therefore, without foreclosing the market for products not reaching the proposed level of performance.

Contract Performance Clauses (CPC): Contract performance clauses are used to specify how a contract must be carried out. As technical specifications and award criteria, also contract performance clauses must be linked to the contract's subject matter and must not concern general corporate practices but only those specific to the product being procured. Link to the subject matter can concern any stage of the product's life-cycle, including its supply-chain, even if not obvious in the final product, i.e., not part of the material substance of the product. The economic operator may not be requested to prove compliance with the contract performance clauses during the procurement procedure. Contract performance

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[4] Buying green, 2016. Buying green! A handbook on green public procurement, 3rd edition, 2016. http://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf

clauses are not scored for award purposes. Compliance with contract performance clauses should be monitored during the execution of the contract, therefore after it has been awarded. It may be linked to penalties or bonuses under the contract in order to ensure compliance.

For each criterion there is a choice between two levels of environmental ambition, which the contracting authority can choose from according to its particular goals and/or constraints:

> The **Core criteria** are designed to allow easy application of GPP, focussing on the key areas of environmental performance of a product and aimed at keeping administrative costs for companies to a minimum.
>
> The **Comprehensive criteria** take into account more aspects or higher levels of environmental performance, for use by authorities that want to go further in supporting environmental and innovation goals.

As said before, the development of EU GPP criteria aims to help public authorities ensure that the goods, services and works they require are procured and executed in a way that reduces their associated environmental impacts and is focused on the products' most significant improvement areas, resulting from the cross-check between the key environmental hot-spots and market analysis. This development also requires an understanding of commonly used procurement practices and processes and the taking on board of learnings from the actors involved in successfully fulfilling contracts.

For this reason, the European Commission has developed a process aimed at bringing together both technical and procurement experts to collate a broad body of evidence and to develop, in a consensus oriented manner, a proposal for precise and verifiable criteria that can be used to procure products with a reduced environmental impact.

This report presents the findings resulting from that process up to the 1st ad-hoc working group meeting that will be held in Seville on 22 November 2016. Consultation questions are integrated in the document and will serve for updating the document in a later stage of the project.

A detailed environmental and market analysis, as well as an assessment of potential improvement areas, was conducted within the framework of this project and was presented in the Preliminary Report on EU Green Public Procurement Criteria for road lighting and traffic signals. This report can be publicly accessed at the JRC website for road lighting and traffic signals (http://susproc.jrc.ec.europa.eu/Street_lighting_and_Traffic_signs/documents.html). The main findings presented in the Preliminary Report are summarised in the next section.

Based on the findings from the Preliminary report, a first draft of the Technical report and criteria proposal was produced and presented at the 1st ad-hoc working group meeting held in Seville on 22nd November 2016. Apart from the comments received at this meeting, written feedback was conveyed by means of a written consultation and via a conference call specifically focussing on energy efficiency, light pollution and product lifetime criteria with the most active stakeholders in those areas. This second draft of the Technical Report and criteria proposals has been produced taking into account the input received in the course of this consultation process.

3 Summary of the Preliminary report

The Preliminary Report provides a general analysis of the product group in question, assessing the relevance of its scope and identifying the most relevant legislation, standards and definitions that apply. As part of the Preliminary Report, a market analysis is also conducted as well as an assessment of the main environment impacts associated with road lighting and the potential for technical improvements to reduce those impacts. These aspects ensure that the Preliminary Report forms the basis for the revision and development of EU GPP criteria in subsequent draft Technical Reports.

3.1 *Scope and definitions*

The scope of existing EU GPP criteria (published in 2012) for this product group covers two different types of lighting, namely "street lighting" and "traffic signals", whose definitions are linked to EN 13201 and EN 12368 respectively.

An initial scoping questionnaire was circulated to stakeholders at the beginning of the project. The majority of responses supported the removal of traffic signals from the scope based on the consideration that this would normally form a different subject matter in procurement contracts. With regards to the scope for street lighting, respondents generally agreed to link the definition to that of EN 13201-1. However, it was also mentioned that aspects relating to metering and dimming controls could be referred to, even though they are not explicitly included in the EN 13201 definition. Power cables and poles were not considered important and can continue to be excluded from the scope. One other comment was that the term "road lighting" should be used instead of "*street lighting*" in order to ensure better alignment with EN 13201.

The existing product group scope, the relevant text in the related standards and the initial proposal in the preliminary report, based on feedback from the initial scoping questionnaire are summarised in Table 1 below.

Table 1. Scope for existing EU GPP criteria published in 2012

Street/road lighting	Traffic signals
Existing (2012) GPP scope: A public street light will be defined as a: "Fixed lighting installation intended to provide good visibility to users of outdoor public traffic areas during the hours of darkness to support traffic safety, traffic flow and public security". This 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). It does include functional lighting of pedestrian and cycle paths as well as roadway lighting.	**Existing (2012) GPP scope:** "Red, yellow and green signal lights for road traffic with 200mm and 300mm roundels. Portable signal lights are specifically excluded."
As provided in the introduction of EN 13201-1:2014: "*…fixed lighting installations 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.*"	**As provided in the scope section of EN 12368:** "*…signal heads with one or more signal lights of the colours red, yellow and/or green signal lights for road traffic with 200 mm and 300 mm roundels and to optical units to be integrated in signal heads to produce the individual signal lights.*"

Scope proposed in Preliminary Report:	Scope proposed in Preliminary Report:
"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 according to standard EN 13201 on road lighting including similar applications as used for car parks of commercial or industrial outdoor sites and traffic routes in recreational sports or leisure facilities" Excluding: lighting poles; building mounts; catenary wire systems; tunnel lighting; monument building or tree lighting; outdoor lighting of workplaces and outdoor sport field lighting.	"Red, yellow and green signal lights for road traffic with 200mm and 300mm roundels. Portable signal lights are specifically excluded." (i.e. no change from previous definition)

A number of definitions were included in the Preliminary Report that are of high relevance to the product group and are summarised below:

a) **M class road areas:** for drivers of motorized vehicles on traffic routes, and in some countries also residential roads, allowing medium to high driving speeds (for EN 13201-1:2014 suggested associated light levels, see Figure 1).
b) **C class road areas:** for use in conflict areas on traffic routes where the traffic composition is mainly motorised. Conflict areas occur wherever vehicle streams intersect each other or run into areas frequented by pedestrians, cyclists, or other road users. Areas showing a change in road geometry, such as a reduced number of lanes or a reduced lane or carriageway width, are also regarded as conflict areas (for EN 13201-1:2014 suggested associated light levels, see Figure 1).
c) **P class road areas**: predominantly for pedestrian traffic and cyclists for use on footways and cycleways, and drivers of motorised vehicles at low speed on residential roads, shoulder or parking lanes, and other road areas lying separately or along a carriageway of a traffic route or a residential road, etc. (for EN 13201-1:2014 suggested associated light levels, see Figure 1).
d) **Adaptive lighting**: temporal controlled changes in luminance or illuminance in relation to traffic volume, time, weather or other parameters (EN 13201-1:2014).
e) **Luminaire**: an apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply (EN 12665:2011).
f) **Lamp:** a unit whose performance can be assessed independently and which consists of one or more light sources. Therefore it may include additional components necessary for starting, power supply or stable operation of the unit or for distributing, filtering or transforming the optical radiation, in cases where those components cannot be removed without permanently damaging the unit.
g) **Light source:** a surface or object designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wavelength of 380 - 780 nm.
h) **Light Emitting Diode (LED):** a light source, which consists of a solid-state device embodying a p-n junction of inorganic material. The junction emits optical radiation when excited by an electric current.
i) **LED package:** an assembly having one or more LED(s). The assembly may include an optical element and thermal, mechanical and electrical interfaces.
j) **LED module:** an assembly having no cap and incorporating one or more LED packages on a printed circuit board. The assembly may have electrical, optical, mechanical and thermal components, interfaces and control gear.
k) **LED lamp:** a lamp incorporating one or more LED modules. The lamp may be equipped with a cap.
l) **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
m) **Control gear:** components required to control the electrical operation of the lamp(s). Control gear 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).

n) Light pollution: Several different definitions have been provide, including: (i) "*any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste*", (International Dark-Sky Association, Rajkhowa, 2014[5]); (ii) "*the sum-total of all adverse effects of artificial light*" (CIE 126:1997); (iii) "*the introduction by humans, directly or indirectly, of artificial light into the environment*" (UNESCO, IAU and IAC);

3.2 *Relevant standards*

Road lighting and traffic signals are well defined by their corresponding standards EN 13201 series and EN 12368.

The technical report CEN/TR 13201-1:2014 gives guidelines on the selection of the most appropriate lighting class for a given situation doesn't give any preference to a class or another, the choice of the class and the relative luminance is still on the authorities/technician's hands. In order to reduce light pollution the selection of the class shall be made by using the principle "*As Low As Reasonably Achievable*" (ALARA) at any moment of time. ..

The European standard EN 13201-2:2016 contains performance requirements for different classes (M1….M6, C1….C5, P1….P6), they will have a positive impact on light pollution because they set requirements on uniformity and glare reduction. Herein, class M1 requires much higher light levels compared to class M6, see Figure 1.

Luminance		Illuminance			Illuminance		
							
= see road		= see objects			= see objects		
view point: car driver		view point: any			view point: any		
EN 13201	L,m	EN 13201	E,m	Emin	EN 13201	E,m	Emin
Class	Cd/m²	class	lx	lx	class	lx	lx
		C0	50				
M1	2	C1	30				
M2	1,5	C2	20				
M3	1	C3	15		P1	15	3
M4	0,75	C4	10		P2	10	2
M5	0,5	C5	7,5		P3	7,5	1,5
M6	0,3				P4	5	1
					P5	3	0,6
					P6	2	0,4

Figure 1. EN 13201-2 road classes and their required light levels

EN 13201 Part 3 deals with calculation of performance, Part 4 contains methods of measuring lighting performance and Part 5 defines energy performance indicators that are presented later in proposed EU GPP criteria. The use of

[5] Rajkhowa R., 2012. Light pollution and impact of light pollution. International Journal of Science and Research (IJSR), 3(10), p.861-867.

standardised calculations and methodology means that designs of different manufacturers are more comparable, which is essential for evaluating competitive offers in procurement.

When renovating, there is the risk that an EN 13201 light class is specified that is much higher than the lighting level that the existing installation delivers. Ideally, procurers should be fully aware of what level of light they actually want or need and should embrace the ALARA (As Low As Reasonably Achievable) principle when deciding on light levels.

3.3 *Market analysis*

The road lighting luminaire sector is a 520 million euro per year industry that provides lighting for some 1.5 million km of roads in the EU28 via an estimated 64 million luminaires. Around 2.38 million luminaires are sold each year in the EU28, with 2.16 million of those (91%) being for the replacement of existing luminaires. This demonstrates the mature nature of the road lighting sector in Europe and suggests a typical luminaire replacement rate of 29 years.

The split in lamp technology amongst existing luminaries on EU roads in 2015 was estimated as shown in Figure 2.

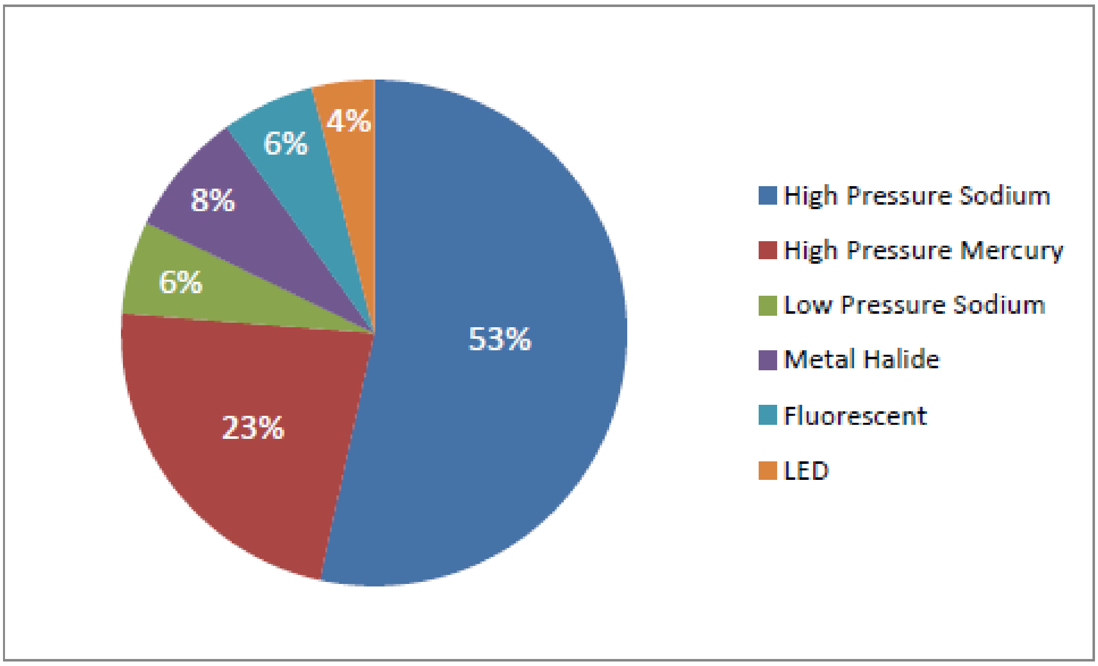

Figure 2. Estimated split of lamp technologies in EU28 road lighting in 2015

Luminaire prices can vary strongly and especially new LED luminaires are substantially more expensive than the average 220 euro, but the price of LED packages for use within luminaires has decreased significantly and is expected to continue decreasing in the future (see Figure 3).

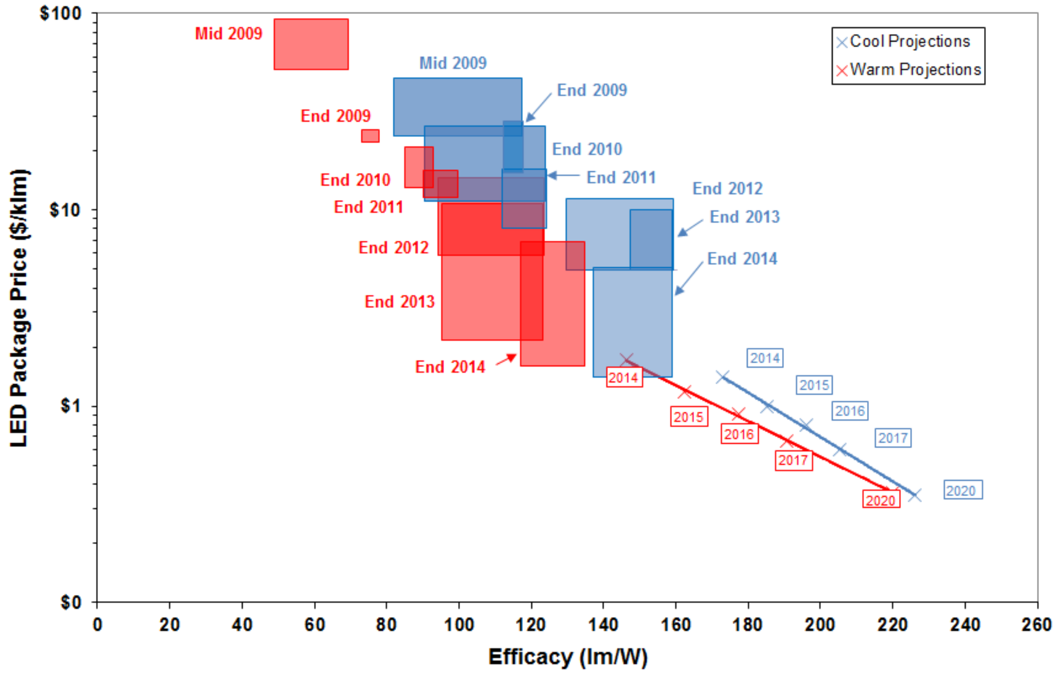

Figure 3. Price-efficacy trade-off for LED packages at 1 W/mm^2 (equiv. 35 A/cm^2) and 25°C (DOE, 2016)[6].

The data in Figure 3 not only demonstrates the decrease in prices but also the increase in lumen efficacy, which will result in lower operating costs for a given necessary light output.

When considering the split of lamp technologies in existing road lighting installations in Europe in 2015, shown in Figure 2, and how this split will look in the near future, there are three key points to consider:

- High Pressure Mercury lamps (HPM) have been phased out since April 2015 as per Regulation 245/2009, so this 23% share will eventually drop to 0%.
- 2015 was a breakthrough year for LED technology in road lighting applications. New sales of road lighting lamps and luminaires have since been dominated by LED technology and so the current 4% share will increase significantly in the next few years.
- Typical service lives of non-LED lamps are of the range of 2-4 years whereas LED lamps may last >15 years.

Consequently, it is widely accepted that LED technology will quite quickly become the dominant road lighting lamp technology in Europe.

[6] US DOE (Department of Energy), 2015. Solid-State Lighting R&D plan. DOE/EE-1228. Last accessed online July 2017.

3.4 *Environmental analysis*

3.4.1 LCA-modelled impacts

The environmental impacts associated with the road lighting installations have been investigated by conducting a review of relevant LCA studies published in the literature.

Despite the many nuances that apply to LCA studies, such as the appropriate choice of functional unit, scope and boundaries, assumed product lifetime, inventory data and the different impact categories that can be reported on, the literature was unanimous in showing that the use phase was the dominant source of all LCA impact categories as a direct result of electricity consumption. This is not surprising when it is considered that approximately 1.3% of all electricity consumed by the EU25 in 2005 (35 TWh) was by road lighting installations.

It was also clear that the importance of the manufacturing stage is going to increase if road lighting becomes more energy efficient and/or a low emission electricity mix is used. The lifetime of LEDs becomes relevant because of the higher influence of the manufacturing phase compared to more traditional light sources. All LCA studies were done including assumptions on LED luminaire life time (>15 years). Therefore, the most important parameters that have to be considered in the GPP criteria are the *energy efficiency, durability and lifetime*.

3.4.2 Non-LCA-modelled impacts

The main "non-LCA-modelled" impact associated with road lighting is light pollution. While there are several different definitions of light pollution, it is clear that they all refer to unnatural light caused by anthropogenic activities. The potential adverse impacts of man-made light pollution can be split into the following:

- Sky glow, specifically man-made sky-glow (as per CIE 126:1997) with particular importance given to light emitted between the horizontal and 10 degrees above the horizontal. Blue rich light scatters more in the night sky than red light and hence can contribute more to sky glow. Blue rich light has typically higher Correlated Colour Temperature.
- Obtrusive light (as per CIE 150:2003) that causes annoyance, discomfort glare or distraction glare which can affect residents in their homes, drivers trying to look ahead and drivers trying to read traffic signals.
- Ecological impact, in the sense that artificial lighting can potentially affect the natural biorhythms of insect populations, nocturnal mammals and birds. The colour spectrum of the light as well as the visible (to humans) light level may be important.

One key factor for combatting light pollution is to avoid over-lighting roads. A central concept to consider when a lighting level has been decided for a particular road section is that of "*As Low As Reasonably Achievable*" (ALARA) and this may include the possibility to dim lights during low traffic periods.

3.5 *Technical analysis*

A review of the key components and technology involved in road lighting installations was carried out and the main points are summarised below and are related to the main lamp technologies which are: LED (Light Emitting Diode); HID (High Intensity Discharge); MH (Metal Halide); HPS (High Pressure Sodium); HPM

(High Pressure Mercury); LPS (Low Pressure Sodium) and CFL (Compact Fluorescent Lamp).

3.5.1 Ballast/control gear/drivers

The purpose of ballasts and control gears is to limit the current supplied to the lamp – this is especially important for HID and LED lamps which cannot be directly connected to a 230VAC source. Ballasts or control gear can be of the magnetic or electronic type, with LED requiring the latter while HPS and MH lamps can use either. Electronic control gears can offer better power control and lamp ignition to HID lamps, which may be linked to improved lamp survival factors (LSF/F_{LS}) and lamp lumen maintenance factors (LLMF/F_{LLM}). However, the lifetime of magnetic ballasts is very long (30-50 years possible) whereas the failure of the weakest individual component in an electronic control gear (e.g. electrolytic capacitors) can bring about the abrupt failure of the lamp.

All ballasts for HID cause a loss of some power, which tends to be more significant when the rated lamp power is lower and when smaller loads are applied in dimmable lamps. Minimum ballast efficiencies have been set in the Ecodesign Regulation 245/2009 and also in the existing GPP criteria published in 2012.

3.5.2 Dimming and control systems

Dimming of light output will always reduce the energy consumption of a lighting installation although energy reductions are not perfectly proportional to light reductions because of standby power needs and the operation of control circuits.

It is possible to retrofit dimming systems between an LED module and its control gear. Besides the obvious benefits of reduced energy consumption, dimming controls allow greater flexibility to prevent over-lighting during certain periods of the night. Another possibility with dimming controls is to allow for overdesigned light sources to be used with initial dimming used to prevent overlighting which can gradually be reduced as the lumen output of the light source decreases with ageing. This is also often referred to as constant light output (CLO) control and/or virtual power output (VPO) control.

There are several different control systems available for dimming controls which can be linked to communication systems in what is a rapidly developing field. Taken to the extreme, dimming controls and two-way communication linked to other sensors at the individual luminaire level could play a vital role in intelligent lighting systems as part of smart city networks. It is also possible to have a local astronomical clock control circuit that sets a fixed curfew control cycle without the need for any communication system.

3.5.3 Lamps and light sources

The market analysis revealed the main lamp technologies used in road lighting (i.e. LED, HID, MH, HPS, HPM, LPS and CFL). The key technical considerations for a particular lamp or light source are:

- The luminous efficacy (i.e. light output divided by power consumption)
- The lamp survival factor (i.e. how many abrupt failures in a certain time)
- The lamp lumen maintenance factor (i.e. gradual reduction of light output with ageing of the light source).

Other considerations relate to the colour rendering index and the correlated colour temperature of a lamp but these will be presented in more detail as supporting rationale and background research for proposed light pollution criteria later in this report.

3.4.3.1 Luminous efficacy (η)

The luminous efficacy of light sources tends to increase as the lamp rated power increases. One notable exception to this relationship is LED technology, where efficacy is independent of rated power. Regulation (EC) No 245/2009 sets minimum luminous efficacy requirements as a function of (i) lamp technology, (ii) nominal lamp wattage and in some cases (iii) if the lamp is "clear[7]" or not and (iv) the colour rendering index (Ra).

The existing GPP criteria published in 2012 follows the same approach as the requirements of Regulation (EC) No 245/2009 by setting minimum luminous efficacy requirements in core and comprehensive criteria.

When comparing discharge lamp technologies for luminous efficacy, LPS performs very well with 140-170 lm/W (for rated power of 26-66W), CFL produces around 81 lm/W (for a rated power of 36W) and HPM lamps produced only 51 lm/W (for a rated power of 250W).

LED can be considered to perform well in comparison to discharge lamp technologies, with efficacies of 100-175 lm/W for lamps and 100-140 lm/W when considering control gear and optical losses. However, there are also poor examples of LED lamps on the market where the luminous efficacy can be as low as 50 lm/W. One possible reason for this was cited as the reuse of LED chips that had been rejected from high level performance group production lines. Such concerns lend greater value to quality monitoring schemes for LED products like ENEC+[8]. Further advances in LED efficacy can be expected to continue in the near future. A theoretical maximum efficacy of around 300 lm/W for white light is achievable with LED[9] and it would not be unrealistic to expect future road lighting installations to be equipped with luminaires delivering light with an efficacy of >200 lm/W.

3.4.3.2 Lamp Survival Factor (LSF/F_{LS} for HID lamps, LxCz for LED lamps)

The terms in the title above refer to the abrupt failure of light sources. Survival factors are expressed as decimals (e.g. 0.8 = 80% and 0.99 = 99%) of units "surviving" after a defined time period. It should be noted that an operating period of 1 year for road lighting typically corresponds to 4000h.

Regulation (EC) No 245/2009 sets minimum LSFs for MH (0.8 at 12000 hours) and HPS (0.9 at 12000 hours or 16000 hours depending on the rated wattage). Current BAT is estimated to greatly exceed these minimum requirements (i.e. 0.99 at 16000 hours for both MH and HPS).

For LED technology the term LxCz is used instead of LSF/F_{LS}. The LxCz term is also linked to a defined time (the abrupt failure fraction as per IEC 62717). A value of L0C10 at 60000h would mean that after 60000 hours of use, 10% of the light sources have failed.

Actual LxCz values for the survival of LED lamps are difficult to predict due to the rapidly developing nature of the technology but in general, LED lamps survive considerably longer than other technologies. This has meant that predictions of

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7 Non-clear lamps refer to those which have coatings or frosting to reduce glare.

8 ENEC+ is an independent and pan-European third-party certification scheme jointly developed by LightingEurope and the ENEC Mark specifically for LED modules and LED-based luminaires.

9 https://www.dial.de/en/blog/article/efficiency-of-ledsthe-highest-luminous-efficacy-of-a-white-led/

LED survival have to be based on extrapolations of test results and should not be considered independently of failure of other components (i.e. control gear components).

3.4.3.3 Lamp Lumen Maintenance Factor (LLMF or F_{LLM} for HID lamps, LxBy for LED lamps)

The terms in the title above refer to the gradual decrease in light output as the light source ages. With the LLMF/F_{LLM} term, values are expressed as a decimal (e.g. 0.8 = 80%) and linked to a specific operating time. A LLMF/F_{LLM} value of 0.85 after 16000 hours means that the light output has decreased by 20% after 16000 hours operation purely due to ageing of the light source.

With LED technologies, the term LxBy is used instead of LLMF/F_{LLM} and is also linked to a defined operating time. A value of L70B10 at 50000h means that after 50000h of operation, 10% of the LED light sources will fail to meet 70% of the initial light output.

3.5.4 Luminaires and Luminaire Maintenance Factor (LMF or F_{LM})

The luminaire is the collective housing for all lamps and light sources, together with any necessary control gear and connections. The luminaire will last longer than any of the components it houses (with the possible exception of magnetic ballasts).

The two primary functions of the luminaire are to (i) distribute the light from the lamp(s) in a manner that fits the lighting installation design needs and (ii) to protect the lamp(s) from potentially damaging external environments (e.g. water ingress and dirt).

The light distribution from a luminaire can be adequately assessed by the provision of a full photometric file. The ability of the luminaire to protect its contents from the environment can be assessed by a standard methodology that results in an "Ingress Protection" (IP) rating being provided (see Annex 5.3 of Preliminary Report for more details).

Luminaires will gradually build up a layer of dust or dirt on its housing which will restrict light output efficacy. With normal discharge lamp technologies, because the lamp needed to be replaced every 2-4 years, cleaning was normally carried out in conjunction with lamp replacement. However, with longer lasting LED lamps, dedicated cleaning cycles will need to be somehow incorporated into the maintenance schedule.

This luminaire pollution effect is taken into account with the Luminaire Maintenance Factor (LMF or F_{LM}) (CIE 154), frequent cleaning and a high IP rating will help to maintain the light output and also results in energy saving. Finally, the Maintenance Factor (MF or F_M) for road lighting is a combination of the lamp maintenance factor F_{LLM} and luminaire maintenance FLM ($F_M = F_{LLM} x F_{LM}$) (CIE 154).

One key aspect to consider is the reparability (or serviceability) of an LED luminaire. The primary distinction between a repairable and non-repairable LED luminaire is the ability to open the luminaire with normal service tools and to remove and replace electronic components and the lamp itself.

4 Summary of main changes from TR 1.0

Apart from changes to the wording of individual criteria, there has also been a significant change to the scope (proposal to remove traffic signals) and to the way that the criteria are structured. In TR 1.0, they were grouped per project stage (e.g. design, lighting equipment, installation etc.) whereas now they are grouped by criteria area (e.g. selection criteria, energy efficiency etc.).For ease of comparison, both criteria structures are provided below.

Table 2. Comparison of criteria structure in TR 1.0 and TR 2.0.

TR 1.0	TR 2.0
Street lighting	**Road lighting**
Design stage	**Selection criteria**
SC – Competencies of the design team	SC1 – Competencies of the design team
TS1 – AECI and PDI	SC2 – Competencies of the installation team
TS2 – Light pollution	CPC1 - Assurance of adequately qualified staff responsible for project
AC1 – Life Cycle Costing (LCC)	**Energy efficiency**
AC2 - Metering	TS1 – Luminaire luminous efficacy
Installation stage	AC1 – Enhanced luminaire luminous efficacy
SC – Competencies of the installation team	CPC2 - Provision of originally specified lighting equipment
TS – Provision of instructions	TS2 – Dimming control capability
CP1 – Putting into service of lighting systems and controls	TS3 – Minimum dimming performance
CP2 – Correct installation	CPC3 – Dimming Controls
CP3 – Reduction and recovery of waste	TS4 – PDI
Road lighting equipment	TS5 – AECI
TS1 – Efficacy and lifetime of luminaires	AC2 – Enhanced AECI
TS2 – Compatibility with dimming and other controls	TS6 – Metering
TS3 – Product lifetime extension	CPC4 - Commissioning and correct operation of lighting controls
TS4 - Reparability	CPC5 - Provision of originally specified lighting equipment
TS5 – Ingress protection	CPC6: Compliance of actual energy efficiency and lighting levels with design claims
Light sources	**Light pollution**
TS1 – Efficacy and lifetime of light sources	TS7 – Ratio of Upward Light Output
TS2 – Failure rate of control gear	TS8 – Ecological light pollution and annoyance
Traffic signals	**Lifetime**
TS1 – Efficacy and lifetime of traffic signal modules	TS9 – Provision of instructions
	TS10 – Waste recovery
	TS11 – LED lamp product lifetime, spare parts and warranty
	AC3 – Extended warranty
	TS12 - Reparability
	TS13 – Ingress Protection (IP rating)
	TS14 – Failure rate of control gear
	CPC7 – Commitment to waste recovery and transport to suitable sites
Traffic signals	
TS1 – Efficacy and lifetime of traffic signal modules	TS1 – Life Cycle Cost
	AC1 – Lowest Life Cycle Cost
	TS2 – Warranty
	AC1 – Extended warranty

With energy efficiency criteria, actual dimming controls are required instead of just compatibility with dimming controls. The Power Density Indicator (PDI) and Annual Energy Consumption Indicator (AECI) requirements have been separated for improved clarity and both calculations have been broken down into clearly defined individual components for greater transparency. It is especially important that the presumed effect of road width on utilance is clearly explained, the influence of luminaire efficacy on PDI is known and the effect of dimming factors on AECI is visible.

A requirement for metering has been proposed as a Technical Specification (TS). Such a criterion is essential in order to accurately evaluate the energy performance of the lighting installation. Unlike traditional lamps, LEDs are available in a much wider range of power ratings. This, coupled with the fact that dimming operations are likely to become more common in the future, mean that it will be difficult to estimate electricity costs simply by knowing the number of light points and the number of hours lit.

With light pollution criteria, the R_{ULO} requirement has been tightened from 1% to 0% for the core level and a new technical specification has been introduced relating to CCT. A limitation on the degree of blue light emitted from the light source is proposed in the comprehensive criterion for situations where insect attraction or increased contribution to sky glow may be an issue.

With lifetime criteria, the waste recovery criterion has been simplified, now no longer requiring a bill of critical raw materials for supplied lighting equipment. The length of standard warranty period has been extended to 8 years (core) and 10 years (comprehensive). The other major change is that an optional award criterion for extended product warranty has been proposed.

Criteria relating only to light sources have been removed because the requirements are essentially duplicated at the level of the luminaire already. The only relevant criteria for light sources were luminous efficacy, LxBy (for LED light sources) or F_{LLM} (for HID light sources).

In general, a number of additional contract performance clauses (CPCs) have been introduced where deemed necessary and any abbreviations relating to ratios (should in theory always begin with R) and factors (should in theory always now begin with F) have been updated.

For traffic signals, the energy efficiency and lifetime criteria have been replaced by a life cycle cost criterion (TS and AC). Warranty criteria have also been introduced (TS and AC) as well as a contractual requirement for correct installation and the provision of instructions.

5 Scope of criteria

The proposal for the scope of the product group in the last Technical Report (TR 1.0) is compared with a new proposal for this report (TR 2.0) in Table xx below.

Table 3. Scope for existing EU GPP criteria

Road lighting and traffic signals	Road lighting
Technical report 1.0 (October 2016) **Road lighting**: fixed lighting installation intended to provide good visibility to users of outdoor public traffic areas during hours of darkness to support traffic safety, traffic flow and public security according to standard EN 13201-2 road classes on road lighting including similar applications as used for car parks of commercial or industrial outdoor sites and traffic routes in recreational sports or leisure facilities" **Traffic signals**: red, yellow and green signal lights for road traffic with 200mm and 300mm roundels according to EN 12368. Portable signal lights are specifically excluded.	**Technical Report 2.0 (July 2017)** **Road lighting:** In accordance with EN 13201-2, the term road lighting refers to fixed lighting installations intended to provide good visibility to users of outdoor public traffic areas during hours of darkness in order to support traffic safety, traffic flow and public security. Specifically excluded are lighting installations for tunnels, toll stations, canals and locks, parking lots, commercial or industrial sites, sports installations, monuments and building facades. **Traffic signals**: red, yellow and green signal lights for road traffic with 200mm and 300mm roundels according to EN 12368. Portable signal lights are specifically excluded.

By referring to EN 13201-2 in the product group scope, it is implied that all of the road classes defined therein are included. The standard splits roads into three broad classes (M, C or P) and grades (e.g. M1-M6, C0-C5 and P0-P5) based on the main types of road user, the volume of traffic, speed limits for vehicles and road geometries.

Stakeholder discussion

Initial stakeholder input was received in the form of responses to the initial scoping questionnaire. Some of the main findings were:

Table 4. Summary of responses from questionnaire (16 responses)

Scoping question	Yes	No	No opinion
Should the scope continue to be aligned with EN 13201?	9.5	5.5	1
Should the scope continue to include traffic signals?	4	4	8
Should there be specific criteria for LED retrofit situations?	10	6	0
Should there be criteria for poles?	3	12	1
Should there be criteria or power cables?	1	11	4
Should there be criteria for metering or billing?	10	5	1
Should there be specific criteria for LED luminaires?	15	1	0

A minority of stakeholders wanted to extend the scope of the product group beyond EN 13201 to include other applications such as parking lots and other areas in commercial and industrial zones. However, when discussing issues such as the calculations for PDI and AECI values for energy efficiency, it quickly became apparent that it would be complicated to set particular ambition levels for energy efficiency for these types of lighting installations.

Some stakeholders criticised the alignment with EN 13201 in the scope because they felt that the standard encourages over-lighting of roads when compared to current typical practice in many EN Member States. However, JRC emphasised that the alignment of the scope with EN 13201-2 does not in any way imply that the EN 13201-1 guidance for setting lighting levels for each road class are to be followed or complied with by procurers who wish to apply the EU GPP criteria. EN 13201-1 simply provides guidance for how to define what class of road you have and then suggests minimum lighting levels for each road class. The choice of lighting levels is ultimately up to the procurer and will be influenced by local, regional or national planning rules. Lighting levels will always be nuanced by site specific factors such as the need for vertical lighting and facial recognition, pole heights, the use of decorative luminaires in residential areas and historical areas and the potential for obtrusive light. The JRC encourage that procurers wishing to follow the EU GPP criteria follow the ALARA (As Low As Reasonably Achievable) principle when deciding on required lighting levels.

Most respondents had no opinion on whether to include traffic signals in the scope or not. All specific comments from respondents on this matter are presented below:

Table 5. Comments about traffic signals received from respondents

For traffic signals in scope	Against traffic signals in scope
Yes, sadly, there still seems to be a market for halogen traffic signals among municipalities, perhaps due to controls or some other factor. This also allows for a detailed review and further improvement in the criteria, including for example efficacy, materials, lifetime and so-on which would no longer be addressed if they were taken out of scope.	I would remove traffic signals as street lighting is quite different area.
	Yes, it would be better to have specifications for street lighting in one (standing alone) document because of different technical system.
	Too many documents will increase the complexity and make it harder to keep the document actual.

Discussions with stakeholders during the project so far have revealed that experience of the group is almost exclusively with road lighting applications instead of traffic signals. It is quite clear that traffic signals is a separate area of expertise from road lighting and that the background research for one is not automatically valid for the other. Consequently it is unclear whether criteria for traffic signals should continue to be included together with road lighting. This will be a matter for discussion at the 2nd AHWG meeting.

Other feedback revealed that there was a strong demand for criteria specifically about LED luminaires and that there should be no criteria for poles and cables. There was also a reasonable level of support to include criteria for metering and for LED retrofit situations. New criteria have been proposed for LED luminaires and metering.

5.1 *Different applications for road lighting criteria*

All municipalities and road authorities require road lighting to some degree and 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 of luminaires within an outdoor public traffic area, while keeping wiring and lighting controls.

d. Retrofit of lighting controls, while keeping original luminaires.

e. Replacement lamps.

For new installations, the approach is quite straight-forward in the sense that a design will be needed which will specify the optimum placement of poles and the luminaire mounting heights and tilt angles. When specifying luminaires and light sources, it is enough to simply look at what are the better performing products on the market and set the energy efficiency criteria accordingly. The design of a new system may be carried out by the contracting authority's in-house staff, or by a street lighting contractor or an independent lighting designer. The installation work is usually carried out by a contractor.

Existing installations will represent the vast majority of procurement exercises in Europe. Due to the continual improvements in energy efficiency of LED lighting technology in the last 5 years and rapidly decreasing costs, procurers with HID lamps in their lighting installations are under pressure to consider alternatives (i.e. points b, c or d above) instead of simply buying the same lamps as before to replace old ones (i.e. point e above).

The overall approach to the GPP criteria is illustrated in Figure 4. In cases where the road lighting installation already exists, the procurer is recommended to do a quick preliminary estimation of the luminous efficacy or PDI or AECI of existing installed road lighting light sources and/or luminaires. If the result is that the existing light sources have a very high luminous efficacy already, this may be sufficient justification to simply relamp the installation. However, in cases where there are doubts about the energy efficiency of the existing installation, any relamping scenario should be costed and checked against life cycle costs of LED retrofitting or redesigns using estimated energy efficiency data. These preliminary assessments do not form part of the EU GPP criteria themselves but further details about them can be found in a separate guidance document for road lighting procurement.

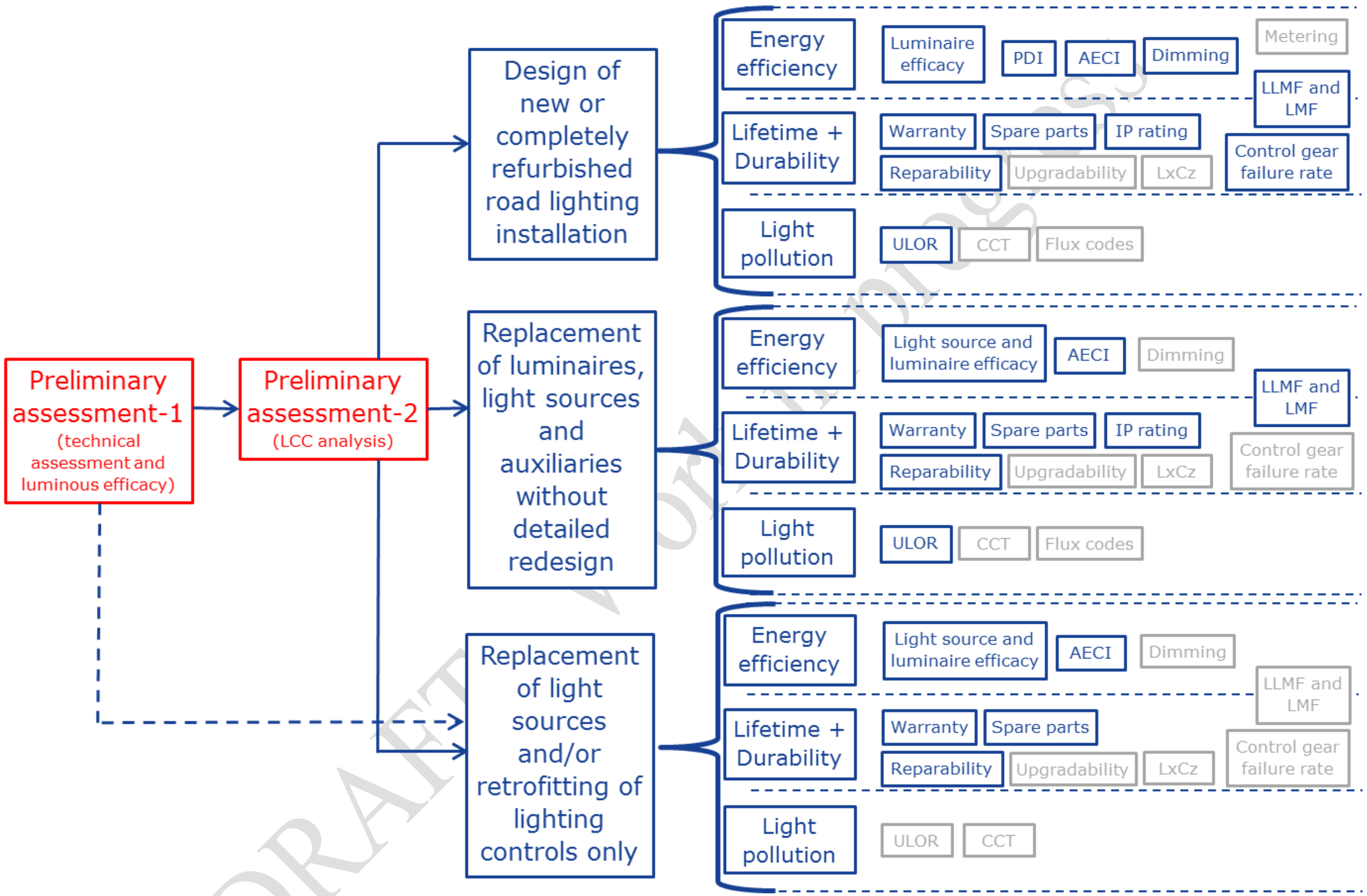

Figure 4. Overview of approach to GPP criteria for the product group "road lighting"

The overall aim of the preliminary checks is to first know how energy efficient the current installation is and second, to determine what kind of savings (energy and cost) are possible with the different options (i.e. redesign with new luminaires, luminaire replacement or only light source/controls replacement).

As can be seen in Figure 4, there are three main options for procurement. For each option, criteria are split into one of three groups: Energy Efficiency, Product Lifetime and Light Pollution. Criteria in blue are considered as being required in almost all circumstances while criteria in grey may or may not apply depending on the situation.

The top option is the most comprehensive because a lighting design is required. This option is most likely for any new roads and renovation on existing heavily trafficked roads and where speed limits and conflict areas represent a sufficient risk to road users. In countries and regions where road lighting classes are specified for the road in question, then a re-design will inevitably be required.

The middle and bottom options are more likely to apply to smaller roads and P class roads (i.e. predominantly for pedestrians) with lower lighting requirements or where minimum lighting classes and other characteristics defined in EN 13201 are not stipulated by regional or national legislation.

The criteria for road lighting are split into three broad criteria groups: energy efficiency, light pollution and product lifetime and durability.

For a given criteria area, minimum technical specifications and/or award criteria are provided together with any notes that explain in what situation these should apply/not apply. When there is an obvious need for a contract performance clause (CPC), a suggested CPC is also provided.

Each criterion is preceded by sections about relevant background research, supporting rationale and stakeholder discussion. Closely related criteria may be grouped together with a common background research and stakeholder discussion.

6 Selection Criteria

As stated earlier in the introduction, selection criteria apply to the tenderer and should focus on aspects related to the capability of the tenderer to meet to the requirements of the contract, should they be successful in the bidding process. Criteria presented here focus on technical aspects although it should be noted that financial aspects can also be specified here.

6.1 *Background research and supporting rationale*

For lighting installation design teams

In order to properly design a road lighting installation, a thorough knowledge of the current market and underlying trends, the EN 13201 standard series, lighting design software and installation practices is needed. Furthermore, a good understanding of the planning and approval processes of outdoor lighting installations will be needed. These processes will be subject to national spatial planning and road legislation and which may fall under the responsibility of municipalities or other authorities. Therefore, this criterion requests evidence to prove that the tenderer will meet clear minimum requirements that will help demonstrate that they have the required know-how and range of competencies to successfully design a new or renovated lighting system. It is also worth highlighting the recent introduction and recognition of the degree of European Lighting Expert in several countries[10], which could potentially be used as a reference in relevant countries.

[10] http://europeanlightingexpert.org/

For teams installing lighting equipment

The same rationale as for the selection criteria for the design team applies to the selection criteria for the installation team. In order to properly install a road lighting installations excellent knowledge is required from the market status, the EN 13201 standard series and installation practices. Therefore this criterion searches for evidence to proof that the required skills are available for the service requested.

Aspects common to designers and installers

In both selection criteria, requirements should not be too stringent as to present a barrier to the market for new or emerging companies. For this reason, the minimum requirements for experience are limited only to the senior member of staff working for the tenderer who will ultimately sign off any final design or approve the adequacy of installation works.

The level of experience can be misleading if only considered in terms of time. Thus it is also important to allow for the recognition of the number of projects and scale of projects as part of experience in tenderer teams.

In some cases, a successful tenderer may sub-contract a more experienced consultant to check and approve their design. In such cases, the tenderer may simply commit to contracting such a consultant should they be awarded the contract but without knowing precisely who that consultant would be yet. Even if sufficiently qualified staff is already directly employed by the tenderer, they may leave the company before the contract is undertaken. For these reasons, it is important that the selection criteria are also covered by a contract performance clause.

6.2 *Stakeholder discussion*

One point that was raised was the lack of any mention of specific lighting design software when stating minimum experience and requirements for the design team or designer. It was added that in some cases the use of different software for the same design can generate variations in the final results although the scale of these variations is uncertain.

One of the basic principles of EU GPP criteria is to try to remain impartial with respect to selection criteria and so it would not be recommendable to stipulate a specific software program and not another one that can be used for the same purpose. However, if the procurer has a history of working with designs using particular software, then they are of course free to specify this in their individual ITT – but one particular piece of software cannot be promoted over others in EU GPP criteria.

Another discussion point was to try to be more specific about the quantity of relevant experience for installers and designers. The need to strike the right balance between a certain minimum experience and unintentionally creating barriers to potential tenderers was emphasised. One potential solution is to place quite stringent requirements only on the person who will finally check, approve and sign off the lighting design / installation work.

The drawback of only requiring a minimum amount of time in the job (i.e. 3 years) does not mean that much relevant project experience has been gained and the drawback of only requiring a minimum number of completed projects is that there is the possibility that 3 small short-term projects are valued more than 1 major long-term project. For this reason, a clause has been inserted to allow the procuring authority to accept experience in a lower number of projects if they are of a sufficient scale.

The other main discussion point was the risk that tenderers insert the names of highly qualified individuals simply to pass the selection criteria but then, if awarded the contract, they would then go and employ someone less qualified, either to save costs or due to the unforeseen unavailability of the original person/people. For this reason, a contract performance clause covering this potential situation has been inserted.

6.3 *Proposed selection criteria*

Core criteria	Comprehensive criteria
SC1 - Competences of the design team	

(Applies when a lighting design is requested in the procurement exercise).

The tenderer shall demonstrate that the design will be checked and approved by personnel with the following minimum experience and qualifications:

- at least three years of experience in lighting design, dimensioning of electrical circuits and electrical distribution networks and having been involved in the design of at least three different outdoor lighting installations,
- certified level of competency in the use of lighting design software for PDI and AECI calculations (e.g. European Lighting Expert certificate)
- experience with the use of validated lighting calculation software (e.g. according to CIE 171),
- holding a suitable professional qualification in lighting engineering or membership of a professional body in the field of lighting design.

Verification: The tenderer shall supply a list of the person(s) who will be responsible for the project should the tender be successful, indicating their educational and professional qualifications, relevant design experience in real projects and, if relevant, any lighting design software quality certification. This should include persons employed by subcontractors if design work is to be sub-contracted.

The procuring authority, at its own discretion, may accept experience in less than three lighting installation designs if the scale of the design project(s) was sufficiently large (i.e. amounting to at least 70% of the scale of the design project that is the subject of the Invitation To Tender), and duration of the design project(s) sufficiently long (i.e. amounting to at least three years.

Core criteria	Comprehensive criteria
SC2 - Competences of the installation team	

(Applies when responsibility for installation is not assumed by the procuring authorities own maintenance staff)

The tenderer shall demonstrate that the installation works will be planned, checked and approved by personnel with the following minimum experience and qualifications:

- at least three years of relevant experience in the installation of outdoor lighting systems and having been involved in the installation of at least three different installation projects,
- having a suitable professional qualification in electrical engineering and membership of a professional body in the field of lighting (e.g. certified lighting technician). The list of relevant installed lighting systems with relative 'scale of the project' should be reported.

Verification:

The tenderer shall supply a list of person(s) responsible for the installation works should the tender be successful, indicating their educational and professional qualifications, training logs and relevant installation experience in real projects. This should include persons employed by subcontractors if installation work is to be sub-contracted.

The procuring authority, at its own discretion, may accept experience in less than three lighting installation works if the scale of the works was sufficiently large (i.e. amounting to at least 70% of the scale of the design project that is the subject of the Invitation To Tender), and duration of the works sufficiently long (i.e. amounting to at least three years).

Core criteria	**Comprehensive criteria**
CPC1 – Assurance of adequately qualified staff to carry out contracted tasks	
(Applies when SC1 and/or SC2 have been applied) The successful tenderer (contractor) shall ensure that the same staff mentioned in the documentation provided to demonstrate compliance with SC1 and/or SC2 are indeed involved in the works covered by the contract. When original personnel assigned to the project are not available for whatever reason, the contractor must communicate this to the procuring authority and provide a substitute of equivalent or higher experience and competency. Proof of the credentials of any substitute personnel shall be submitted in the same manner as described in SC1 and/or SC2, as appropriate.	

Questions to stakeholders:

Q1. Would you support a proposal to insert a list of relevant professional bodies and qualifications from different Member States (and help provide examples of such from your own Member States)?

e.g. UK: Certified by the Institution of Lighting Engineers and a member of the Institution of Lighting Professionals.

Q2. What are the main lighting design software programs used for road lighting? Should they need to be validated against CIE 171[11]? What is the scale of potential variation caused by using different software for the same designs?

[11] http://agi32.com/blog/tag/cie-1712006/

7 Energy efficiency criteria

With road lighting installations, for any given minimum lighting requirement, there is a clear link between environmental benefits and improved energy efficiency of light sources and luminaires. Cost savings is also a clear driver for improved energy efficiency although in this respect care has to be taken to focus on life cycle costs and not simply operational costs. As the market for LEDs in outdoor lighting matures, capital costs are decreasing all the time and as electricity costs continue to increase, the relative importance of energy efficiency in life cycle cost calculations increases too.

Due to the importance of energy efficiency criteria on both environmental and economic aspects, a minimum cut-off requirement is proposed as a technical specification and an award criterion is proposed in order to encourage tenderers to go further.

A potential contract performance clause is also provided to ensure that the lighting installation actually delivers on the minimum energy efficiency and lighting requirements. Arguably the best way to ensure compliance with predicted energy consumption performance is to have a metering system for the lighting installation split by defined zones or even to monitor power consumption at the level of the individual luminaire which would be reported automatically to a remote system.

Apart from more efficient lighting, attention must be paid to the potential savings via the use of dimming controls to reduce light output, and thus energy consumption, during programmed periods of expected low use of roads. The importance of dimming is reflected in a technical specification for compatibility of light sources and luminaires with dimming controls and minimum % dimming possibilities and controls.

For each criterion, it is stating under what type of situation it should be applied, i.e. the design of a new lighting installation, the re-design of an existing installation or simple re-lamping of an existing installation.

<u>The importance of energy efficiency</u>

There is broad agreement in the life cycle assessment community that the dominant source of environmental impacts associated with road lighting is electricity consumption during the use phase. The outputs of studies in the literature generally follow the same tendency as given below in Figure 5.

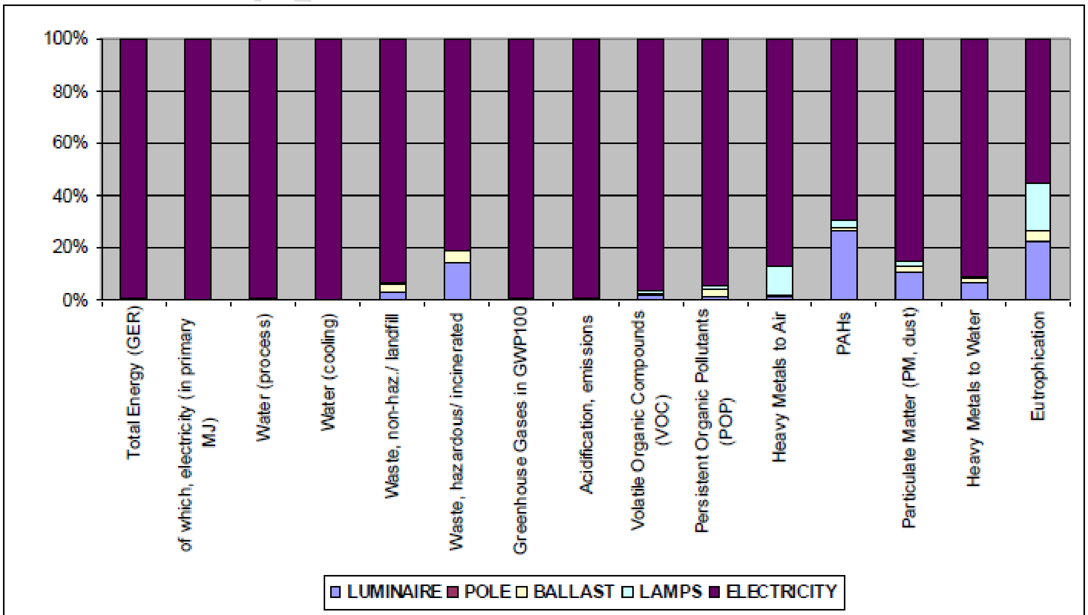

Figure 5. Breakdown of the life cycle environmental impacts of road lighting (Van Tichelen et al., 2007)

Despite this clear relationship, it is worth noting that as lamp technologies become for energy efficient, impacts associated with materials used may become relatively more important. This will ultimately depend on the environmental footprint of the specific materials used and the lifetime over which the lamp and other components can be expected to last.

Existing EU GPP criteria for energy efficiency

In the 2012 EU GPP criteria, minimum requirements for luminous efficacy were defined for different lamp technologies when *lamps, ballasts or luminaires were being purchased*. Apart from the effect of different lamp technologies, the minimum required luminous efficacies varied as a function of the rated wattage because the power rating has an influence on the energy efficiency of the main lamp technologies used in 2012. Energy losses due to ballasts were treated separately.

This was a far from ideal solution because simply replacing existing lamps and ballasts with more energy efficient ones may simply result in over-lighting while the energy consumption remains the same.

When considering criteria for *new lighting installations or renovation of existing installations*, the 2012 EU GPP criteria did make some attempt to link energy efficiency to the lighting level of class C and class P roads:

- Maximum 0,044 $W/(lux \cdot m^2)$ if $E \leq 15$ lux
- Maximum 0,034 $W/(lux \cdot m^2)$ if $E < 15$ lux

However, energy efficiency requirements linked to only two lighting levels (above or below 15 lux) is not appropriate considering that EN 13201-1:2014 suggested lighting levels for C and P class roads are set at 0.4, 0.6, 1.0, 1.5, 2.0, 3.0, 7.5, 10, 15, 20, 30 and 50 lux (see Figure 1).

The rise of LED lighting technology means that there are now many options for improving the energy efficiency of road lighting installations and that energy efficiency criteria should aim to be as horizontal as possible, without being nuanced for different installed power ratings and lamp technologies.

Key terms and definitions from EN 13201-5

In order to ensure a consistent approach to defining the energy efficiency of a road lighting installation, it is recommended to follow the definitions and methodology provided in EN 13201-5: 2016 "Road lighting – energy performance indicators". This standard introduces several key definitions:

- **Luminous efficacy** (η), expressed in lm/W.
- **Power Density Indicator** (PDI) expressed in $W/(lx.m^2)$.
- **Annual Energy Consumption indicator** (AECI) expressed in $kWh/(m^2.y)$.
- **Operational profile**: the number of hours the lighting installation will be switched on for each day and at what percentage of full power it will operate at for each hour.
- **Road profile**: the layout of the road, including any sidewalks and other areas intended to be lit and excluding any intermediate areas, such as vegetated strips and central reservations, not intended to be lit.

The key terms for measuring energy efficiency are PDI and AECI, although these cannot be calculated without first knowing the luminaire efficacy, road profile and operational profile.

7.1 *Luminaire efficacy*

7.1.1 Background research and supporting rationale

The luminous efficacy is basically how much useful light (in lumens) can be produced by a given unit of power (1 Watt). Luminous efficacy can be defined at various different levels: of the light source, of the luminaire containing the light source or the installation containing all the luminaires. A calculation defined in EN 13201-5:2016 for luminous efficacy of an installation is as follows:

$$\eta_{inst} = C_L \ x \ F_M \ x \ U \ x \ R_{LO} \ x \ \eta_{ls} \ x \ \eta_P$$

Where:

- η_{inst} is the installation luminous efficacy in lm/W
- C_L is the correction factor where a design is based on luminance or hemispherical illuminance instead of illuminance
- F_M is the overall maintenance factor of the lighting installation (this is a combination of individual maintenance factors for decreased lumen output from the light source and for dirt gathering on the housing), it is the product of F_{LLM} and F_{LM}.
- U is the utilance of the installation (i.e. the fraction of light output reaching the target area)
- R_{LO} is the optical efficiency of the luminaire (i.e. how much of the light output of the light source leaves the luminaire)
- η_{ls} is the luminous efficacy of the light source alone (in lm/W)
- η_p is the power efficiency of the luminaire (i.e. accounting for power losses in control gear).

Data provided by lighting equipment manufacturers about luminous efficacy will provide information about the light output and power consumption of the light source alone and when mounted in the luminaire. Power losses in control gear may or may not be reported separately, although this should not be important for the currently proposed EU GPP criteria so long as the combined overall power consumption figure is provided.

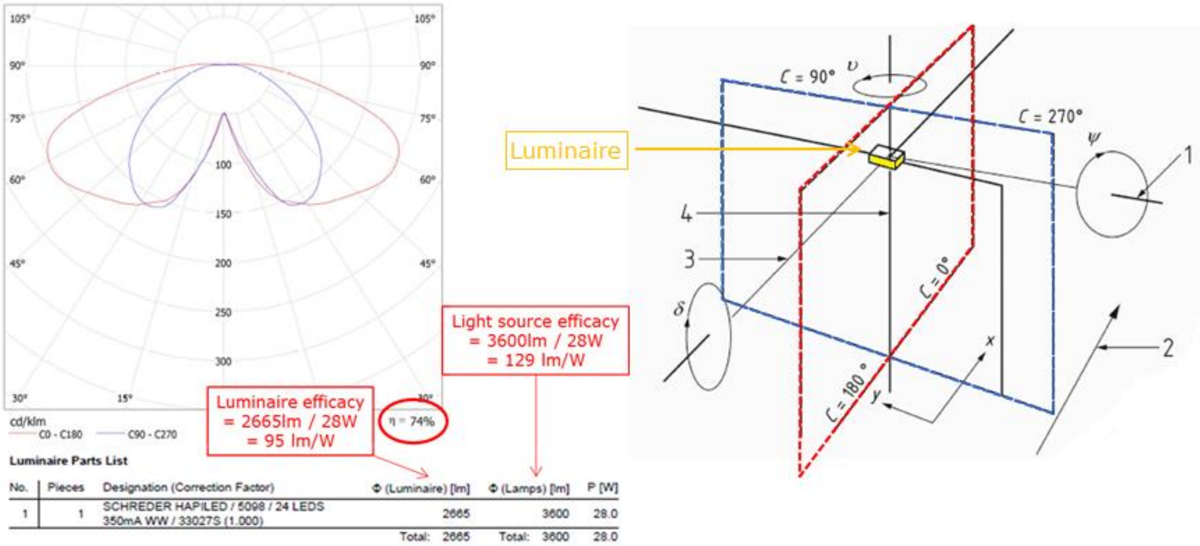

Figure 6. Example of light output and power consumption data provided in a luminaire manufacturer data sheet (left) and a 3-D illustration of the 0-180 and 90-270 axes (right)[12].

In the above case, the optical efficiency (R_{LO}) of the luminaire was 74% (or 0.74) and the luminaire efficacy (the product of R_{LO}, η_{ls} and η_p) was around 95 lm/W. The step from luminous efficacy of luminaire to the luminous efficacy of the installation is quite a big one.

[12] Luminaire data sheet was for SCHREDER HAPILED/5098/24 LEDS 350mA WW/33027S and the 3-D illustration of the 0-180 and 90-270 is adapted from EN 13201-3.

One crucial aspect is the utilance (U). To better estimate the utilance, detailed information about the road layout, target areas to be illuminated, pole layout, mounting height of luminaires and tilt angles of luminaires would be required. The Belgian approach to this is described later in section 7.3.1 when describing approaches to PDI and AECI specifications.

Maintenance factors will mean that the luminaire efficacy will vary with time, even if dimming controls are installed to gradually "dim less" in order to maintain a constant light output in deliberately over-designed lighting installations. This aspect is presented in more detail in section 7.3.4.

Initial proposal in TR 1.0

In TR 1.0, it was proposed to have some minimum requirements for luminaire efficacy (105 lm/W for core level and 120 lm/W for comprehensive level). The main justification for this criterion was that it forms the basis for any calculations of energy efficiency of the installation (i.e. PDI or AECI) and is much easier to verify, with data readily available from suppliers. In projects where a detailed design is not specified for whatever reason, especially when light sources are to be retrofitted to existing luminaires, the luminaire efficacy will be an important contribution to demonstrating the energy efficiency of the installation.

7.1.2 Stakeholder discussion

The main criticism of criteria for luminaire efficacy was that a good efficacy value does not guarantee an energy efficient road lighting installation. However, the counter argument is that it is extremely difficult, if not impossible, to deliver an energy efficient road lighting installation using luminaires with a poor luminous efficacy.

It was felt by some stakeholders that ambition levels should not be varied for different types of luminaire, but paradoxically concern was expressed that the current proposals would only allow for luminaires with white LED light sources, effectively excluding warm LED and low wattage HPS. Other stakeholders felt that a clear distinction must be made between efficacies for "pure" road lighting luminaires and efficacies in urban areas where luminaires may also have some sort of decorative design and also need to provide amenity lighting as well as road lighting. In Belgium, the Synergrid technical specification C4/11-3 for LED luminaires excludes luminaires that are used in ground lamps and spotlights, used in illuminated markers or lighting columns less than 3m high or used in appliances that are purely for artistic or architectural purposes.

Italian GPP approach

It was claimed that in Italy, a distinction is indeed made between "pure road lighting" and road lighting for pedestrian walkways and in historic city centres. National legislation has been introduced to support the implementation of a Parameterized Energy Index for Luminaires (IPEA) – essentially a labelling system for road lighting luminaires that is largely based on luminous efficacy that results in labels from A+++++ (A5+) to F.

This label is scaled according to the relevant reference luminaire efficacy, which varies according to the lamp wattage and the road type as shown below.

Table 6. Italian reference values for luminaire efficacy for different outdoor lighting applications

Rated Power	**Luminaire efficacy reference values**				
	Road lighting	**Area lighting, roundabout, parking lot**	**Pedestrian area, bike lane**	**Green area lighting**	**City centre with historic lantern**
P < 65	73	70	75	75	60
65 < P < 85	75	70	80	80	60
85 < P < 115	83	70	85	85	65
115 < P < 175	90	72	88	88	65
175 < P < 285	98	75	90	90	70
285 < P < 450	100	80	92	92	70
450 > P	100	83	92	92	75

Dividing the actual luminaire efficacy by the reference luminaire efficacy generates the IPEA value. The higher the IPEA value, the higher the performance label assigned to the actual luminaire. For example, "G" is <0.40, "F" is 0.40-0.55, "E" is 0.55-0.70, "D" is 0.70-0.85 and "C" is 0.85-1.00. The B (1.00-1.10), A (1.10-1.20), A+ (1.20-1.30), A++ (1.30-1.40) and higher labels apply when the actual luminaire performance exceeds the reference efficacy value.

Looking specifically at the reference efficacy values for "road lighting", the different luminaire efficacies required to achieve a particular IPEA label can be easily calculated.

Table 7. Translation of Italian IPEA values into luminaire efficacies for different labelling classes for "road lighting".

Rated power (W)	Reference Luminaire efficacy (lm/W)	IPEA labelling class										
		A5+	A4+	A3+	A2+	A+	A	B	C	D	E	F
<65	73	116.8	109.5	102.2	94.9	87.6	80.3	73	62	51.1	40.1	29.2
65-85	75	120	112.5	105	97.5	90	82.5	75	63.8	52.5	41.3	30
85-115	83	132.8	124.5	116.2	107.9	99.6	91.3	83	70.6	58.1	45.7	33.2
115-175	90	144	135	126	117	108	99	90	76.5	63	49.5	36
175-285	98	156.8	147	137.2	127.4	117.6	107.8	98	83.3	68.6	53.9	39.2
285-450	100	160	150	140	130	120	110	100	85	70	55	40
>450	100	160	150	140	130	120	110	100	85	70	55	40

In terms of ambition level, minimum requirements for EU GPP criteria would fall somewhere between A+ and A5+. The above levels and classes apply only for "road lighting", but the reference luminaire efficacy values for different roads, such as pedestrian paths, cycle paths and historic city centres is included in the table below for comparison.

According to Italian stakeholders, the IPEA values above were developed based on EN 13201, 245/2009/EC and 347/2010/EC as well as market enquiries and field experience. From the Italian experience, it is clear that city centre lighting is considered as less efficient than road lighting but that lighting of bike lanes and pedestrian areas can be more efficient

For pure road lighting luminaires, one stakeholder felt that the proposed efficacies in TR 1.0 (i.e. 105 and 120 lm/W) could be made even more ambitious. There is a plethora of market data for LED-based luminaire efficacy from the US. Therefore it is worthwhile to consider ambition levels in the context of this market data.

From an EU GPP perspective, the main drawbacks of the Italian approach are related to the labelling going well beyond A and complications with updating the reference levels to account for technological progress. The reference to a national level energy labelling system, which has presumably not been developed in accordance with the Energy Labelling Directive (2010/30/EU), is not recommended in EU GPP criteria published by the Commission. However, the actual numbers linked to the labels for luminaire efficacy (IPEA) and PDI (IPEI) could be used to support particular ambition levels for lighting in certain circumstances.

DesignLights Consortium (DLC)

An example of a tiered approach can be seen from the DesignLights Consortium as illustrated in Figure 7 below. The first tier is between minimum requirements for a "standard Qualified Products List (QPL)" (of 90-100 lm/W) and of a "premium QPL" (of 110-120 lm/W).

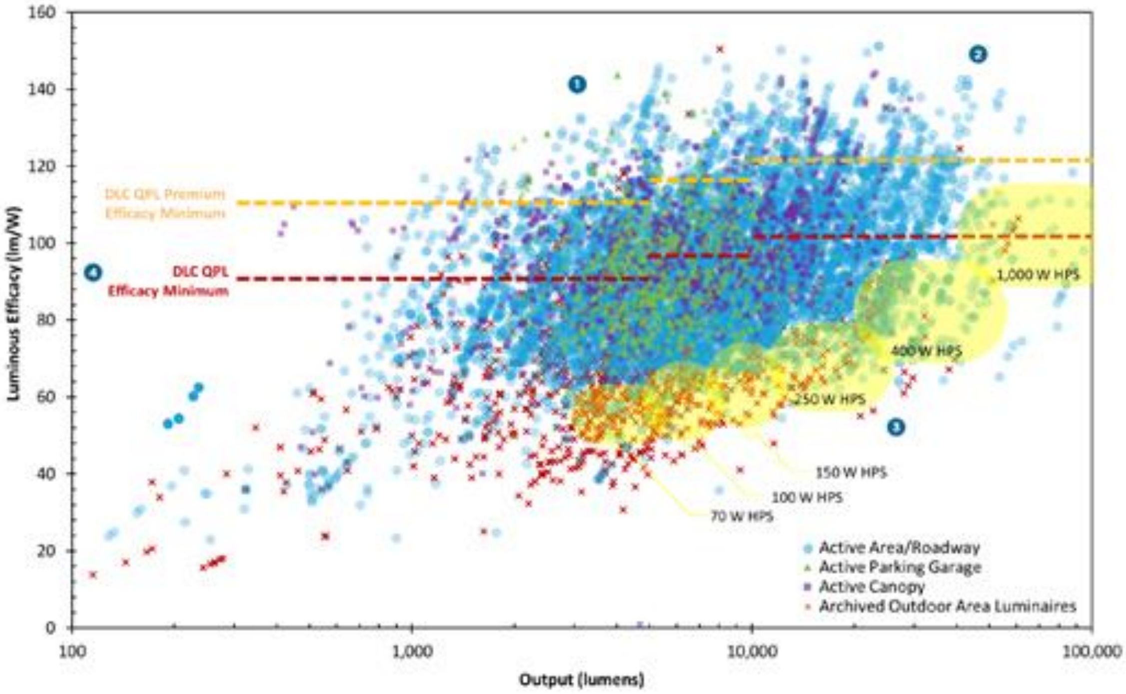

Figure 7. US DOE Lighting Facts database of road lighting luminaires with luminaire output (lumens) versus luminaire efficacy (source DOE[13] 8/2016)

Figure 7 shows that while the typical luminaire efficacies of HPS lamps (indicated in yellow areas) depends on the lumen output and wattage, the LED data for area/roadway lighting (blue points) is effectively independent of power rating and lumen output – except perhaps when output drops below 500 lumens. The DLC have recognised some minor relationship between luminous efficacy and lumen output for LED by stepping the minimum requirements for luminaires to appear on their Qualified Products List in 2016 by setting minimum requirements of:

- 90 lm/W up to 5000 lumen output,
- 95 lm/W for 5000-10000 lumen output
- 1000 lm/W for >10000 lumen output

Figure 7 also highlights how much LED-based luminaires for road lighting (blue points) can exceed HPS-based luminaires (yellow areas) in terms of luminous efficacy for outputs between 3000 and 30000 lumens. This increase in efficacy of HPS-based luminaires as the output increases is clear from Figure 7. This tendency was well

[13] DOE (10/2016): "CALiPER Snapshot Report on Outdoor Area Lighting', available on https://energy.gov/eere/ssl/articles/new-caliper-snapshot-report-outdoor-area-lighting

reflected for all HID type lamps in the current GPP criteria published in 2012. However, with LED technology there is no technical reason to introduce weaker requirements for luminaires with a lower wattage and/or road illuminance. When comparing the minimum requirements for the DLC QPL (Qualified Products List), it is clear that only high power (1000W) HPS lamps could meet the requirements.

Stakeholders generally acknowledged that any fixed minimum requirement for energy efficiency in GPP criteria would need to be reassessed as LED technology continues to rapidly improve. Due to the fact that GPP criteria are fully revised every 5 to 6 years but not periodically updated, the best way to do this would be to introduce a tiered approach to the PDI or luminous efficacy reference values, which could then be increased in a tiered approach.

Stakeholder proposal based on US Dept. of Energy (DoE) data

Three tiers of luminaire efficacy were proposed based on LED luminaire efficacy data trends between 2011 and 2016 and with the intention of targeting the top 75% of LED luminaires on the market for core level and the top 50% for comprehensive level.

An analysis of luminaire efficacy data from the US DOE (Department of Energy) database was submitted by one stakeholder to justify the tiered approach. The data covered around 5600 street light luminaires for models on the market from 2012 to 2016.

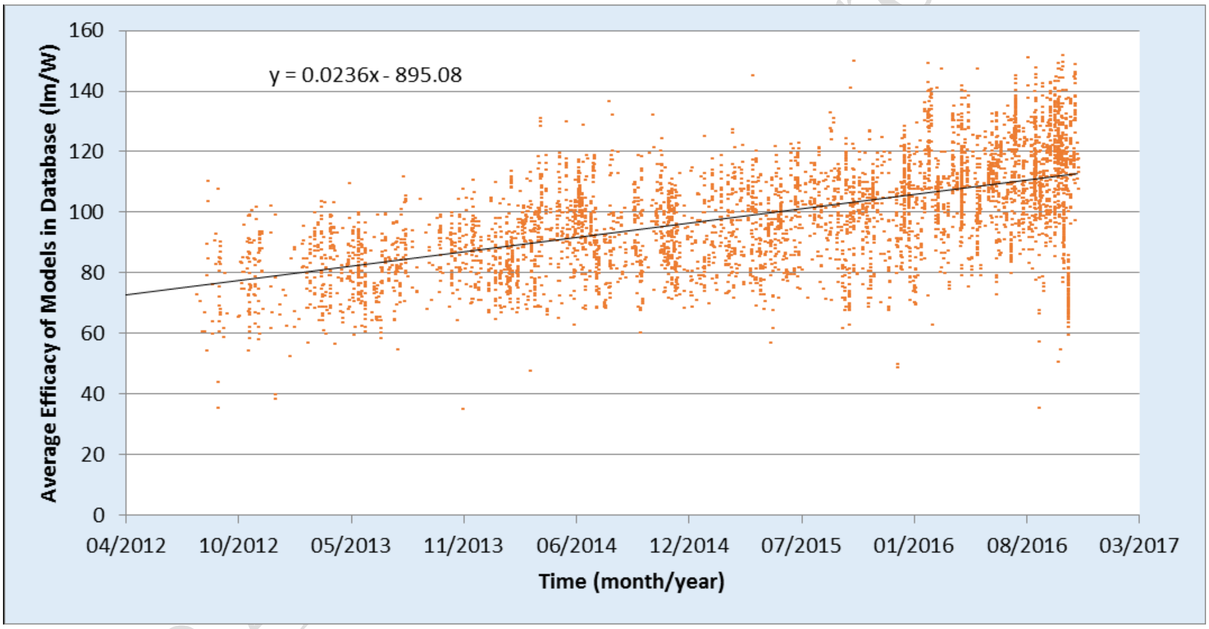

Figure 8. Scatter plot of luminaire efficacy data from 2012-2016 in the US DOE database.

The trendline shows an increase of approximately 8.6 lm/W each year between 2012 and 2016. The next step was to consider the percentage of 2016 street light luminaire models complying with different minimum cut-off's for luminaire efficacy. This led to the following observations:

- 96% meeting 80 lm/W
- 75% meeting 102 lm/W
- 50% meeting 112 lm/W

The stakeholder proposal was therefore to set core criteria ambition level to 102 lm/W and the comprehensive level criteria to 112 lm/W *if the criteria were to be published in 2016*. However, since the criteria are expected to be published in early 2018, accounting for the continued market improvements, it was proposed that the ambition level be set to 120 lm/W (core) and 130 lm/W (comprehensive) and run until 2020. After that, the ambition level would increase by 17 lm/W and in 2022, it would increase by another 17 lm/W. It was agreed that any reference values for luminous efficacy should be set at the level of the luminaire, so that any optical losses from luminaires and power losses from ballasts and control gear are accounted for.

On the other hand, some stakeholders expressed concern that too high a level of ambition might essentially exclude low wattage HPS and warm LED as possible options. It was also commented that in historic areas in city centres, it is possible that luminaires have a decorative function which would limit their luminous efficacy.

One possible workaround is to keep the ambition level for luminaire efficacy lower (e.g. use 2016 reference values in 2018) in the technical specification (which is essentially a minimum cut-off value) but then to award points to tenderers who specify luminaires with higher luminous efficacy in proportion to how much the minimum required efficacy is exceeded. The precise ambition level will no doubt be discussed further at the 2nd AHWG meeting.

When asked about what type of format the photometric file should be provided in, stakeholders mentioned EU lumdat (.ldt) and (.xls). However, the most important point was that the file format was compatible with open source software such as Dialux, Relux or Oxytech freeware.

7.1.3 Criteria proposals for luminaire efficacy

Core criteria	**Comprehensive criteria**
TS1 Luminaire efficacy	
(Applies when light sources or luminaires are to be replaced in an existing lighting installation and no re-design is carried out) The lighting equipment to be installed shall have a luminaire efficacy higher than 102 lm/W* ***Verification:*** The tenderer shall provide a standard photometric file that is compatible with open source software and that contains technical specifications of the light source or luminaire, measured by using reliable, accurate, reproducible and state-of-the-art measurement methods. Methods shall respect harmonised international standards, where available. **Due to the rapid technological developments in luminaire efficacy of LED-based lighting, it is proposed that the reference values stipulated here should increase over the next 6 years, to avoid them becoming obsolete before the EU GPP criteria are due for revision again. The proposed future values are:* • *2018-2019: 120 lm/W* • *2020-2021: 137lm/W* • *2022-2023: 155 lm/W* *In certain cases, e.g. use of decorative luminaires in historic city centres, or where a very low (e.g. <2100K) CCT is also specified, the procurer may choose to apply a lower*	*(Applies when light sources or luminaires are to be replaced in an existing lighting installation and no re-design is carried out)* The lighting equipment to be installed shall have a luminaire efficacy higher than 112 lm/W* ***Verification:*** The tenderer shall provide a standard photometric file that is compatible with open source software and that contains technical specifications of the light source or luminaire, measured by using reliable, accurate, reproducible and state-of-the-art measurement methods. Methods shall respect harmonised international standards, where available. **Due to the rapid technological developments in luminaire efficacy of LED-based lighting, it is proposed that the reference values stipulated here should increase over the next 6 years, to avoid them becoming obsolete before the EU GPP criteria are due for revision again. The proposed future values are:* • *2018-2019: 130 lm/W* • *2020-2021: 147 lm/W* • *2022-2023: 165 lm/W* *In certain cases, e.g. use of decorative luminaires in historic city centres, or where a very low (e.g. <2100K) CCT is also specified,*

minimum luminous efficacy.	*the procurer may choose to apply a lower minimum luminous efficacy.*
AC1: Enhanced luminaire efficacy	
(Applies when light sources or luminaires are to be replaced in an existing lighting installation and no re-design is carried out) Up to X points shall be awarded to tenderers who are able to provide light sources or luminaires which exceed the minimum luminous efficacy defined in TS1. Maximum points (X) will be awarded to the tender with the highest luminous efficacy value and points shall be proportionately awarded to any other tenders whose light sources or luminaires exceed the minimum requirements of TS1 but do not reach the value of the highest efficacy tender.	
CPC2: Provision of lighting equipment that complies with efficacy claims	
The contractor shall ensure that the lighting equipment (including light sources, luminaires and lighting controls) is installed exactly as specified in the original tender. If the contractor changes the lighting equipment from those specified in the original tender, explanations must be provided in writing for this change and the luminous efficacy of the luminaire shall be at least equal to or better than the original (according to EN 13032-1 or EN 13032-4). In either case, the contractor shall deliver a schedule of the actually installed lighting equipment together with manufacturer invoices or delivery notes in an appendix. If alternative lighting equipment is installed, test results and reports for luminous efficacy from the manufacturer(s) of any new light sources and luminaires shall be provided.	

Questions to stakeholders (Luminaire luminous efficacy criteria):

Q1. What are your opinions about the proposed ambition levels and tiered approach?

Q2. What are the specific scenarios when lower luminaire efficacy cut-off's could be justified, why and by how much compared to the values in TS1?

Q3; Do we need a measurement certificate and quality assurance system to avoid overstating performance?

7.2 *Dimming controls*

7.2.1 Background research and supporting rationale

Dimming the light output of a road lighting installation saves energy. The relationship between dimming and power consumption is almost directly proportional for LED-based luminaires.

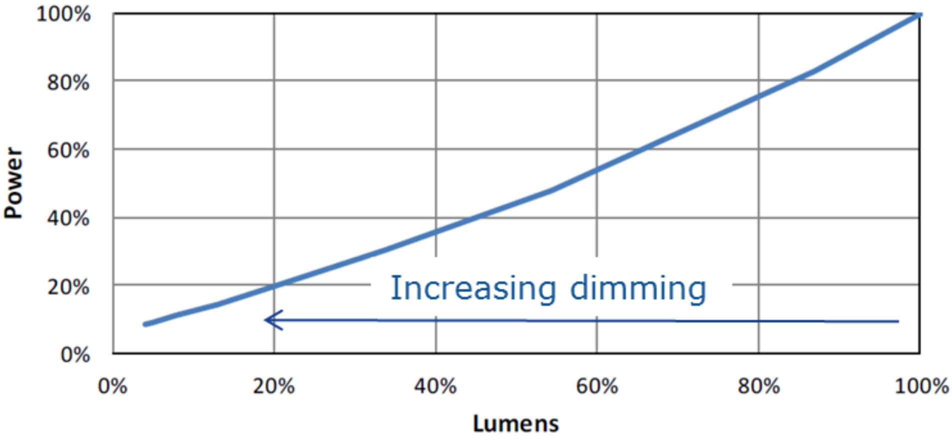

Figure 9. Relationship between power consumption and dimming of light output[14]

Many dimming controls can easily go down to 10% of maximum light output and some can even go to 1%. However, as the dimming levels increase, the basic low-level power consumption of the drivers and control units becomes increasingly significant, as can be demonstrated when the plotting luminaire luminous efficacy for the same luminaire under different dimming conditions.

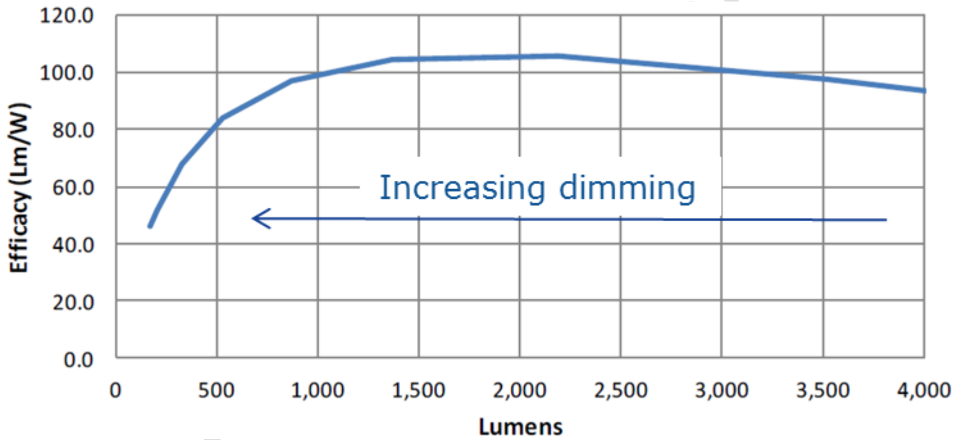

Figure 10. Relationship between luminaire efficacy and dimming of light output[15]**.**

When considering the data from Figure 9 and Figure 10, it is clear that all dimming is beneficial in terms of reduced costs and environmental impacts related to energy consumption. However, it should be noted that when dimming to extremely low levels (i.e. dimming to less than 20% of maximum light output), the luminous efficacy of the luminaire will reduce.

Another benefit of dimming is that it is possible to minimise light pollution on demand. In some cases, where a more efficient lamp has been retrofitted without the control drivers and ballast being modified or replaced accordingly, it is possible that the new lamp uses the same power input to simply generate more light, even if this is more than was desired. Dimming controls can correct for this.

Existing EU GPP criteria

Annex VII of Ecodesign Regulation EC/245/2009, which provides benchmarks for luminaires, states that:

[14] From: "Energy savings with Fluorescent and LED dimming", National Electrical Manufacturers Association (NEMA), 2015. Accessed online July 2017.
[15] From: "Energy savings with Fluorescent and LED dimming", National Electrical Manufacturers Association (NEMA), 2015. Accessed online July 2017.

"*Luminaires are compatible with installations equipped with appropriate dimming and control systems that take account of daylight availability, traffic and weather conditions, and also compensate for the variation over time in surface reflection and for the initial dimensioning of the installation due to the lamp lumen maintenance factor*."

The same wording is used as a comprehensive level award criterion in the current GPP criteria (published in 2012). It is worth noting that the criterion only requires "compatibility" with dimming and not the installation of dimming controls as such.

Without dimming controls, it is possible that lighting installations are either over-designed to produce excessive lighting at the beginning (before lumen output depreciation) or that they will sooner fail to meet the initially designed lighting levels (again due to lumen output depreciation).

The gradual depreciation in lumen output is a common issue for all lighting technologies and is related to both decreased output due to the light source itself (can only be addressed by reduced dimming or light source replacement) and also due to dirt gathering on the luminaire (can be addressed by increased cleaning cycles).

Operational profile

In order to reduce costs, local authorities are increasingly looking at the possibility of dimming during curfew hours (i.e. periods of low road use, typically midnight to 6am). The recognition of dimming is reflected in the EN 13201-5 standard (Road lighting Part 5 – Energy Performance Indicators), which defines the term "*operational profile*".

The operational profile refers to how long the lighting installation is powered up on a daily basis. With the possibility of dimming controls, the alteration of the level of power creates the possibility for many different operational profiles. Some examples of operational profiles are provided in Figure 11 below.

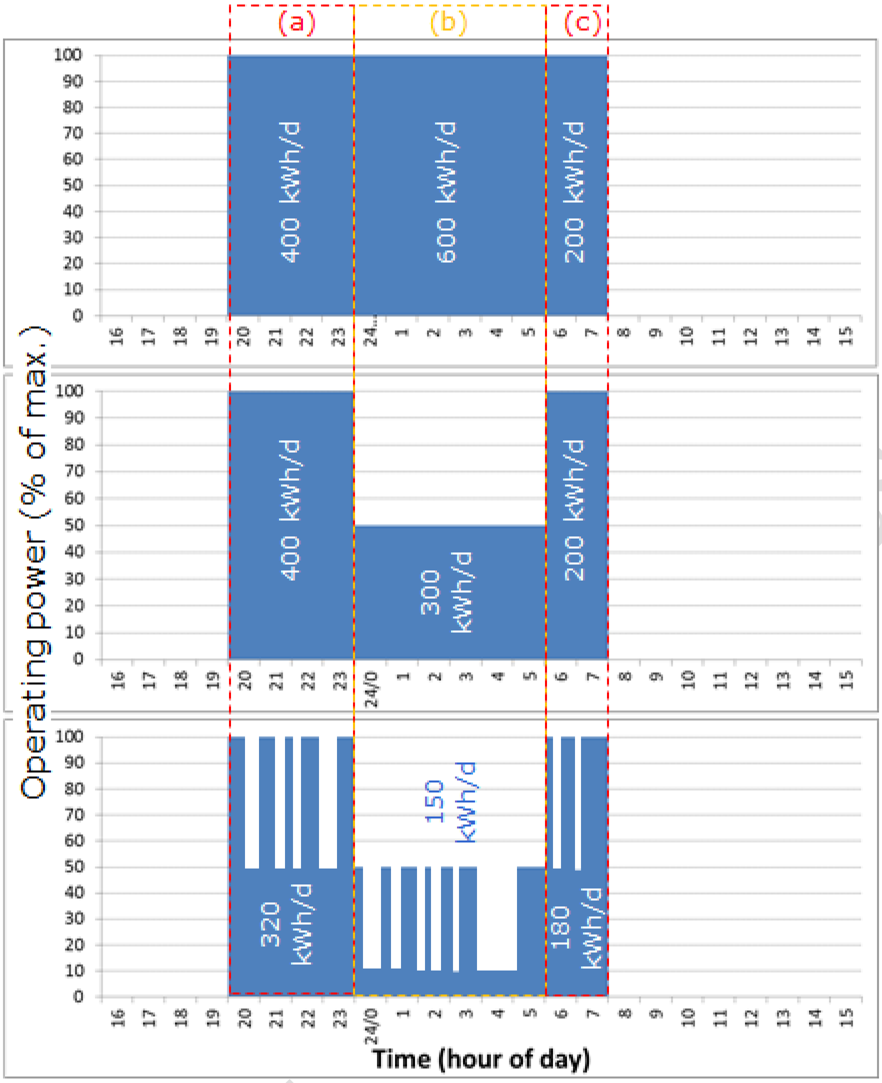

Figure 11. Examples of different operational profiles for road lighting installations during period a) evening peak hours, b) off-peak hours and c) morning peak hours (adapted from EN 13201-5). Consumption figures included refer to a 100kW installation

The top profile in Figure 11 refers to a simple on/off scenario for a lighting installation where the start and end time are programmed – this is typical of most existing installations and in this particular case, would consume 1200 kWh/d.

The middle profile in Figure 11 shows the implementation of a dimming scenario, where light output is reduced by 50% during the expected hours of low use (in this case from 0000 to 0600) – resulting in a consumption of 900 kWh/d – 25% less than the same undimmed installation.

The lower profile refers to a situation where the default light output is the same as in the middle profile, but only when sensors indicate that road use is above a certain minimum level. If road use is lower than this defined level, the lighting output will be automatically decrease from the default lighting level (from 100% to 50% during peak times or from 50% to 10% during off-peak times). Although the exact energy savings will vary from day to day, the road traffic pattern used in the assumption for Figure 11 resulted in a consumption of 650 kWh/d – almost 30% less than the simple curfew dimmed installation and almost 46% less than the same undimmed installation.

Possible cases where dimming control might not payback

Given the major operational cost savings that are possible with dimming controls, it seems unlikely that such an investment would not pay for itself. However, attention must be paid to the capital costs of dimming controls and the power rating of the luminaire. As the power rating decreases, the capital costs become more significant.

One example is with a low wattage luminaires where the extra cost for dimming controls (estimated around 50 euro) does not outweigh the savings. A quick calculation shows that for a 20W luminaire, the cost saving by reducing average energy consumption by 30% through dimming for 20 years is similar to the extra cost of the controls:

$$0.3\ x\ 20W\ x\ 4000h.yr^{-1}\ x\ 20yr\ x\ 0.11€.kWh^{-1} = 52.80€$$

The factor 0.3 corresponds to an easily achievable 30% energy saving due to implementing an operational profile that accounts for a 50% dimming during curfew hours (e.g. midnight to 6am) and prevents over-lighting of the newly installed luminaire which was specified to allow for gradual reductions in lumen output.

Future increases in electricity prices and future decreases in the costs of dimming controls will make dimming control more attractive from an investment perspective. In order to be able to take advantage of these potential future trends, and especially considering that many LED luminaires installed today will be expected to continue to operate for 10-20 years without any replacement, it is recommended that all installed luminaires and light sources are at least compatible with dimming controls.

Before deciding on whether to invest in dimming controls or not, procurers are encouraged to use the preliminary check based on LCC costing prior to launching any ITT.

7.2.2 Stakeholder discussion

Stakeholders were in general in favour of dimming controls being promoted, even in core criteria, where the installation of simple controls based on an astronomical clock could be specified. However, opinions differed about how exactly dimming should be promoted in the criteria.

In the proposal in TR 1.0, degrees of dimming were addressed indirectly simply by adjusting the CL factor in the equation that was proposed to measure the AECI. A CL factor of 1.1 was proposed for LED-based lighting in order to account for initial over-design to account for lumen output depreciation. It was proposed to reduce this factor from 1.1 to 0.85 (core) or to 0.75 (comprehensive). In order to maintain a constant AECI value, this would essentially require dimming of around 23% and 32% for core and comprehensive criteria respectively.

The assumptions behind the indirect dimming ambition levels were questioned by one stakeholder. Different opinions were expressed about the degree of dimming that would be allowable in certain situations. However, it is possible that procurers will already have clear ideas about what dimming scenarios they wish to implement (if any) and this could be specified in the Invitation to Tender (ITT) as a dimming ratio for the average illuminance with dimming divided by the average illuminance if no dimming was applied (e.g. E,m_{dim} / E,m_{nodim}). A similar idea was also suggested about the desire to see procurers specify AECI values with and without dimming.

For the purposes of calculating the impact of dimming on energy consumption tenderers should ideally provide the power curve for the luminaire with light output plotted against power consumption. The relationship is generally proportional except in high dimming scenarios where standby power consumption by control gear would become important.

Due to the fact that nearly all installations can benefit from dimming, for example to provide constant light output regulation (CLO) independent of the flux depreciation over time a requirements for dimming shall be included in the EU GPP criteria. The proposal in TR 1.0 about dimming was perhaps not so visible to procurers, so stand-alone criteria are proposed in TR 2.0. The installation of simple dimming controls based on an astronomical clock is provided as a basic requirement.

7.2.3 Criteria proposals for dimming

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">TS2: Dimming control compatibility</td></tr>
<tr><td colspan="2">(This criterion applies to all calls for tender, whether simply for relamping purposes, for re-design of existing lighting installations or the design of new lighting installations).

All light sources and luminaires shall be compatible with dimming controls.

Verification:

The tenderer shall provide documentation from the manufacturer(s) of the light sources and luminaires that are proposed to be used by the tenderer are compatible with dimming controls.

In cases where controls are not integrated into the luminaire, the documentation should state what control interfaces can be used for dimming.

The documentation shall also state what dimming methods are compatible, for example:
• Dimming based on pre-set curfew hours of low road use intensity.
• Initial dimming of over-designed lighting installations to compensate for gradual decreases in lumen output.
• Variable dimming to maintain a target illuminance in variable weather conditions</td></tr>
<tr><td colspan="2">TS3: Minimum dimming performance</td></tr>
<tr><td>Unless a preliminary LCC indicates otherwise, or the road lighting class is already the lowest one, this criterion applies to all calls for tender. The dimming scenario below is just one possible suggestion – procurers should have their own ideas and mention these in their ITT).

All light sources and luminaires shall be installed with fully functional dimming controls that are programmable to compensate for lumen output depreciation and for setting 1 level of curfew dimming which should be as low as 50% of maximum light output.

Verification:

The tenderer shall provide documentation from the manufacturer(s) of the light sources and luminaires that are proposed to be used by the tenderer showing that they are compatible with dimming controls.

The documentation shall also state what dimming controls are incorporated, for example:
• constant light output to compensate for lumen depreciation,
• pre-set curfew dimming or
• variable dimming based on weather conditions or traffic volume.</td><td>Unless a preliminary LCC indicates otherwise, or the road lighting class is already the lowest one, this criterion applies to all calls for tender. The dimming scenario below is just one possible suggestion – procurers should have their own ideas and mention these in their ITT).

All light sources and luminaires shall be installed with fully functional dimming controls that are programmable to compensate for lumen output depreciation and for setting 2 levels of curfew dimming which should be as low as 50% (level 1) and 10% (level 2) of maximum light output.

Verification:

The tenderer shall provide documentation from the manufacturer(s) of the light sources and luminaires that are proposed to be used by the tenderer showing that they are compatible with dimming controls.

The documentation shall also state what dimming controls are incorporated, for example:
• constant light output to compensate for lumen depreciation,
• pre-set curfew dimming or
• variable dimming based on weather</td></tr>
</table>

The documentation shall also clearly provide a power curve of light output versus power consumption, state the maximum dimming possible and provide instructions about how to programme and re-programme the controls.	conditions or traffic volume. The documentation shall also clearly provide a power curve of light output versus power consumption, state the maximum dimming possible and provide instructions about how to programme and re-programme the controls.
CPC3: Dimming control	
(Applicable to TS1 and TS2) If, for whatever reason, the contractor changes the light sources and/or luminaires from those specified in the successful tender, the new light sources and/or luminaires shall be at least • equally compatible with dimming controls as the originals, • have the same programmable flexibility, • be able to achieve at least the same maximum dimming and • have a similar power curve. Agreement on this matter shall be settled by the provision of similar documentation from the manufacturer(s) of the new light sources and/or luminaires that would justify the selection of the new luminaires and/or light sources.	

Questions to stakeholders (Dimming criteria):

Q1. What are the main different options for dimming control and how do they differ in cost and ease and flexibility of programming/reprogramming?

Q2. In which roads classes and scenarios is dimming most/least justifiable?

Q3. Would you support award criteria to compensate for more expensive and more sophisticated dimming controls? If so, in what types of road would this be most relevant?

7.3 *Power Density Indicator (PDI) and Annual Energy Consumption Indicator (AECI)*

7.3.1 Background research and supporting rationale for PDI

The PDI value, in W/(lx.m^2) essentially tells us how much power is consumed to provide a certain amount of maintained average illuminance (lx) over one square metre. Generally speaking, the lower the PDI value, the better the lighting system energy efficiency. It is relative to the installed illumination and therefore does not take into account over-lighting.

The PDI value is technology neutral and should include power consumption from all components of a luminaire with light source installed. For this reason, there is no need to set overlapping requirements for individual types of lamps and ballasts.

Calculating PDI[W/(lx.m²)] or [W/lm]

The Power Density Indicator is calculated according to EN 13201-5:2016 as follows:

$$PDI = D_P = \frac{P}{\sum_{i=1}^{n}(E_i \ x \ A_i)}$$

Where P is the system power, Ei is the average maintained horizontal illuminance of sub-area A. and n is the number of sub-areas. Any one particular sub-area may have illuminance classes defined as luminance requirements, L,m (e.g. M-class road sections) or illuminance, E,m or illuminance requirements E,hs (e.g. C or P class road sections). The following conversion formulas for switching from luminance and illuminance are provided in EN 13201-5:2016:

- *Illuminance (E,m) = Luminance ($\bar{L}$,m) / 0.07 (where 0.07 is a general "rule of thumb" coefficient for a reference asphalt surface, in cd/(m^2.lx. For greater accuracy, in-situ measurements of the asphalt road surface reflectivity should be taken (especially if not asphalt!) and results generated via a specialised lighting program).*
- *Illuminance (E,m) = Hemispherical illuminance (E,hs) / 0.65*

It should be noted that 1 W/(lx.m²), i.e. the unit of PDI, is equivalent to 1 W/lm which is the reciprocal value of the installation efficacy in lm/W. The PDI indicator does not take into account dimming and/or over-lighting.

As indicated above, it is important to be aware of the target area to be lit, A, and this in turn requires knowledge about the road profile. It is important to be aware of the road profile and the target area to be lit when calculating the PDI.

Road profile

The road profile describes the layout of the road sections to be lit, lighting points, any adjacent pedestrian areas intended to be lit and any vegetated areas or central reservations not intended to be lit, see Figure 12 below.

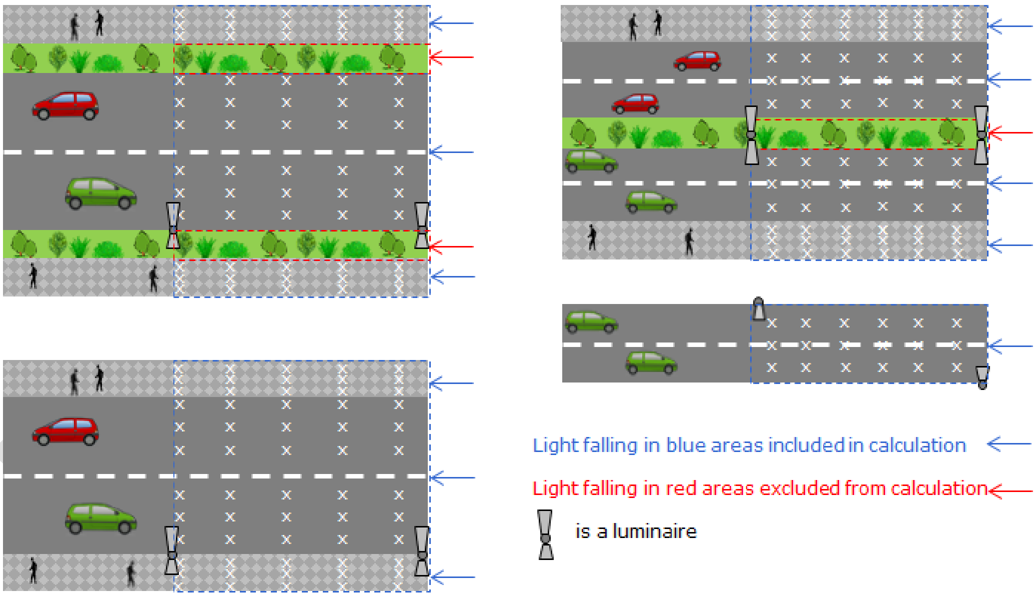

Figure 12. Examples of different possible road profiles and the associated areas to be included in any PDI calculations (adapted from EN 13201-5)

The results for PDI and AECI will be influenced by light output that is essentially "spilled" onto non-target areas. Consequently, a clear understanding of the road profile is important to ensure that different designs are comparable. In certain circumstances, where there is a degree of freedom about the placement of luminaires, the road profile will need to be considered in detail to deliver the optimum energy efficiency without creating problems due to glare or a lack of uniformity. Note that road classes M1-M6 have Edge Illumination Ratio (EIR) and if the carriageway of a road is not surrounded by other areas, the surrounding areas used for calculating EIR are not included in the calculation of power density indicator. As a consequence this can lower the PDI.

***Example calculations with real data – (i) road only*[16]**

The following example is for a road where the ***target average maintained luminance is 1.00 cd/m²***. To minimise the potential for over-lighting, the target luminance also must not be exceeded by more than 25% (i.e. luminance must be between 1.00 and 1.25 cd/m² - the lower within this range the better). The EN 13201-5:2016 standard is less stringent in this respect, allowing average luminance to be exceeded by up to 50%.

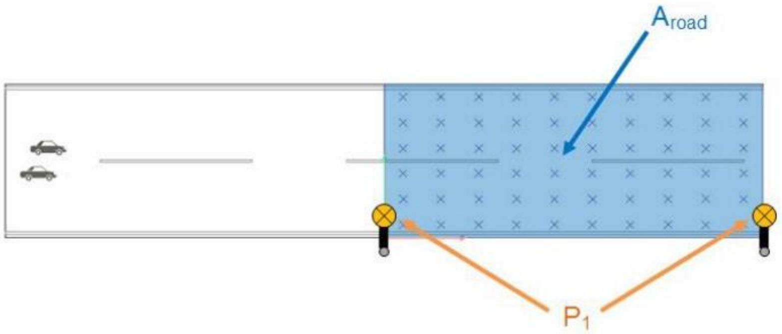

Figure 13. Target area for the calculation of PDI in one road sub-area (Source: Synergrid).

To calculate PDI, it is necessary to use suitable lighting calculation software and the photometric file of the light source and luminaire. A real example of the main data needed to calculate PDI include:

- Road width = 7m
- Distance between light poles = 36m
- Sub area, A_{road} = 252m²
- Height of luminaires = 8m
- Power consumption of the two luminaires (P1) = 115 W (HPS lamp 110W on electronic ballast)
- Luminous flux of the lamp = 10000 lm
- Maintenance factor = 0.92 (IP66, glass cover)

From these data, the average maintained illuminance on A_{road} can be calculated to be 14.4 lx (including the maintenance factor). Once the illuminance is known, the PDI can be calculated as follows:

$$PDI = D_P = \frac{P_1}{E_{road}\ x\ A_{road}} = \frac{115W}{14.4lx\ x\ 252m^2} = 0.032\ W.lx^{-1}.m^{-2}$$

A final check is required to see if the average maintained luminance level is adequate, so it is necessary to convert illuminance into luminance:

$$Illuminance\ (lx)\ x\ surface\ reflectivity\ coeff. = Luminance\ (cd.m^{-2})$$
$$= 14.4lx\ x\ 0.0722cd.lx^{-1}.m^{-2} = 1.04cd.m^{-2}$$

[16] From Synergrid Technical specification 005. Public lighting equipment. C4/11-2: Prescriptions for luminaires. Photometric requirements.

The final luminance result was indeed compliant with the example (i.e. between 1.00 and 1.25 cd.m^{-2}) and the PDI was calculated as 0.032 W.m^{-2}.lx^{-1}.

Example calculations with real data – (ii) road with sidewalk

In cases where the road profile requires different lighting levels for at least 2 different areas, the calculation of PDI is more complex and another example (again from the Synergrid technical specification document) is provided below:

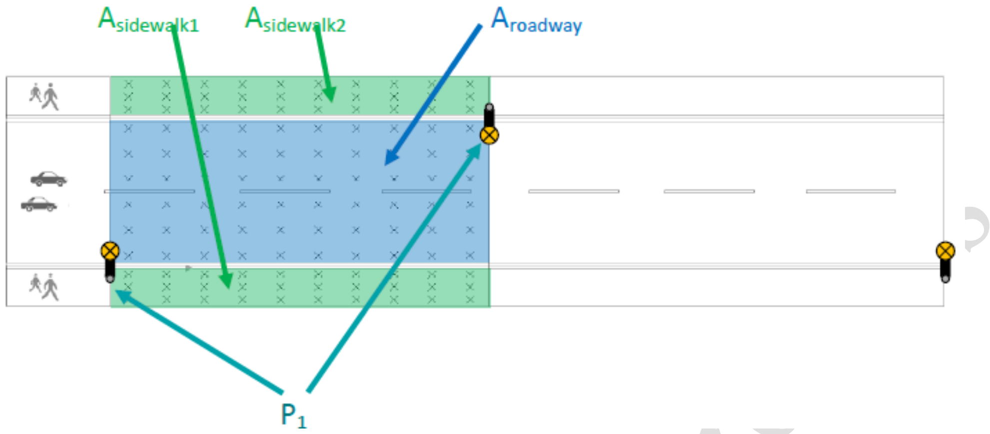

Figure 14. Target areas for calculation of PDI where two lighting classes are required in one sub-area (Source: Synergrid).

The following details can be used in lighting software to calculate the average maintained illuminance on the road and on the sidewalks:

- Width of roadway = 7m
- Width of the sidewalk = 2m (on each side)
- Distance between the light poles = 25m
- Sub area A_{road} = 175m^2
- Sub area $A_{sidewalk1}$ = 50m^2
- Sub area $A_{sidewalk2}$ = 50m^2
- Power rating of luminaire P1 = 103W (90 W MHHP with electronic ballast)
- Maintenance factor = 0.87 (MHHP lamp, IP 66, glass cover)
- Luminous flux = 10500 lm
- Height of the luminaire = 8m

This results in an average maintained illuminance on road of 17.4lx (including the maintenance factor and on the sidewalks of 12.2lx (again including the maintenance factor)

The clearest explanation of the PDI calculation is by following the "absolute method" described in the Synergrid specification. It is necessary to read of the percentages of light output from the luminaire that fall on each of the target areas, as illustrated in Figure 15.

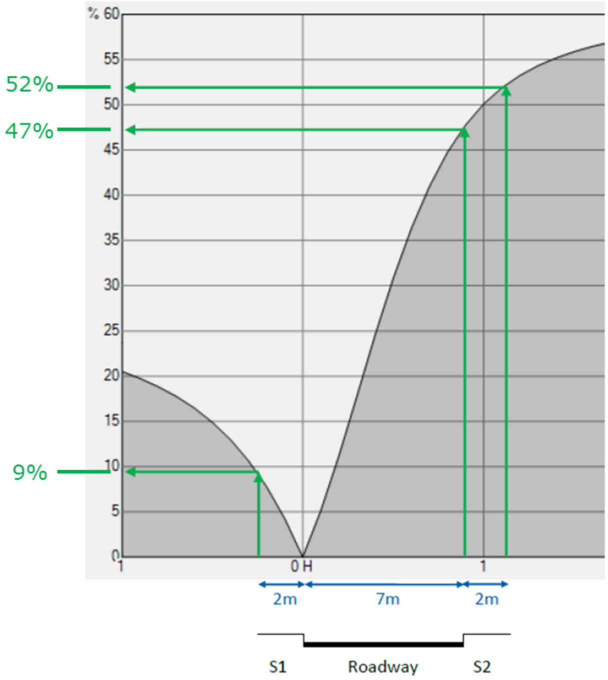

Figure 15. Reading of the "utilance" of luminous flux from luminaire (Source: Synergrid).

The extrapolation of data reveals that 9% of the luminous flux lands on sidewalk 1, 47% lands on the road and 5% (i.e. 52% - 47%) lands on sidewalk 2 – resulting in an overall utilance of 61%, or 0.61.

For the calculation of PDI to be true, it is also necessary to account for the energy that is spent on light that does not reach the target areas. So percentage of power used to illuminate the road is essentially 77% of the 103W (i.e. 47%/61% x100), on sidewalk 1 it is 14.8% of the 103W (i.e. 9%/61% x 100) and on sidewalk 2 is it 8.2% of the 103W (i.e. 5%/61% x100). This two sidewalk values can be combined (i.e. taking 23% of the power) since, due to the staggered layout of lighting points shown in Figure 14, they will receive the same total luminous flux overall.

So the PDI calculations now become:

$$PDI = D_{Proadway} = \frac{0.77\ x\ 103W}{17.4lx\ x\ 175m^2} = 0.026\ Wm^{-2}lx^{-1}$$

And

$$PDI = D_{Psidewalk1+2} = \frac{0.23\ x\ 103W}{(12.2lx\ x\ 50m^2) + (12.2lx\ x\ 50m^2)} = 0.0194\ Wm^{-2}lx^{-1}$$

For ease of comparison with different designs, the PDI for the road, sidewalk 1 and sidewalk 2 can also be aggregated into a single value so long as the average (and maximum) maintained luminance/illuminance levels are specified equally and are complied with by all designs.

Limitations of PDI

Although the PDI is a useful measure of the energy efficiency of the installation, it is not so easy to understand for procurers, who will be most interested in the electricity bill. As the term suggests, PDI, is only an indicator of energy efficiency and not a direct measure of energy consumption.

Because PDI is relative to the installed illumination, it does not take into account overlighting. For example, it is possible for a road to have a very low PDI value even when in reality the lighting levels on the road, and thus the energy consumption, could be much higher than they needed to be. This is why it is necessary to have some check that luminance or illuminance levels do not exceed targets by more than a certain amount (e.g. 25%). The PDI can potentially be weighted to factor in constant light output (CLO) and dimming scenarios by adjusting the system power value but how this number is arrived at is not so transparent in the standard PDI calculation.

PDI should not be used as a stand-alone requirement for energy efficiency. In order to avoid potential perverse outcomes, it is very important that the procurer specifies the average and maximum maintained lighting levels required for each sub-area of the road.

Simplified calculation of PDI proposed in TR 1.0

Criteria for energy efficiency were proposed based on the PDI and AECI values whose ambition levels were based on a general simplified rule of thumb for that related road width to the PDI values which was as follows:

$$PDI\ (mW.lx^{-1}m^{-2}) = FF\ x\ \frac{161(mW.lx^{-1}.m^{-1})}{RW\ (m)} = PDIref$$

The general rule of thumb was constructed based on data for many different road classes from the best EN standard examples listed in EN 13201-5 (based on values from Q1/2014) and from values submitted in Lot 37 ecodesign preparatory study for lighting systems (values from Q2/2016).

The FF term refers to "fitting factor", which was proposed to be set at 1.3 for the core level and 1.1 for the comprehensive level.

A single approach for different road classes was justified because the energy efficiency of LED technology does not vary much when the light output (and thus power rating) changes (see Figure 7). However, the PDI values may be influenced when the road width changes due to changes in the utilance factor (the fraction of total light output from the luminaire that reaches the target surface).

7.3.2 Stakeholder discussion about PDI

About the simplified PDI calculation proposed in TR 1.0

It was agreed that the proposed method was indeed a simpler one than the standard way for calculating PDI. However, one stakeholder felt it should be even simpler, proposing a single ambition level for PDI in all roads of PDI < 0.035 (they justified this level of ambition by saying that it could be considered equivalent or better than a clear, medium wattage HPS luminaire).

Other stakeholders felt the 161/RW approach was too simple, did not reflect the complexity of real road geometries and was effectively permitting the spilling of light in narrower roads. It was added that the use of a single fitting factor of 1.3 (core) or 1.1 (comprehensive) may be problematic when C and P class roads are taken into consideration and when more decorative luminaires and poles may be used. It would instead be better if different fitting factors could be applied to different defined scenarios. It was also commented that the reference values proposed in Table 4-1 of TR 1.0 and the constant value of 161, which is based on data in Table 4-1, would also have to be periodically revised as technology continues to advance.

If a tiered approach is considered necessary for luminaire efficacy, then it would surely also be needed for PDI as well. Exactly how luminaire efficacy would affect PDI is a matter for further discussion, because, in addition to the possible nuances that can apply to luminaire efficacy (such as decorative luminaires etc.) it is possible that the same increase in luminaire efficacy would have bigger or smaller effects on PDI values depending on what lighting level is desired and of course, on the road width.

However, the relationship to road width in the simplified PDI calculation proposed in TR 1.0 was criticised because this effectively lowers the energy efficiency ambition level for narrower roads. It was defended that this is simply a reflection of a real life situation, as it becomes more difficult to direct light only onto a narrower targets without requiring a greater number of lighting points or spilling more light from the target area.

One stakeholder mentioned that it would be useful to take increased luminaire efficacy (lm/W) due to technological progress over time into account and this also will influence PDI and AECI. Therefore luminaire efficacy should be included somehow in the target values for PDI and AECI.

Italian approach to PDI requirements

One stakeholder provided details about the approach to PDI in Italy, where the term "IPEI" (defined as the Parameterized Energy Index for Lighting Systems) has been designed to give a broad evaluation of lighting installation energy efficiency in a comparable manner. IPEI is related to the ratio between PDI (or Dp) and a fixed reference value (PDI_{ref} or Dp,r) that is defined for each road lighting class as per the definitions in EN 13201 (i.e. M-class, C-class and P-class roads).

Table 8. IPEI (reference PDI values) for different Italian road classes

Road class	PDI (IPEI) (W/lux.m^2)		
	Road lighting	Area lighting, roundabout, parking lot	Pedestrian area, bike lane
M1	0.035		
M2	0.037		
M3	0.040		
M4	0.042		
M5	0.043		
M6	0.044		
C0		0.03	0.039
C1		0.032	0.042
C2		0.034	0.044
C3 (P1)		0.037	0.048
C4 (P2)		0.039	0.051
C5 (P3)		0.041	0.053
P4		0.043	0.056
P5		0.045	0.059
P6		0.047	0.061
P7		0.049	0.064

The reference PDI_{ref} is less demanding for classes with lower luminance/illuminance requirements - which is justified since these will use lower wattage lamps that may have lower inherent luminaire efficacies. Denominated road types are: '*road lighting (M classes)*', '*area lighting, roundabout, parking (C&P classes)*' and '*pedestrian or bike lane' (P classes)*'. Depending on the IPEI ratio energy efficiency labels are given to lighting installations (G to A5+). The IPEI labels serves as a benchmark in public tenders in Italy.

Belgian approach to PDI requirements

One stakeholder made reference to a Belgian standard (Synergrid C4/11-2, 2016 version) that defines the minimum energy efficiency requirements (PDI and AECI) for M class roads and that these requirements have indeed been linked to road width as shown in the table below.

Table 9. Maximum PDI values permitted for Belgian M-class and C-class roads

Road width	Lighting class (M2-M5 and C2-C4) Maximum PDI values permitted (in W/lx.m^2))						
	M2	M3	M4	M5	C2	C3	C4
4m	0.035	0.05	0.05	0.05	0.06	0.065	0.07
5m	0.035	0.045	0.045	0.045	0.05	0.055	0.06
6m	0.035	0.04	0.04	0.04	0.04	0.045	0.05
7m	0.03	0.035	0.035	0.035	0.03	0.035	0.04
8m	0.025	0.03			0.03	0.035	0.04
9m	0.02	0.03			0.03	0.035	0.04
10m	0.02	0.03			0.03	0.035	0.04
11m	0.02	0.03					

The data in Table 9 reveal that as the road width decreases, the maximum permitted PDI value increases. This is consistent with the general idea that it is more difficult to efficiently light narrower roads due to light spilling over the target area (i.e. the "utilance" factor decreases).

The PDI requirements also become more relaxed as the lighting level required decreases (i.e. moving from M2 to M5 or C2 to C4) because these will require lower wattage lamps that may result in inherent lower luminaire efficacies. While this reasoning holds true for HID type lamps, it is not really the case for LED-based lamps, whose efficacies are much less dependent on operating power.

The Belgian requirement is very pragmatic but is only applicable in regions where there is a common approach to classifying the required lighting levels for roads. Since this is not common across the EU, it is not recommended to refer to road classes at all in the criteria but instead to the average maintained luminance or illuminance level specified by the procurer.

7.3.3 Background research and supporting rationale for AECI

The Annual Energy Consumption Indicator (AECI, expressed in Wh.m^{-2}) is considered as a more intuitive indicator for procurers to understand since it can easily be converted to kWh or kWh.km^{-1}) to effectively express the final electricity consumption of a particular road lighting installation. The AECI takes into account over-lighting and dimming.

Calculating AECI (W/(m2.yr)

The standard calculation defined in EN 13201-5 is closely linked to the PDI calculation but is simpler in principle and can be calculated independently, taking into account all the periods when power consumption is different:

$$AECI = D_E = \frac{\sum_{j-1}^{m}(P_j \; x \; t_j)}{A}$$

Where P_j is the operational power required (in W) in the j^{th} period of operation, t_j is the length of time (in hours) during a one year period that the j^{th} period is in operation, A is the area that is lit (m^2) and m is the number of periods with different operational power.

Using the same calculation example from Synergrid as mentioned earlier for PDI (see Figure 13), the only details necessary are:

- Sub area, A_{road} = 252m^2
- Luminaire power consumption = 115 W (HPS lamp 110W on electronic ballast)
- Operation time = 4282h

The AECI calculation for that sub-area then becomes:

$$AECI = D_E = \frac{115W \; x \; 4282h}{yr.252m^2} = 1954 \; Wh.m^{-2}.yr^{-1}$$

The above example is extremely simple and is typical of traditional lamp technologies where there is no CLO, dimming control or parasitic energy consumption. EN 13201-5:2016 specifically mentions the possibility to include parasitic energy consumption in the AECI calculation. This will become increasingly important as road lighting technology shifts towards smarter controls and remote monitoring and data acquisition.

Limitations of AECI

One of the fundamental flaws of AECI, if used as a standalone requirement, is that it does not link in any way to the lighting level. It may be possible to generate a low AECI value simply by having inadequately low lighting levels or assumptions on dimming scenarios. Consequently, in order to be able to compare different tenders in a fair way, it is necessary to link any specifications for AECI to the average maintained illuminance or luminance required on the road area.

As with PDI, the actual value of AECI will vary depending on whether adjustments to operating power with CLO drivers are made to compensate for lamp lumen maintenance factors (decrease in luminous flux output with ageing) and possible luminaire maintenance factors (dirt accumulation).

The calculation method for AECI is in principle simpler than PDI but neither of them are particularly transparent when it comes to seeing all the input variables (e.g. maintenance factor, dimming scenarios and utilance) that can influence the result. This was part of the rationale behind the alternative calculation for AECI proposed in TR 1.0.

Alternative calculation of AECI proposed in TR 1.0

The equation for calculating AECI followed the same approach as the proposal for PDI but also added a combined factor for constant light output and curfew dimming (1.1 in core, 0.8 in comprehensive), multiplied by the minimum average illuminance level (lx) to be maintained and then multiplied by the factor 0.004. The core level equation is:

$$AECI\ (kWh.m^{-2}.yr^{-1}) < 1.1\ x\ \frac{161\ mW.lx^{-1}.m^{-1}}{RW(m)}\ x\ E,m\ (lx) x\ 4000\ h.yr^{-1}\ x\ \frac{1(kW)}{1000000(mW)}$$

Where:

- 161/RW = PDI_{ref} (in $mW.lx^{-1}.m^{-2}$).
- RW = Road Width, in metres, including any emergency lanes, sidewalks and cycle paths that are to be lit by the same light points.
- E,m is the calculated maintained average illuminance (in lux).

7.3.4 Stakeholder discussion about AECI

Feedback about simplified AECI calculation

The same comments submitted about the 161/RW factor for the PDI calculation also apply here to the AECI and are not repeated.

The choice of CL values of 1.1 and 0.85 were confusing to some stakeholders. The idea was that it should account for the incorporation of dimming but because it is also combined with a fitting factor that was applied to the PDI calculation, we end up with one value above 1.0 and another below 1.0, despite the fact that dimming scenarios should inherently take the factor below 1.0.

Another criticism was that the AECI calculation, in a similar manner to the PDI calculation, was not transparent enough to see the influence of luminaire efficacy on the result. The ambition level of AECI should evolve in parallel with the projected improvements in LED luminaire efficacy over the next 6 years. In order to do this correctly, the AECI calculation needs to be broken down to clearly show the influence of luminaire efficacy.

In contrast, another stakeholder wished for the AECI calculation to be simplified further, proposing to replace (161/RW) with (65 x E,m x RW). In this proposal, the "65" reference value was generated by assuming a luminous efficacy of 103 lm/W for the luminaire, a maintenance factor of 0.85 and a utilance of 0.7.

Comments about AECI vs PDI

There was considerable discussion about whether or not criteria should be set for PDI. The main argument against PDI was that it was an additional complexity that procurers might not understand properly. The main argument in favour of PDI criteria is that it ensures that the design delivers enough light to the road for a certain amount of power consumption. Increasing spilled light will increase power consumption but not light on the road, so it would increase the PDI. Consequently, the PDI enables any subsequent AECI value to be contextualised correctly because it is linked to a certain illuminance or luminance level on the road.

One stakeholder stated that the usefulness of the PDI criterion really depends on how interested the procurer is in minimum lighting levels and design performance – which can vary depending on the nature of the road. For example:

- Where details of road layout, lighting level or dimming are not specified by the procurer in sufficient detail and there is little or no flexibility in the design, the calculation of PDI is not so valuable and only AECI linked to a defined reference PDI would be necessary.
- When sufficient details are provided and flexibility in the design is possible, there is a real opportunity to optimise PDI (and thus AECI) by good design. So in this case, a PDI criterion could be specified and allowed to be used in the AECI calculation.

In order to cover both situations, it would therefore be necessary for EU GPP criteria to address PDI and AECI separately.

New proposal for TR 2.0

Based on the feedback received, a new equation has been proposed in the criteria presented here in TR 2.0 for AECI that also takes into account reference PDI and via that PDI factor, the road width and possible future increases in ambition level as luminaire efficacies increase. The equations are broken down in the criteria so that readers can see exactly what variables influence the final result.

The concept of PDI_{ref} has been expressed as:

$$PDI_{ref}(W.lx^{-1}.m^{-2}) = \frac{1}{\eta_{lum}\ x\ F_M\ x\ U}$$

Where:

- η_{lum} is the luminaire efficacy (in lm/W).
- F_M is the maintenance factor (accounting for both lamp lumen depreciation and dirt on the luminaire housing, i.e. $F_{LLM}xF_{LM}$).
- U is the utilance (expressing the % of total light output that lands on the target areas).

The actual value of luminaire efficacy to use will be same as finally agreed for TS1 and any tiers to luminaire efficacy in the future would also apply here. The proposed luminaire efficacies are currently set at 102 lm/W (core) and 120 lm/W (comprehensive) according to products on the market **today**. In cases where decorative luminaires are specified, it is suggested that an efficacy of 90 lm/W could be used.

A maintenance factor of 0.85 (subtracting 0.10 for lamp lumen depreciation, F_{LLM} and 0.05 for dirt accumulation, F_{LM}) is suggested here but this can be altered by the procurer. The maintenance factor can be considered as the combined effect of all factors that decrease the light output from the luminaire such as lamp lumen output depreciation and dirt accumulation on the luminaire. The latter factor will be influenced by the degree of atmospheric pollution (especially particulate matter), the type of luminaire casing material and the cleaning frequency. Local authorities have often used general calculation tables to estimate the maintenance factor.

Table 10. Example of a table to estimate the maintenance factor for road lighting[17].

Cleaning interval (months)	Luminaire maintenance factor (F_{LM})								
	IP2X			IP5X			IP6X		
	High pollution	Medium pollution	Low pollution	High pollution	Medium pollution	Low pollution	High pollution	Medium pollution	Low pollution
12	0.53	0.62	0.82	0.89	0.90	0.92	0.91	0.92	0.93
24	0.48	0.58	0.80	0.87	0.88	0.91	0.90	0.91	0.92
36	0.45	0.56	0.79	0.84	0.86	0.90	0.88	0.89	0.91
48	0.42	0.53	0.78	0.76	0.82	0.88	0.83	0.87	0.90

High pollution is generally considered to occur in large urban or heavily industrialised zones. Medium pollution is attributed to semi-urban, residential or light industrial zones and low pollution is attributed to rural areas.

It is clear from Table 10 that the Ingress Protection rating will also have a major effect, at least between IP2X and IP5X. Other GPP criteria mentioned later (see TS12) recommend a minimum IP5X in some cases and IP6X in the majority of cases.

However, the traditional rules of thumb for luminaire maintenance factors in the UK were shown to be overly conservative by Sanders and Scott. A more appropriate approach was to consider mounting height and to split areas into different "environmental zones".

Table 11. Actual observed data of maintenance factor for IP65 luminaires in UK

Cleaning interval (months)	E1: national parks, areas of outstanding natural beauty		E2: generally outer urban and rural residential areas		E3: generally urban residential areas		E4: generally urban areas having mixed residential and commercial use with high night time activity	
	≤6m	≥7m	≤6m	≥7m	≤6m	≥7m	≤6m	≥7m
12	0.98	0.98	0.98	0.98	0.94	0.97	0.94	0.97
24	0.96	0.96	0.96	0.96	0.92	0.96	0.92	0.96
36	0.95	0.95	0.95	0.95	0.90	0.95	0.90	0.95
48	0.94	0.94	0.94	0.94	0.89	0.94	0.89	0.94

The data collected by Sanders and Scott reveals that in general, the lumen depreciation due to dirt accumulation is much lower than previously assumed. This may be due to improved emission control on vehicles, decreased industrial activity in the UK or other factors. Interestingly, the data also revealed that mounting height had no effect on luminaire maintenance factors in areas of low pollution but did have an effect in areas of higher pollution.

Regardless, the main purpose of showing these tables is to explain that the choice of maintenance factor is important. While the F_{LLM} is confirmed by the lighting equipment manufacturer, the F_{LM} is very much up to the procurer to define and may use overly conservative rules of thumb that led to overdesign in the lighting installation.

The utilance is determined according to road width as follows: >10m→U=0.7; 9m→U=0.63; 8m→U=0.56; 7m→U=0.49; 6m→U=0.42 and ≤5m→U=0.35. This is the general guide to follow unless the procurer decides to choose their own utilance based on site specific freedoms or restrictions for optimising the lighting design. For reference, the highest utilance that can be realistically considered is 0.78, and that is when there are no constraints on the placement of poles and mounting heights of luminaires. In sites where there are lots of constraints on optimising the optical design, a utilance of 0.35 may be justifiable even for road that are wider than 5m.

[17] Sanders and Scott, 2008. Review of luminaire maintenance factors, Mott MacDonald.

The concept of the reference AECI has been expressed as:

$$AECI_{ref}\ (kWh.m^{-2}.yr^{-1}) = F_{dim}\ x\ E, m_{spec.}(lx)\ x\ PDI_{ref}(W.lx^{-1}.m^{-2})\ x\ T(h.yr^{-1})\ x\ \frac{1kW}{1000W}$$

The F_{dim} factor accounts for dimming and should represent the decrease in power consumption based on luminaire power curves and the dimming scenarios that are defined by the procurer in the ITT (if any). The greater the degree of dimming specified, the closer the factor approaches zero. If no dimming is specified, this factor should be set at 1 in order to ensure comparability between designs.

$E,m_{spec.}$ represents the illuminance level (in lx) for the road according to the specification. For M class roads, where luminance (in Cd/m^{-2}) is specified instead of illuminance (in lx), the units need to be converted to lx by accounting for the surface reflectivity of the road surface. For asphalt road surfaces, a general rule of thumb for surface reflectivity coefficient of 0.07 $cd.m^{-2}.lx^{-1}$. This coefficient can be used to switch between illuminance and luminance levels for a given road. The procurer can have an idea about how typical luminance or illuminance levels can vary between different road classes by referring to Figure 1.

The PDI_{ref} term is as defined above in this same sub-section.

T is the time (h) the lighting installation is actually consuming power per year. The exact value should be defined by the procurer but is typically 4000 hours per year. However, in cases where parasitic power consumption is calculated, this would be a constant 24 hours per day consumption (i.e. 8760h per year).

The kW/W term is simply a conversion factor.

7.3.5 Criteria proposals for PDI and AECI

Core criteria	**Comprehensive criteria**
TS4 Power Density Indicator (PDI)	
(Applies when a new lighting installation is being designed or when a re-design is required due to renovation of an existing lighting installation). The tenderer shall, based on the minimum lighting requirements, background information and assumptions defined by the procurer, demonstrate that the proposed lighting installation design can meet the following relevant requirement for energy efficiency: • PDI < 1.3 x PDI_{ref} *(for installations where road pole and light point positions of existing installations cannot be altered)*, or • PDI < 1.2 x PDI_{ref} *(for new lighting installations where road pole and light point positions can be optimised in the design).* The PDI_{ref} value (in $W/(lx.m^2)$) shall be defined by the procurer and calculated according to the following equation: $PDI_{ref} = 1/(\eta_{ref}\ x\ F_{Mref}\ x\ U_{ref})$ Where η_{ref} is the luminaire efficacy defined	*(Applies when a new lighting installation is being designed or when a re-design is required due to renovation of an existing lighting installation).* The tenderer shall, based on the minimum lighting requirements, background information and assumptions defined by the procurer, demonstrate that the proposed lighting installation design can meet the following relevant requirement for energy efficiency: • PDI < 1.1 x PDI_{ref} (for installations where road pole and light point positions of existing installations cannot be altered), or • PDI < 1.0 x PDI_{ref} (for new lighting installations where road pole and light point positions can be optimised in the design). The PDI_{ref} value (in $W/(lx.m^2)$) shall be defined by the procurer and calculated according to the following equation: $PDI_{ref} = 1/(\eta_{ref}\ x\ F_{Mref}\ x\ U_{ref})$ Where η_{ref} is the luminaire efficacy defined

by the procurer (102 lm/W* suggested), F_{Mref} is the maintenance factor defined by the procurer (0.85 suggested) and U_{ref} is the reference utilance defined by the procurer, where suggested values vary depending on the road width

Road width (m)	Utilance
≥10m	0.7
9m	0.63
8m	0.56
7m	0.49
6m	0.42
≤ 5m	0.35

For EN 13201-2 road classes M whereby the carriageway of the road is not surrounded by other areas; the reference utilance can be 0.05 lower because of edge illumination requirements (EIR).

The procurer shall provide, as a minimum, the following additional information to help tenderers calculate the PDI of their design:

- Road profile and target minimum maintained luminance or illuminance requirements for different sub-areas (for existing installations the fixed pole layout and light points shall also be provided).
- Any minimum requirements for maintenance factors.
- In cases where luminance is used, the road reflection coefficient shall be specified.
- Any specific reference utilance to use, if different from default values.

Verification

The tenderer shall state what lighting software has been used to calculate the PDI value and provide a clear calculation, where the values for luminaire efficacy, maintenance factor and utilance of their proposed design are visible. The calculation results will include the measurement grid and calculated illuminance values.

The PDI result shall also be expressed as both a number in units of $W/(lx.m^2)$ and as a multiple of the PDI_{ref} value defined by the procurer.

**suggested reference luminaire efficacy for 2016. Proposed to increase to 120lm/W in 2018, 137lm/W in 2020 and 155lm/W in 2022.*

by the procurer (112 lm/W* suggested), F_{Mref} is the maintenance factor defined by the procurer (0.85 suggested) and U_{ref} is the reference utilance defined by the procurer, where suggested values vary depending on the road width

Road width (m)	Utilance
≥10m	0.7
9m	0.63
8m	0.56
7m	0.49
6m	0.42
≤ 5m	0.35

For EN 13201-2 road classes M whereby the carriageway of the road is not surrounded by other areas; the reference utilance can be 0.05 lower because of edge illumination requirements (EIR).

The procurer shall provide, as a minimum, the following additional information to help tenderers calculate the PDI of their design:

- Road profile and target minimum maintained luminance or illuminance requirements for different sub-areas (for existing installations the fixed pole layout and light points shall also be provided).
- Any minimum requirements for maintenance factors.
- In cases where luminance is used, the road reflection coefficient shall be specified.
- Any specific reference utilance to use, if different from default values.

Verification

The tenderer shall state what lighting software has been used to calculate the PDI value and provide a clear calculation, where the values for luminaire efficacy, maintenance factor and utilance of their proposed design are visible. The calculation results will include the measurement grid and calculated illuminance values.

The PDI result shall also be expressed as both a number in units of $W/(lx.m^2)$ and as a multiple of the PDI_{ref} value defined by the procurer.

**suggested reference luminaire efficacy for 2016. Proposed to increase to 130lm/W in 2018, 147lm/W in 2020 and 165lm/W in 2022.*

TS5 Annual Energy Consumption Indicator (AECI)

(Applies when a new lighting installation is being designed or when a re-design is required due to renovation of an existing lighting installation). The tenderer shall provide the design of a lighting installation that, based on the minimum lighting requirements, background information and assumptions defined by the procurer, can meet the following relevant requirement for energy consumption: • AECI (kWh.m^{-2}) < 1.3 x F_{dim} x E,m) x PDI_{ref} x T(h) x 1kW/1000W *(for installations where road pole and light point positions of existing installations cannot be altered),* or • AECI (kWh.m^{-2}) < 1.2 x F_{dim} x E,m x PDI_{ref} x T(h) x 1kW/1000W *(for new lighting installations where road pole and light point positions can be optimised in the design*). If the proposed design includes devices that have a parasitic power consumption, this shall be accounted for during all 8760 hours and simply during operational periods. The procurer shall provide, as a minimum, the following additional information for calculating the AECI: • The desired average maintained illuminance (E,m) of the selected road ignoring any curfew dimming. • The time (h.yr^{-1}) the lighting installation is actually consuming power per year, it is typically 4000 hours per year. • The dimming factor (F_{dim}) is determined by the desired operational profile stated by the procurer for the lighting installation and the power curve of the lighting equipment. • An upper limit for E,m that must not be exceeded in the design to prevent overlighting (typically 25%). ***Verification*** The tenderer shall state what lighting software has been used to calculate both the PDI and AECI values of the proposed design and provide a clear calculation, where the values for Fdim, E,m, as well as the actual values of luminaire efficacy, maintenance factor and utilance used to calculate the design PDI.	*(Applies when a new lighting installation is being designed or when a re-design is required due to renovation of an existing lighting installation).* The tenderer shall provide the design of a lighting installation that, based on the minimum lighting requirements, background information and assumptions defined by the procurer, can meet the following relevant requirement for energy consumption: • AECI (kWh.m^{-2}) < 1.1 x F_{dim} x E,m x PDI_{ref} x T(h) x 1kW/1000W *(for installations where road pole and light point positions of existing installations cannot be altered),* or • AECI (kWh.m^{-2}) < 1.0 x F_{dim} x E,m x PDI_{ref} x T(h) x 1kW/1000W *(for new lighting installations where road pole and light point positions can be optimised in the design*). If the proposed design includes devices that have a parasitic power consumption, this shall be accounted for during all 8760 hours and simply during operational periods. The procurer shall provide, as a minimum, the following additional information for calculating the AECI: • The desired average maintained illuminance (E,m) of the selected road ignoring any curfew dimming. • The time (h.yr^{-1}) the lighting installation is actually consuming power per year, it is typically 4000 hours per year. • The dimming factor (F_{dim}) is determined by the desired operational profile stated by the procurer for the lighting installation and the power curve of the lighting equipment. • An upper limit for E,m that must not be exceeded in the design to prevent overlighting (typically 25%). ***Verification*** The tenderer shall state what lighting software has been used to calculate both the PDI and AECI values of the proposed design and provide a clear calculation, where the values for Fdim, E,m, as well as the actual values of luminaire efficacy, maintenance factor and utilance used to calculate the design PDI.

AC2: Enhanced AECI
(Applies when TS4 has been applied in an Invitation to Tender (ITT).   Up to X points shall be awarded to tenderers who are able to provide designs that result in a lower AECI than the maximum limit defined in TS5.   Maximum points (X) will be awarded to the tender with the lowest AECI value and points shall be proportionately awarded to any other tenders whose designs are lower than the maximum requirements of TS5 but do not reach the value of lowest energy consuming tender.

7.4 *Metering*

7.4.1 Background research and supporting rationale

As shown in the Preliminary report the operational costs of electricity are the major source of environmental impacts. The purchase of electricity is a major contributor to the total cost of ownership of road lighting installations and can represent a significant fraction of total energy costs for municipalities.

As mentioned in the Preliminary report (section 3.3.3), more and more cities understand that a metering system for a road lighting network may play a strategic role in reporting on energy consumption and CO2 emission reduction measures. A metering system could potentially be added to the existing road lighting system, even if non-LED technologies are in place.

The electricity has to be billed and purchased for road lighting, but in a lot of cases there are no meters to count the electricity consumption. In those cases it usually means that the bill to pay is estimated by the lamp power and the operation time without considering the real consumption, which may vary especially if dimming and CLO drivers are used. With traditional HID lamp technologies and operating practices, this was not a major issue because lamps only came in a limited number of power ratings (e.g. 50W, 70W, 110W), the same type of ballasts were used (and rule of thumb losses assumed) and operational profiles did not account for CLO, curfew dimming or user volume-based dimming.

However, with the rise of LED technology, lamps are available in a much wider range of power ratings. The use of CLO drivers to avoid excessive power consumption and over-lighting of installations during initial years of operation is increasingly being considered. For municipalities and road authorities under budgetary pressure or wishing to reduce light pollution, the ability to dim light output during defined periods of low use is attractive.

If dimming control programs that are activate different dimming levels based on real life, in-situ variations in daylight or traffic are used (see bottom option in Figure 11), it will be impossible to accurately predict electricity consumption. In these cases especially, the metering of electricity consumption at the luminaire level, or at least at the level of the installation responding to these dimming controls, is the only way to ensure that the billing for electricity is accurate and to also know how these dynamic dimming controls perform compared to simpler fixed curfew dimming controls.

Metering at the level of the luminaire could provide valuable information about the lifetime performance of the light source and control gear. If reported remotely, luminaire metering would also identify any abrupt failures. Remotely reported metering data could also be valuable if attempting to identify the cause of abrupt failures (e.g. during storm periods or at the same time as a traffic accident or incident of vandalism). Long term metering data could provide valuable information to manufacturers as well, to compliment the laboratory data they already have.

Reference to the Measuring Instruments Directive (MID) was made in the criteria proposed in TR 1.0 and such a reference is maintained in the TR 2.0 proposals. However, due to the costs and effort involved in complying with the requirements of the MID, this condition should only apply to a meter installed at the sub-station or transformer for an entire lighting installation and not to any meters that would be installed at the individual luminaire level.

7.4.2 Stakeholder discussion

The interest in metering was highlighted by a request to consider the creation of a database with the real electricity consumption of the road lighting by authorities in each city. The best quality data would be based on lighting installations and networks that are metered. However, it would still be possible to report data based on the MWh consumption that is billed and the number of lighting points covered in that bill. If possible, the number of kilometres of road covered should be defined too.

Stakeholders confirmed that metering of electricity consumption in road lighting installations is not common practice. Consumption is often estimated for billing purposes by multiplying the number of luminaires by the typical luminaire power consumption and factoring in any dimming scenarios. Some extreme examples in the UK were cited where billing for electricity consumption was simply based on a fixed cost per luminaire and did not account for any lower consumption due to higher efficacy light sources or dimming. It was questioned if metering was actually a "green" criterion although it would be very useful in the aforementioned extreme cases and also in verifying operational performance (and costs) relating to energy efficiency for any road lighting installation. It would also provide real data and provide direct positive feedback to road network managers on any measures taken to improve energy efficiency.

A distinction was made between metering at the level of the installation and at the level of the individual luminaire. The main problems with installing metering systems for installations were related to the need to comply with different regulations, additional costs and, in urban areas at least, limited space for new electrical cabinets and/or limited space in existing cabinets. At the individual luminaire level, it is possible to specify control gear that is at least compatible with metering and that remote reporting of electricity consumption offers significant potential in monitoring operational performance, especially if linked to constant light output controls but also to detect abrupt failures in some or all of the light sources in a particular luminaire. Considering the potential to embrace smart lighting principles, some stakeholders were in favour of introducing individual luminaire reporting compatible with remote systems as an award criterion, since it would entail additional costs.

7.4.3 Criteria proposals for metering

Core criteria	**Comprehensive criteria**
TS6 - Metering	
(Applies only when the procurer deems that metering is of interest) The procurer shall state any specific technical requirements for the metering system in the ITT. The tenderer shall provide details of the proposed metering equipment and any ancillary equipment required in order to	*(Applies only when the procurer deems that metering may be of interest)* The procurer shall state any specific technical requirements for the metering system in the ITT. The tenderer shall provide details of the proposed metering equipment and any ancillary equipment required in order to

monitor electrical consumption at the lighting installation level for the same lighting installation that is the subject matter of the ITT. The metering device must be capable of logging data on a 24 hour basis that can later be manually or remotely downloaded. ***Verification:*** The tenderer shall provide the technical specifications of the metering and measurement system and provide clear instructions on how to operate and maintain this system. A calibration certificate compliant with the Measuring Instruments Directive 2004/22/EC (MID) shall be provided for each control zone.	monitor electrical consumption at the individual luminaire level for the lighting installation that is the subject matter of the ITT. The metering device must be capable of remotely reporting real time power and cumulative electricity consumption to a central database. ***Verification:*** The tenderer shall provide the technical specifications of the metering and measurement system and provide clear instructions on how to operate and maintain this system.

Questions to stakeholders:

Q1. How significant can the costs of installing metering (either in a junction box for the installation or at the individual luminaire level) be to the overall cost of a particular lighting installation?

Q2. Is metering at the luminaire level with remote reporting to centralised systems going to increase in the future?

7.5 *Contract performance clauses relating to energy efficiency*

7.5.1 Background research and supporting rationale

A CPC was proposed to ensure the correct functioning of any specified controls (e.g. timers, daylight controls, CLO drivers etc.) that relate to routine operation and dimming of the installation. The correct operation of these controls will have a direct impact on energy consumption (i.e. PDI and AECI values).

As with the CPC for luminaire efficacy (CPC2), the contractor is obliged to provide the originally installed lighting equipment as specified in the design used in the successful tender except in cases where equivalent or better performing equipment can be provided at no extra cost to the procurer. The need for this CPC is to prevent the contractor from substituting the originally specified lighting equipment for inferior (and cheaper) products. However, if cheaper products are available on the market that are of equivalent or superior performance, then this CPC also allows for this so long as it is clearly communicated to the procurer and adequate supporting evidence is provided of the performance of the alterative lighting equipment.

A comprehensive level CPC has been proposed, which only applies to contracts where a re-design or a new design has been carried out. The CPC requires that a road area selected by the procurer, free of obstructions such as trees, bus-stops and parked vehicles and as free as possible from interference from other background light sources such as advertising boards and buildings, is tested for actual lighting levels and compared with the actual power consumption of the relevant luminaires.

7.5.2 Stakeholder discussion

Stakeholders were cautious about any promotion of specific control systems at the installation level because this is highly unlikely to be requested when network wide control systems are already in place. Regarding presence detectors, one stakeholder referred to a project where 1 in 5 presence detectors were found to be performing inadequately after only 1 year of operation, resulting in increased energy consumption. Consequently, it would not be recommended to install these types of controls without metering of electricity consumption (ideally at the level of individual luminaires linked to remote data recording systems). Further research into possibilities to specify "self-commissioning" luminaires in EU GPP criteria was requested. Such self-commissioning would involve automatic in-situ checks against a defined set of operational parameters that can be defined and adjusted if needed.

The comprehensive level CPC6 proposal goes further by requiring a randomly chosen road segment to be assessed for photometric performance by field measurements of illuminance and energy efficiency (PDI and AECI values over a 1 week period) to check that they are sufficiently close to or even exceed design performance. For verification of the PDI the measurement grid and calculated illuminance values should be provided by the designer and they can be verified by an illuminance meter (+/- 10 %) (10 cm above the road surface).

Stakeholders had strong opinions about this of post-completion monitoring of energy efficiency performance. It was emphasised that although it was very useful and obliges the contractor to comply, this would introduce additional costs and should only be used in contracts that cover larger installations. In smaller installations or installations using only traditional HID lamps, CPC4 and CPC5 would be sufficient.

It was also considered important to distinguish between "urban" and "non-urban" road lighting when considering the use of CPC6. Due to potential interference with light measurement in urban areas due to blocking by balconies and trees or background light from windows, cars and advertisements, it was recommended to only consider applying the comprehensive level CPC to non-urban lighting installations.

Another distinction was made between traditional lamp technologies (no follow up measurement recommended) and LED lighting (follow up measurement recommended). The reason for this was due to the fact that LED can vary significantly in terms of wattage and optics.

The option to measure illuminance instead of luminance was supported because it is possible that the reflectance of the real road differs significantly from the assumed reflectivity used in photometric calculations.

When considering onsite verification of light levels and energy consumption, the work of CEN TC 169 regarding verification steps should be considered and acceptable tolerances should be considered in terms of Annexes E and F of EN 13201-4.

One key question that arose with the comprehensive level CPC was "what happens in cases of non-compliance"? Ultimately this should be defined by the procurer and clearly stated in the ITT. Options would be either to remedy the works at no additional cost or the application of financial penalties in proportion to the discrepancy between claimed energy efficiency and photometric performance. There is also the option to provide bonuses in the case of superior performance.

7.5.3 Criteria proposals

Core criteria	**Comprehensive criteria**
CPC4: Commissioning and correct operation of lighting controls	

The successful tenderer (contractor) shall ensure that new or renovated lighting systems and controls are working properly.

- Any daylight linked controls shall be calibrated to ensure that they switch off the lighting when daylight is adequate.
- Any traffic sensors shall be tested to confirm that they detect vehicles, bicycles and pedestrians, as appropriate.
- Any time switches, CLO drivers and dimming controls shall be shown to be able to meet any relevant specifications defined by the procuring authority in the ITT.

If after the commissioning of the system, the lighting controls do not appear to meet the relevant requirements above, the contractor shall be liable to adjust and/or recalibrate the controls at no additional cost to the procuring authority.

The contractor shall deliver a report detailing how the relevant adjustments and calibrations have been carried out and how the settings can be used.

Note: *For large utilities it may be required that the new or renovated installation is simply compatible with the existing control systems used for the wider lighting network. In this situation, this CPC would also refer to compatibility of controls with the existing control system.*

CPC5: Provision of originally specified lighting equipment

The contractor shall ensure that the lighting equipment (including light sources, luminaires and lighting controls) is installed exactly as specified in the original tender.

If the contractor changes the lighting equipment from those specified in the original tender, explanations must be provided in writing for this change and the luminous efficacy of the luminaire, the parasitic power consumption of lighting controls and the degree of flexibility in programming of lighting controls shall be at least equal to or better than the originals.

In either case, the contractor shall deliver a schedule of the actually installed lighting equipment together with manufacturer invoices or delivery notes in an appendix.

If alternative lighting equipment is installed, test results and reports for luminous efficacy from the manufacturer(s) of any new light sources and luminaires shall be provided as well as relevant documentation stating the performance of any new lighting controls.

CPC6: Compliance of actual energy efficiency and lighting levels with design claims

	Where relevant, a suitable non-urban road sub-area shall be selected by the procurer where the luminaire positioning is in line with the PDI photometry study for in-situ photometric measurements (according to EN 13032-2) and energy consumption measurements (according to EN 13201-5) during an agreed period of one week. The selected sub-area must be free of significant interference to lighting caused by trees, bus-stops or parked vehicles and from background light levels caused by advertising boards or buildings. For roads with luminance requirements, it will be acceptable to provide illuminance data so long as the road surface reflectivity

<table>
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<td>assumed in the design calculations for PDI has previously been stated.

The parameters influencing the uncertainty in illuminance measurements mentioned in Annex F of EN 13201-4 should be considered. It is advisable to use automated illuminance measurement systems and to agree on the illuminance and data point tolerances before the project (±10% is suggested).

During the same one week period peak power [W] and energy consumption [kWh] shall be measured and/or calculated for the relevant light points.

The in-situ measured values of PDI and AECI shall be ±5% of the design AECI value and ± 15% of the design PDI value.

Note: The consequences of non-compliance with the design values for PDI and/or AECI should be defined in the ITT. Options could include:

• Remedial works to be undertaken at no additional cost to the procurer.
• Financial penalties in proportion to the degree of non-compliance (perhaps related to foreseeable additional electricity costs over a defined period caused by the poorer performing installation).

In cases where non-compliance is disputed, the contractor may repeat the measurements on the same sub-area or, if it can be argued that the sub-area was not suitable for measurement, select another sub-area. The procurer shall not be liable for the cost burden of any additional measurements.

If the performance is actually better than the design predictions, then no penalties should apply.</td>
</tr>
</table>

Questions to stakeholders:

Q1. What are the main limitations of in-situ measurements of illumination, what degree of accuracy is possible from the instrumentation available and what is the general scale of potential interference from background light or obstacles?

Q2. Are there any issues with mobile monitoring of illuminance or luminance using vehicle based instrumentation? Can we ask for measurements 10cm above the road level in order to be more practical?

8 Light pollution criteria

As mentioned in the Preliminary report, light pollution is one of the environmental impacts associated with road lighting that is not captured by LCA analysis. Broadly speaking, light pollution can be considered as the sum of all adverse impacts of artificial light on the environment due to any part of the light from a lighting installation that:

1. is misdirected or that is directed on surfaces where no lighting is required
2. is excessive with respect to the actual needs
3. can cause overt adverse effects on human beings and environment"

Some strong opinions were expressed by certain stakeholders about this topic, with the most extreme arguments stating that the most environmentally friendly road lighting system is the one that was never built in the first place.

Although the aforementioned argument is technically correct and perfectly valid, it must be emphasised that the EU GPP criteria does not intend in any way to influence the decision to light a road or not. The way EU GPP criteria should fit into procurer decisions is illustrated in Figure 16.

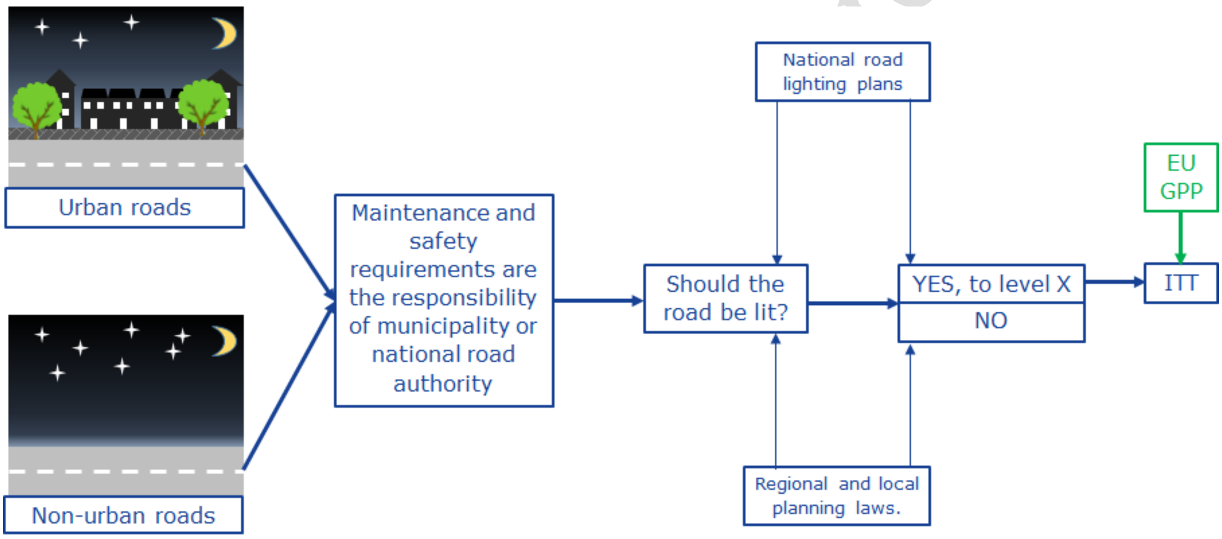

Figure 16. Role of EU GPP criteria in planning process for road lighting installations

From Figure 16, it is clear that the decision making process of whether or not to light a road is the responsibility of the relevant public authority and that the decision will ultimately be determined by provisions made in national, regional and local planning procedures. Only once the decision to light a road has been taken and an Invitation to Tender (ITT) is drafted would EU GPP criteria potentially apply.

One example of national planning guidelines for limits on upward light pollution is that of the UK, which is based on technical guide CIE 126:1997. In a similar manner, Catalonia[18] (Spain) has developed its own planning law for public lighting.

[18] Ley 6/2001. de 31 de mayo, de ordenación ambiental del alumbrado para la protección del medio nocturne.

Table 12. Upward light limits as a function of environmental zone in UK and CIE 126

Environmental Zone	Maximum R_{ULO} (%)	
	UK[19]	CIE 126
E1: Areas with intrinsically dark landscapes: national parks, areas of outstanding natural beauty	0	0
E2: Areas of low district brightness: generally outer urban and rural residential areas	2.5	5
E3: Areas of medium intrinsic brightness: generally urban residential areas	5	15
E4: Areas of high district brightness: generally urban areas having mixed residential and commercial use with high night time activity	15	25

The concept of light pollution can broadly be considered as the alteration of natural light levels by human activities, including the emission of artificial light. Light pollution may undermine enjoyment of the night sky (phenomenon sky glow), be harmful to species or be a source of annoyance to people (glare and obtrusive light).

8.1 *Ratio of Upward Light Output (R_{ULO} or ULOR[20])*

8.1.1 Background research and supporting rationale

Sky Glow

The central argument for having criteria that limit the upward light output ratio is that it can help reduce light pollution or night time "sky glow" and also help limit obtrusive light in built-up urban areas.

For self-evident reasons, one of the first stakeholder groups to raise concerns about sky glow from light pollution was astronomers. The Royal Astronomical Society (RAS) in the UK found that 80% of their members could not, or could barely see the Milky Way, having to travel 5-50 miles before being able to find suitable viewing conditions[21].

LED luminaires typically include glass envelopes, lenses, optical mixing chambers, reflectors and/or diffusers to obtain the desired light distribution. This makes them better suited to deal with ambitious R_{ULO} requirements. With traditional HID cobra-heads there was a trade-off when choosing between drop refractor type lenses and flat glass lenses. Drop lens units were typically used for wider pole spacings and more uniform lighting patterns. Flat glass units usually have less upward light output, better control of light trespass into residential windows, and lower high angle glare. However, flat glass also reduces the total light output or efficiency of the luminaire due to increased internal reflections. Internal reflections can be attenuated by using anti-reflective coatings.

From the point of view of environmental impact and products available on the market there are no grounds to discriminate R_{ULO} requirements according to EN 13201-2 road classes. It should be noted that P classes only occur in residential areas and therefore they could be subjected to less strict requirements.

Thanks to the use of satellite mounted cameras and sensors, it is possible to have an idea of the actual levels of light pollution across the whole of Europe.

[19] ILE, 2002. Guidance notes for the reduction of light pollution. The Institution of Lighting Engineers, UK.
[20] ULOR (Upward Light Output Ratio) is the same to ULR (Upward Light Ratio) and R_{ULO}.
[21] http://www.ras.org.uk/events-and-meetings/123

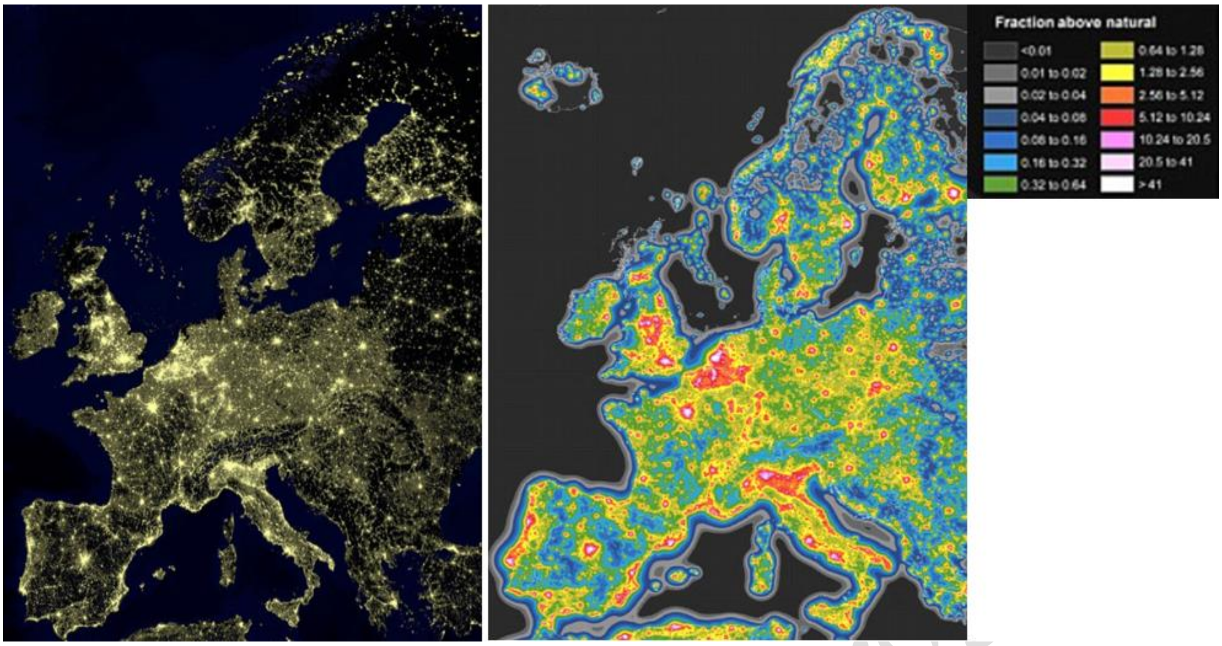

Figure 17. Light pollution in Europe: "Earthlights 2002" published by NASA (left) and VIIRS DNB data from the Suomi NPP satellite (right)[22].

From the images in Figure 17 it is clear that Europe has significant levels of light pollution. The particular impact of major cities can be seen in the cases of Madrid, Paris, London and Rome compared to surrounding areas. The largest areas of consistently high light pollution are in northern Italy, the “low countries” (Belgium and the Netherlands), Western England and on the coastline between Lisbon and Porto.

According the data presented by Falchi et al., (2016) around only around 7% of the land in Europe suffers from light pollution levels that are high enough to prevent viewing of the Milky Way. However, unfortunately around 60% of the European population live in these polluted areas. Concern was expressed by the authors about a significant amount of light pollution being missed in the future as the many lighting installations shift to LED. The problem with LED is that, unlike traditional sodium lamps, it emits a significant portion of its light output in the 400-500nm range. The sensitivity of the satellite mounted VIIRS DNB (Visible Infrared Imaging Radiometer Suite Day Night Band) sensor is only useful between 500 and 900nm. So one consequence of a shift to more energy efficient street lighting could possibly be that there is a perceived drop in light pollution levels measured by VIIR DNB that may or may not be true.

Blue light can hinder naked eye astronomic observations by increasing sky glow because it scatters more in the atmosphere and the eye is more sensitive to it at low light levels35.

<u>*Existing criteria and ambition level*</u>

The existing EU GPP criteria, published in 2012, make a distinction between road classes (ME1-ME6, CE0-CE5, S1-7 and roads split by use type (functional or amenity lighting). UOR requirements were much higher, ranging from 3 to 25%.

The best benchmark recommended in EC 245/2009 is to have ULOR at a maximum of 1% for all road luminaires. Because the GPP criteria are voluntary and have the aim of increasing awareness of environmental criteria that can apply in ITTs, it is proposed that

[22] Falchi et al., 2016. The new world atlas of artificial night sky brightness. Science Advances, Vol. 2(6) e1600377.

all luminaires have a ULOR of 0% when tested in the laboratory. A distinction is made between scenarios where light points are flexible (luminaires must be installed horizontally) ad where existing light points must be used (exceptions made for retrofitting existing installations). This last point is due to the fact that light poles are most often installed at some distance from the road and in order to direct the light on the road they are inclined (typically 5 to 15°).

8.1.2 Stakeholder discussion

Stakeholders highlighted the major benefits that were possible in reducing light pollution from road lighting due to reduced upward light output from luminares, better directed optics using LED technology and curfew dimming. It was pointed out that municipalities would also have to be pro-active in other areas beyond the scope of EU GPP criteria for road lighting if they wanted to minimise light pollution as much as possible. Examples of other areas where action would be required included: lighting of monuments, buildings, parks, advertisements, commercial and private properties.

About R_{ULO}

In the TR 1.0, it was proposed that R_{ULO} should be less than 1% for all road classes and lumen outputs for both the core and comprehensive ambition level.

The initial proposal was criticised by stakeholders from several different perspectives. One simple criticism was that the terminologies and acrynoms should be updated to reflect recent changes in terminology in international standards (EN 12665:2011 could be considered as a case in point). It was pointed out that R_{ULO} (percentage of total light output above 90°) might address diffuse light pollution to the night sky but does nothing for addressing obtrusive light into adjacent areas. In order to address obtrusive light, procurers should be able to stipulate requirements for certain CIE flux codes at 80° and 70° to the horizontal. To better understand these requirements, flux codes should be considered in the context of the flux diagram provided in EN 13032-2.

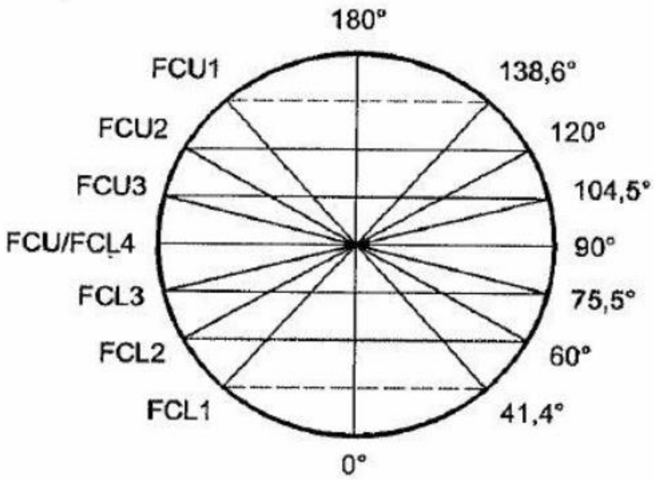

Figure 18. Illustration of illuminated zones applicable to CEN flux codes.

An example requirement for a flux code would be FCL3 >99 for comprehensive level (meaning that 99% of total light output is below the 75.5° angle). The actual 1% R_{ULO} specified for core and comprehensive was considered as unambitious by some stakeholders who added that 0% was particularly easy to achieve for correctly installed LED luminaires. However, it was added by another stakeholder that some degree of upward light output (e.g. 1%) may be desirable in road lighting in old city centre locations with historical buildings. Another comment suggested that a R_{ULO} of 15% could be suitable in areas where vertical illumination is required. Regardless, any measurements of R_{ULO} should be based on luminaire data from accredited laboratories (Article 44 of Directive 2014/24) in accordance with the photometric intensity tables in EN 13032-1:2004+A1:2012 and EN 13032-4:2015. Specifically for LED luminaires, measurements according to Annex D of IEC 62722-1 should be considered. It was added that field measurements of R_{ULO} are not practical.

One potential problem with restrictions for R_{ULO} was that it might lead to unintended impacts on the energy efficiency (requiring more light points) or, where no extra light points are introduced, on the level of uniformity. Some stakeholders added that they were accustomed to working with glare classes instead of R_{ULO}, although these two considerations do not fully overlap in terms of road lighting design. However, any implementation of GPP criteria related to G classes would be more complex and require additional guidance. However, despite the additional complexity, it was stated that Italian GPP criteria currently take G classes into account.

Other stakeholders complained that 0% R_{ULO} will still not prevent sky glow because light will also be reflected off the road surface. However, it was countered that such reflection must represent a less significant contribution to sky glow than directly emitted upward light.

8.1.3 Criteria proposals for R_{ULO} (or ULOR)

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">TS7 Ratio of Upward Light Output (R_{ULO})</td></tr>
<tr><td colspan="2">(Applies to all contracts where new luminaires are purchased and applies equally, irrespective of road class or lumen output. However, in situations where vertical illumination is required, procurers should consider if 0% R_{ULO} is still appropriate)

All luminaire models purchased shall be rated with a 0% R_{ULO} according to photometric data.

In cases of new lighting installations, the luminaires shall be installed horizontally to ensure that 0% R_{ULO} is achieved on the road. The boom angle shall not exceed 10° unless this can be justified for energy efficiency reasons.

In cases of existing lighting installations, luminaires will have a boom angle correction if the boom angle is above 15°

Verification:

The photometric file shall be provided including the photometric intensity table from which the R_{ULO} is calculated according to EN 13032-1, EN 13032-2, EN 13032-4,Annex D of IEC 62722-1 or other relevant international standards.

In cases where luminaires are not installed horizontally, the photometric file shall prove that there is no significant upward light emission within the installation angle.</td></tr>
</table>

8.2 *Ecological light pollution*

8.2.1 Background research and supporting rationale

The most important aspect of light pollution is the potential harm it may cause to species. Many thousands of years of evolution in harmony with natural photic environments has being disrupted by human settlement and activity. Levels of artificial lighting have increased dramatically in developed countries to the extent that light pollution levels can even be considered as an indicator of economic activity[23]. The nature of the photic environment can play an important role on mating behaviour, ease of predation, ease of predator evasion, nesting and foraging behaviours. A growing body of evidence in the academic literature is leading to the conclusions that night time light can seriously disrupt the nocturnal behaviour of many species. The degree of impact on the behaviour of different species and their potential to adapt to artificial lighting may vary significantly.

The effect of light on insect behaviour and survival is especially relevant since they play a vital role in food pyramids in all ecosystems. Insects that are attracted by lights can be subjected to different effects, which Eisenbeis[24] described as:

- The "fixated or capture effect", where insects are drawn to the light and so fixated by it that they effectively do not feed, reproduce or attempt to evade predators. They may flight directly to the light, suffering traumas due to burns, overheating, dehydration, wing damage or, if lighting in on bridges, possible drowning.
- The "crash barrier effect", where a row of road lights may act as an effective barrier preventing the passage of insects to potentially important food sources and breeding habitats.
- The "vacuum cleaner effect", where areas of 50 to 600m may be devoid of certain insect species due to the strength of the draw of artificial light sources.

Two examples worth mentioning are moths and mayflies. Moths are well known to suffer from the "fixated effect", flying towards lights and remaining there all night, losing opportunities for feeding and reproduction. Light sources can mask the dim moonlit glows of natural flowers that moths have evolved to feed on. Once distracted by artificial light, moths are less prone to carrying out evasive manoeuvres to avoid predation by bats[25]. The attraction of moths to artificial lights greatly increases predation opportunities for bats, birds and spiders but, in the context of road lighting, all of these species are brought closer to the road, were collisions with road traffic would be fatal.

Mayflies, and very important food source for fish in many ecosystems, spend most of their lives underwater but after their final moult, they develop wings and live for as little as 30 minutes or as long as a few days. During this short period, mating occurs and females will lay their eggs on the first surface they land on. The draw to artificial lights will end up with eggs being laid in inadequate locations on many occasions.

The effect of artificial light at night has been shown to affect the migratory routes of birds[26]. Light-induced grounding and mortality of sea-birds is an especially serious issue

[23] Henderson et al., 2012. Measuring economic growth from outer space. American Economic Review, 102(2), p.994-1028.
[24] Eisenbeis, G., Artificial night lighting and insects: Attraction of insects to streetlamps in a rural setting in Germany. P.281-304 In Eds. Rich and Longcore, 2006. Ecological consequences of Artificial Night Lighting.
[25] Frank, K., Effects of Artificial Night Lighting on Moths p.305-344 In Eds. Rich and Longcore, 2006. Ecological consequences of Artificial Night Lighting.
[26] La Sorte et al., 2017. Seasonal associations with urban light pollution for nocturnally migrating bird populations. Global Change Biology, DOI: 10.1111/gcb.13792

that has been observed in petrel and shearwater families, and shown to affect already endangered sea bird species[27].

Exposure of loggerhead sea turtles to yellow and orange lights (but not red light) has been shown to cause a reduction in nesting attempts, delay the nesting process of attempts that were made and cause notable disruption and disorientation in sea finding behaviour[28]. Disruption to sea finding behaviour is especially an issue for sea turtle hatchings. The reflection of moonlight on the sea naturally attracts the hatchlings to the sea. In a recent Brazilian study[29], low moonlight levels alone are sufficient to complicate sea finding for sea turtle hatchlings but that they still moved in the general direction of the sea. When artificial light was present, more than half of the deviations in hatchling trajectory were actually away from the sea and towards the artificial light source.

In cases where lighting is deemed necessary for human activity, the only potential role EU GPP criteria could perhaps play is to encourage dimming as far as possible and/or consider the choice of spectral output from the artificial light source. Although there is much research still to be carried out in this area, a literature review of ecological impacts of light pollution on different types of species has led to the following guidance table[30]:

Table 13. General guide to effect of different spectral bands of light on different species

	UV	Violet	Blue	Green	Yellow	Orange	Red	IR
wavelength (nm)	<400	400-420	420-500	500-575	575-585	585-605	605-700	>700
freshwater fish	x	x	x	x	x	x	x	
marine fish	x	x	x	x				
shellfish (zooplankton)	x	(x)	(x)					
amphibia&reptiles	x	x	x	>550	x	x	x	x
birds	x	x	x	x		x	x	x
mammals (excluding bats)	x	x	x	x			x	
bats	x	x	x	x				
insects	x	x	x	x				
	note: (x) = assumed possible but not identified in literature							

With the general shift to LED lighting the spectral distribution of LED emission, which can vary significantly from one model to another needs to be considered. In areas of high ecological value, dimming or even complete extinction during curfew hours should be considered for road lighting for both ecological and energy efficiency reasons.

Blue rich light

Much recent debate, both in scientific circles and in public news, has referred to the potential health effects of blue rich light on humans, specifically due to impacts on circadian rhythm[31]. This is related to the recently discovered intrinsically photosensitive retinal ganglion cells (ipRGCs), which are crucial for delivering light information to parts

[27] Rodriguez et al., 2017. Seabird mortality induced by land-based artificial lights. Conservation Biology, In press, DOI: 10.1111/cobi.12900.
[28] Silva et al., 2017. Light pollution affects nesting behaviour of loggerhead turtles and predation risk of nests and hatchlings. J Photochem Photobiol B, Biol. 173, p.240-249.
[29] Simoes et al., 2017. Influence of artificial lights on the orientation of hatchlings of Eretmochelys imbricate in Pernambuco, Brazil. Zoologia, June, DOI: 10.3897/zoologia.34.e13727
[30] Biodiv, 2015. Les Cahiers de BIODIV'2050 n°6, 'Eclairage du 21ème siècle et biodiversité- Pour une meilleure prise en compte des externalités de l'éclairage extérieur sur notre environnement', 7/2015, available at : http://www.mission-economie-biodiversite.com/publication/eclairage-du-21eme-siecle-et-biodiversite
[31] AMA, 2016. American Medical Association. Report of the Council on Science and Public Health. Human and environmental effects of Light Emitting Diode (LED) community lighting.

of the brain controlling the biological clock. Potential health effects on humans are specific to certain wavelengths and not necessarily to broader sections of the blue light region. The Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) recently (July 2017) published its preliminary opinion on potential risks to human health of LEDs[32]. According to SCHEER, significant further research is needed before it can be determined if the effects of certain short wavelength light on circadian rhythms can be linked to adverse human health effects or not.

However, for road lighting in particular, the exposure time of people is relatively short compared to indoor light sources and so this is a much more relevant discussion for indoor lighting.

Generic terms such as "*blue light*," "*blue-rich LEDs*," and "*blue content*" used with lighting are not very specific and in fact can be misleading[33]. Actual emissions of "*blue light*" require a knowledge of the full spectral distribution of a light source. The general public perception is that white light from LED is associated with a significant proportion of "blue light" in its emission. Today (April 2017) this assumption is generally true because many white LEDs are based on phosphor converted blue light and consequently many of the high efficacy white LEDs have a relative high amount of blue light in their colour spectra.

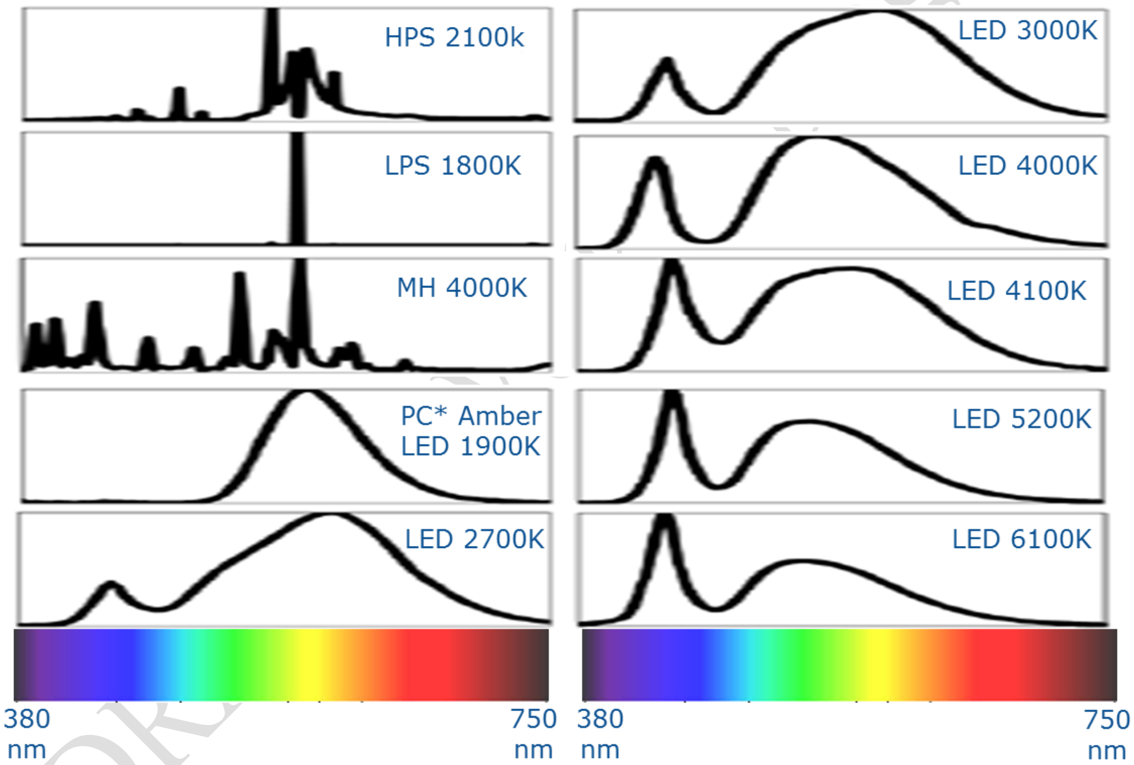

Figure 19. Spectral Power Distributions (SPDs) of different light sources commonly used in road lighting[34]. *PC stands for Phosphor Converted.

As shown in Figure 19, traditional HID lamp technologies can be entirely free of blue light (LPS), have very low "blue light" output (HPS) or have significant output in the blue wavelength ranges (MH). With LED technology, it is possible to tailor the relative outputs of "blue light" and those in the green-yellow-red light ranges. However, the only way to eliminate the blue light output altogether is to down convert the blue light emitted from diodes into longer wavelength light (still in the visible spectrum) using a phosphor.

[32] SCHEER, 2017. Preliminary opinion on potential risks to human health of Light Emitting Diodes (LEDs)
[33] US DOE, Street lighting and blue light – Frequently Asked Questions. Accessed online, July 2017.
[34] US DOE, 2017. An investigation of LED Street Lighting's Impact on Sky Glow. Accessed online July 2017.

However, even for a light source emitting blue light, depending on the other relevant wavelengths emitted, the human eye may perceive it as white or as other colours. There are different blends of white light defined. The perceived "colour" of a white light source by the human eye is most often expressed as the Correlated Colour Temperature (CCT). The term CCT is expressed in units of Kelvin and corresponds to the temperature that a "black body" would need to have in order to emit light corresponding to the same appearance as the light source in question.

In this context, the CCT is an approximate and unreliable metric for gauging the potential health and visibility influences of a lighting source but is a perfect reflection of human perception. Confusingly, the higher the CCT, the "colder" is the appearance of the light (i.e. more white-blue). So a "warm LED" would actually have a lower CCT than a "cold LED". This is illustrated in Figure 20. Overcast daylight is typically 6500 K.

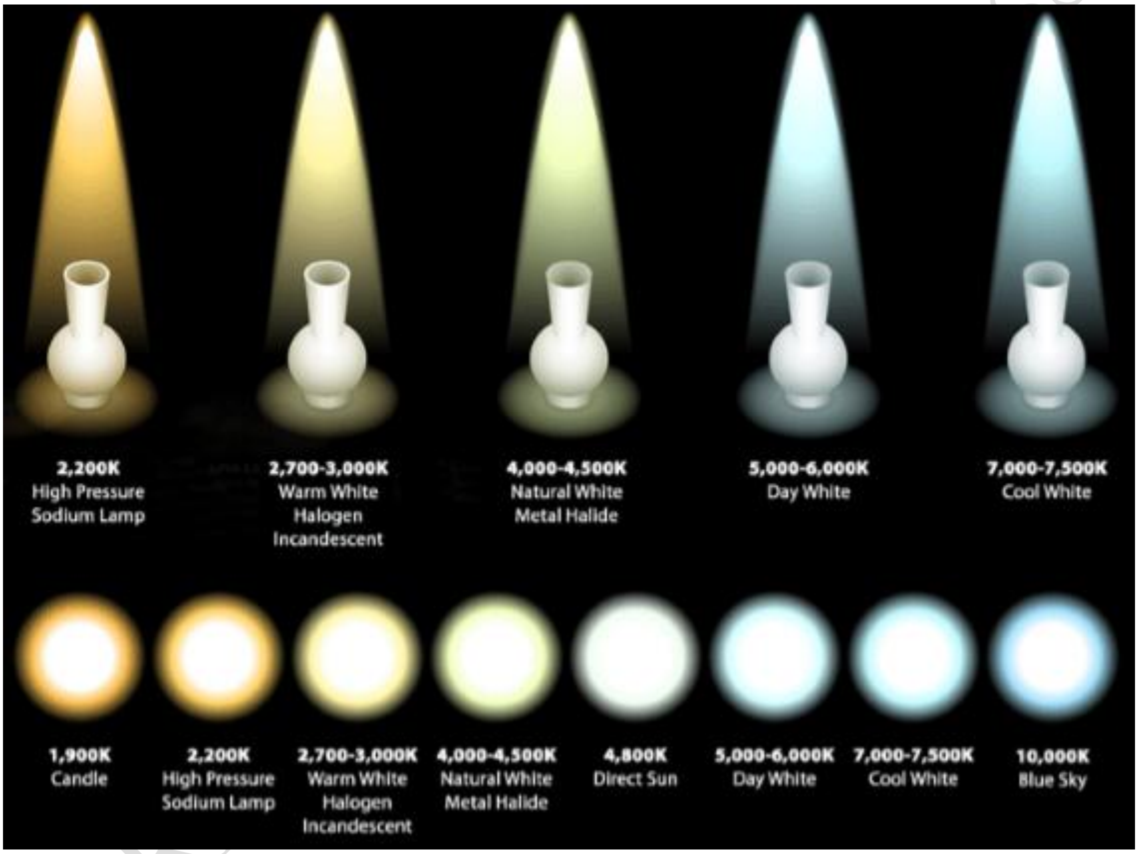

Figure 20. Illustration of different correlated colour temperatures (CCTs).

An advantage of "blue light" is that at very low light levels the human eye is more responsive to blue light due to so-called scotopic vision in comparison to photopic vision[35]. The area between or combination of photopic and scotopic vision is called mesopic vision.

[35] US DOE, 'Street Lighting and Blue Light Frequently Asked Questions'. Accessed online, July 2017.

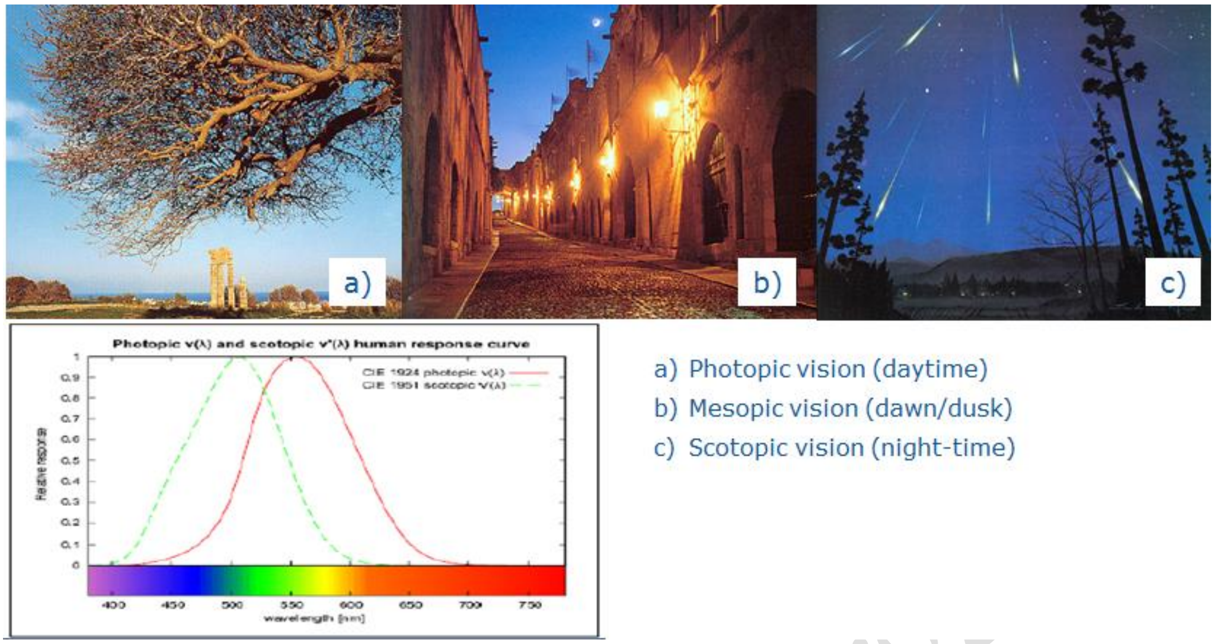

Figure 21. Illustration of the differences in photopic, mesopic and scotopic vision (a-c) and in the response of human photoreceptors in photopic and scotopic environments[36].

Cool white (e.g. 5000 K) tend to have more blue in their spectra compared to warm white (e.g. 3000 K). Hence there are advocates to promote cool white light sources with so-called increased mesopic vision. This is not recognised in EN 13201-2:2016 but is acknowledged in the US standard IES TM-12 'Spectral Effects of Lighting on Visual Performance at Mesopic Lighting Levels'.

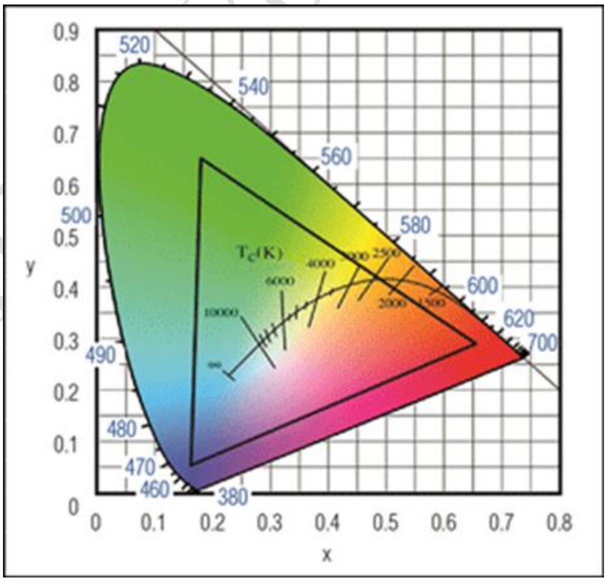

Figure 22. The CIE 1931 x,y chromaticity space showing the colour temperature locus and CCT lines: the lower the CCT, the more red light[37].

Some general recommendations can be made regarding this topic:

[36] Presentation slides on "Lighting Fundamentals", shared by one stakeholder.
[37] https://www.maximintegrated.com/en/app-notes/index.mvp/id/5410

- Do not use the term blue light in any GPP criteria unless relating to spectral emission within a defined wavelength range..
- Only use CCT if the criterion is related to aesthetic requirements relating to light perceived by humans (rather than light perceived by other species).
- Do not justify criteria on blue light restrictions or CCT in road lighting due to potential human health effects because exposure times are too small compared to indoor exposure.

8.2.2 Stakeholder discussion

When prompted, a split opinion was received from stakeholders about photobiological safety of LED light sources. One group felt that this should be addressed by EU GPP criteria while the other group felt that this should be addressed by other means. Reference was made to the IEC 62471-1, CIE 62778, EN 60598-1 and EN 60598-2-3 standards, which cover this issue. One suggestion was to state that EU GPP criteria require that any LED luminaire be compliant with Risk Group 0 or Risk Group 1 limits for light hazards.

An intermediate proposal (between TR 1.0 and TR 2.0) that was discussed amongst a sub-group of the most active stakeholders in the group was to consider light pollution in different ways. For example, one criterion for sky glow (R_{ULO}) and another criterion for the visual quality of the light for humans and nocturnal species (CCT and CRI) impacts of road lighting.

Concerns were expressed about any requirements for lower CRI values, as it would result in the need for higher emissions of "blue light" and/or higher levels of illuminance to achieve a given visual acuity for humans.

Some stakeholders where highly critical of justifying lower CCT values in the comprehensive level criterion on the basis of impact on nocturnal species since much research still needs to be done in this area and potential impacts could vary greatly from species to species. A further review of research related to the impact of light on nocturnal species such as birds, bats, insects and aquatic species was requested. Despite these concerns there was some support for criteria related to CCT, but with the nuance that CCT alone will not address concerns about light pollution.

One of the arguments against proposals for low CCT values was that lower CCT LEDs had lower energy efficiency. This prompted an analysis of US data by one stakeholder who kindly provided the results of their analysis (see below).

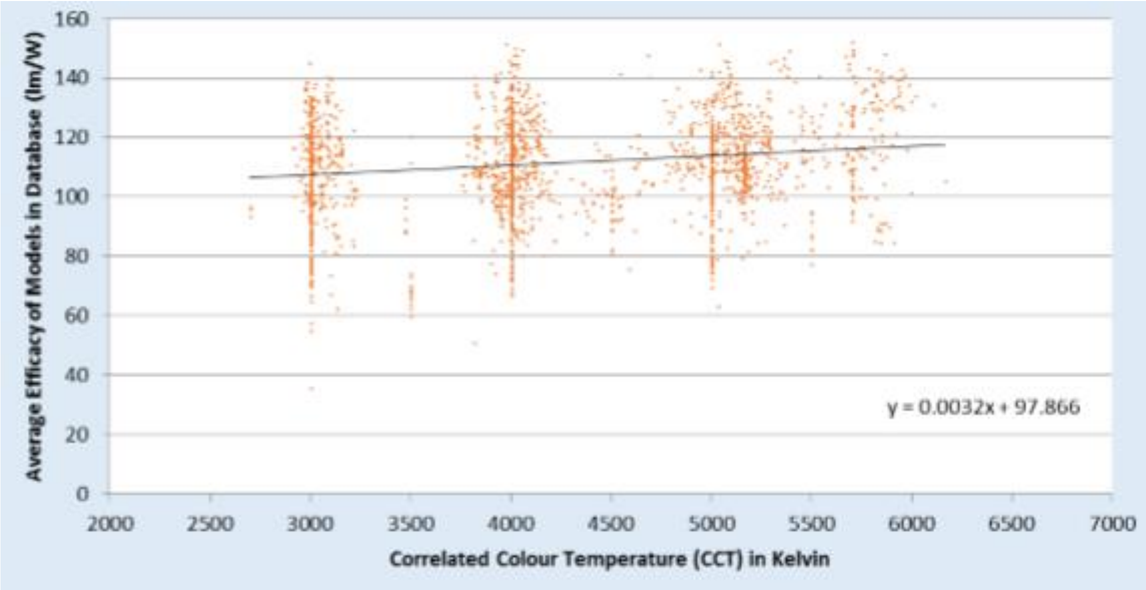

Figure 23. Effect of CCT on luminaire efficacy of 2016 models in the Lighting Facts database of the US DOE.

The data in Figure 23 reveal only a modest decrease in luminaire efficacy of around 3lm/W, per 1000K change within the typical LED CCT range of 2500 to 5500K. This is equivalent to around a 3% decrease in luminaire efficacy and is not considered sufficient as to justify it as a significant trade-off (i.e. lower CCT results in lower energy efficiency).

When asked if the criteria for CRI and CCT should only be applied always or only in certain situations, most stakeholders agreed that this should be decided by the tenderer. The interpretation of guideline CIE 126 (1997) for identifying areas where light pollution is a concern will not be applied in an identical way across different Member States.

It was also added that requirements for lower CCT values is an indirect way of reducing concerns about the emission of blue light from cooler LED lighting. Some stakeholders were in favour of CCTs <3000K being specified in EU GPP criteria while others were opposed to the idea. Those against disputed this assumption that blue light output and CCT are correlated. This prompted one stakeholder to share the graph below.

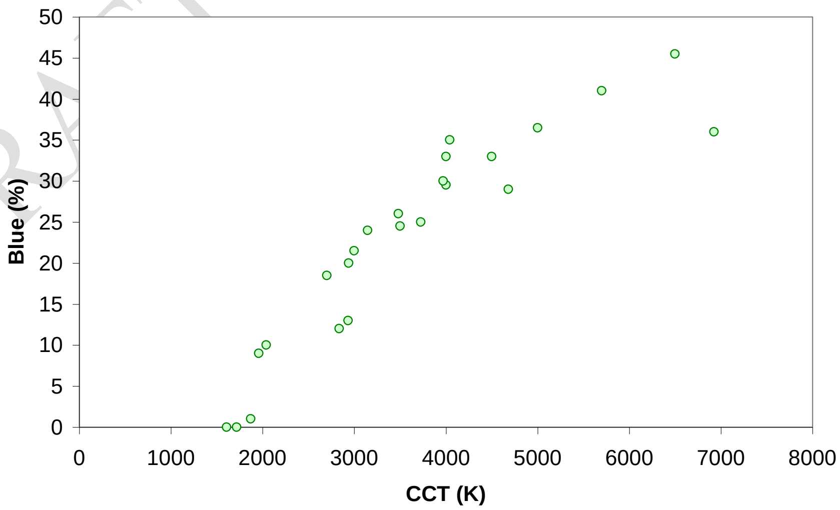

Figure 24. Correlation plot of blue light spectral power output versus CCT for different light sources.

Despite the general correlation shown above, it was repeated that there is no fixed relationship between CCT and the fraction of light output in the "blue" wavelength range.

Even though some stakeholders were against the specification of CRI and CCT in light pollution criteria, any requirements stipulated in the criteria should be linked to standard methods defined in CIE 13.3:1995 and CIE 15:2004 for CRI and CCT respectively. These parameters are also mentioned in IEC 62717 and IEC 62722 (parts 1 and 2).

Regarding the subject of photobiological safety of road lighting, a mixed response was received with some stakeholders wanting this to be addressed in EU GPP criteria and others not. Those in favour referred to a requirement that assessment according to IEC 62471 should reveal luminaires to fall into risk groups 0 or 1 only. Other relevant standards included IEC 62778:2012 (for assessment of blue light hazard) and EN 60598 (general requirements for luminaires).

Annoyance, glare and obtrusive light

Light is a relatively subjective quality and as public authorities have shifted towards more energy efficient LED road lighting, this has led to a "whitening" of road lighting. There are numerous examples in the news of citizens complaining about the change in "atmosphere" in a residential or historic city centre location after sodium lamps have been changed to LED-based light sources.

Common complaints are that the change creates a "hospital or prison-like" feel to the lighted area despite the fact that other aspects such as energy efficiency and facial recognition are improved. Procurers should be sensitive to the potential reaction of local residents to any LED-based substitution of HPS or LPS lamps. In cases where objections can be expected or have already been voiced (e.g. historic city centre and residential zones), criteria should relate to CCT (e.g. <3000K) in certain environmental zones.

There is a standard approach for assessing the glare from road lighting is set out in the recent EN 13201-2:2016, which defines intensity classes for the restriction of disability glare and control of obtrusive light G*1, G*2, G*3, G*4, G*5 and G*6 in Annex A. In general, as the glare class becomes more stringent, less light is permitted on the ground coming directions higher than 70°, 80° and 90° below the horizontal.

Light pollution from obtrusive light to humans and the methods for reduction are discussed in guideline CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations'.

8.2.3 Criteria proposals for ecological light pollution and annoyance

Core criteria	Comprehensive criteria
TS8 Ecological light pollution and annoyance	
(The CCT condition applies to areas where "cold" lighting would be deemed unacceptable by the procurer.) When deemed necessary due to specific local ecological impact, light levels shall be dimmed to less than 50% during curfew hours. The CCT of road lighting at full design light output in urban areas shall be ≤3000 K. ***Verification:*** The tenderer shall provide measurements	*(The blue/violet light limit applies to road lighting in areas where the procurer has reason to believe that emissions of blue/violet light will adversely affect local species and the CCT condition applies to areas where "cold" lighting would be deemed unacceptable by the procurer.)* When deemed necessary due to specific local ecological impact, light levels shall be dimmed to less than 30% during curfew hours and the spectral output of the luminaire shall be below 250µW/lm 10% in the 400 to 490nm wavelength

of CCT reported in accordance with CIE 15. With dimming, the tenderer shall provide details of the proposed dimming controls and the range of dimming capabilities, which shall at least permit dimming based on an astronomical clock. For LED lighting, results shall be considered in the context of IEA 4E SSL recommendations.	range The CCT of road lighting at full design light output in urban areas shall be ≤2700 K. ***Verification:*** The tenderer shall provide measurements of CCT reported in accordance with CIE 15. When blue/violent light emissions are to be quantified, the tenderer shall provide the light source spectrum (<10 nm & 8 bit resolution) from the manufacturer together with a calculation of the intensity of light emitted in the 400-500nm range. When dimming is required, the tenderer shall provide details of the proposed dimming controls and the range of dimming capabilities, which shall at least permit dimming based on an astronomical clock. For LED lighting, results shall be considered in the context of IEA 4E SSL recommendations.

Questions to stakeholders:

Q1. Any opinions about the blue light requirement in the comprehensive criterion? Can this be reasonably quantified? Is there much experience with using such a criterion?

Q2. Is the potential contribution of blue light to sky glow effectively negated by also requiring 0% R_{ULO}? Or is light reflected off the road surface also significant enough?

9 Lifetime

A lighting installation may perform well from an energy efficiency perspective and may deliver the desired quantities and qualities of light after installation but this is irrelevant if the installation is not able to maintain such performance for very long. Problems with the reliability and durability of lighting installations will have direct economic impacts and less direct environmental impacts.

All the criteria in this section are in one way or another related to guaranteeing a minimum useful lifetime of the lighting equipment that is procured. Longer life products that can be repaired or even upgraded to extend their useful life are an important part of European efforts to shift towards a circular economy.

9.1 *Provision of instructions*

9.1.1 Background research and supporting rationale

As lamps and luminaires will probably have to be replaced or repaired at least once in their lifetime, it is important that the procurer has the knowledge on how this should be done in order to carry out replacement and repair operations in a correct and timely manner.

When controls are provided with the system, the procurer has to know exactly how to operate and calibrate them. Periodic recalibration of controls may be necessary as part of maintenance strategies. Besides extending the useful lifetime of the lighting equipment, correct maintenance and repair will also ensure that real-life energy consumption (AECI) can be maintained within the original design window.

9.1.2 Stakeholder discussion

In the proposals in TR 1.0, it was recommended to define a Contract Performance Clause (CPC) requiring the provision of instructions for key aspects related to the lifetime (disassembly of luminaire, replacement of light sources and minimum specifications for replacement light sources) and operation (of lighting controls, including timer or daylight level linked switches) of luminaires.

Stakeholders generally acknowledged the importance of adequate instructions but highlighted the fact that when the contract relates to only one part of a larger lighting network, the requirements for lighting controls will probably already be defined by procurers in technical specifications so that they fit in with the pre-existing centralised control scheme. In any case, it is still useful to have instructions at the level of the individual luminaire in case of the need for in-situ repair or adjustment.

9.1.3 Criteria proposals for provision of instructions

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">TS9 Provision of instructions</td></tr>
<tr><td colspan="2">
(Applies in cases where the equipment and/or controls in the particular lighting installation are different from the normal equipment installed elsewhere on the wider lighting network operated by the procurer).

The tenderer shall provide the following information with the installation of new or renovated lighting systems:
• Disassembly instructions for luminaires
• Instructions on how to replace light sources (where applicable), and which lamps can be used in the luminaires without decreasing the energy efficiency.
• Instructions on how to operate and maintain lighting controls.
• For daylight linked controls, instructions on how to recalibrate and adjust them.
• For time switches, instructions on how to adjust the switch off times, and advice on how best to do this to meet visual needs without excessive increase in energy consumption.

Verification:

Confirmation that written instructions will be provided to the contracting authority.

Note: For large utilities these instructions can be part of the tender requirements, hence in this situation a statement of compliance with the tender requirements is sufficient.
</td></tr>
</table>

9.2 *Waste recovery*

9.2.1 Background research and supporting rationale

Most procurement contracts in EU countries will relate to the renovation or relamping of existing lighting installations. This will result in the generation or waste lamps, ballasts, luminaires and other auxiliary controls. The disposal of waste electronic and electrical equipment (WEEE) has historically been a problem and a loss of potential valuable raw materials which are present in small amounts in each individual component or product.

Large scale organised collection of WEEE will maximise opportunities to recover valuable raw materials and is one of the main drivers behind the WEEE Directive (2012/19/EU). Under the Directive, Member States are obliged to create systems and infrastructure for the collection and recycling of WEEE.

The main aim of any criterion on WEEE compliance for tenderers is to basically ensure that they know where to take the WEEE and commit to doing so if awarded the contract. In a review of the implementation of the WEEE Directive across Europe, it was found that only 4 of the EU-28 countries were collecting more than 50% of the estimated WEEE generated.

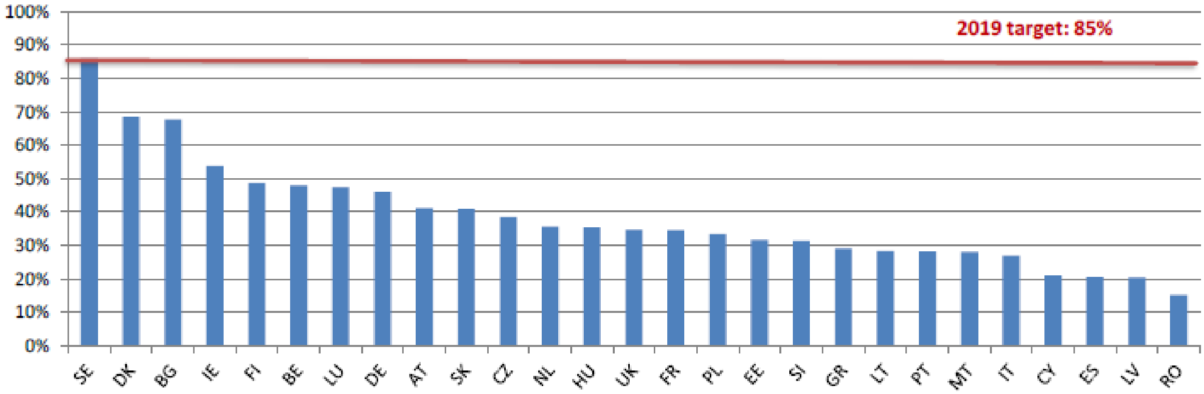

Figure 25. WEEE collection rate in different Member States in 2010[38].

In order to improve WEEE collection and disposal rates in line with the targets of 85% set for 2019 Member States will have to overcome the following problems:

- High rates of unaccounted collection (e.g. due to mislabelling of scrap).
- Improper disposal in household waste
- Limited enforcement and monitoring capacities (e.g. illegally shipped outside of EU).

The same report cited above indicated that there was a significant potential for improving the collection rates of "Category 3 WEEE" (i.e. lamps) although it must be noted that this was a catch-category for both interior and exterior lights for both roads, vehicles and buildings.

9.2.2 Stakeholder discussion

In TR 1.0, CPCs were proposed for the contractor to commit to collecting, sorting and disposing of waste lamps, luminaires and lighting controls for recycling and, where relevant, to facilities accepting WEEE (Waste Electrical and Electronic Equipment). The comprehensive level CPC introduced the additional requirement to produce a bill of materials for a number of specified metals in the waste stream.

Stakeholders were generally of the opinion that a commitment to respecting the requirements of the WEEE Directive was sufficient and that requirements relating to bills of materials would represent additional costs and be of doubtful value when it comes to renovation at least 10-20 years in the future. Furthermore, it was pointed out that the specific information requested in the proposed comprehensive level CPC in terms of the quantities of the specific metals listed does not reflect current practice. How requirements for this CPC apply to different situations need to be clarified, i.e. (i) disposal of waste from a renovation project during the initial execution of the contract and (ii) design for recyclability for a potential future disposal of the new lighting equipment installed during the execution of the contract. Regardless, the scope of the CPC should be clarified (e.g. luminaires, light sources, control equipment, cabinets etc.).

One stakeholder added that the future recyclability of lighting equipment may be hampered by the presence of hazardous materials such as mercury. It could be justified that EU GPP could set criteria for mercury free lamps to be used on the basis that it may enhance the future recyclability of the waste lamp. LED lighting is mercury free and although high pressure mercury lamps have effectively been phased out by Regulation (EC) 245/2009 since 2015, it is still possible for many other different HID-based lamps

[38] EC, 2014. Study on collection rates of waste electrical and electronic equipment (WEEE).

still on the EU market to contain mercury[39]. Further consultation on a potential criterion relating to mercury free lamps is proposed to be discussed at the 2nd AHWG meeting.

9.2.3 Criteria proposals for waste recovery

Core criteria	Comprehensive criteria
TS10 Waste recovery	
The tenderer shall implement appropriate environmental measures to reduce and recover the waste that is produced during the installation of a new or renovated lighting system. All waste lamps and luminaires and lighting controls shall be separated and sent for recovery in accordance with the WEEE directive. Any other waste materials that are expected to be generated and that can be recycled shall be collected and delivered to appropriate facilities. ***Verification:*** The tenderer shall provide details of the waste handling procedures in place and identify suitable sites to which WEEE and other recyclable materials can be taken to for separation, recycling and heat recovery, as appropriate.	
CPC7 Commitment to waste recovery and transport to suitable sites	
The contractor shall provide a schedule of the wastes collected during the project and provide details of any sorting that has been applied prior to transport to suitable sites identified in the original tender or to other suitable sites where wastes can be sorted, processed, recycled and, if relevant, subject to heat recovery. Delivery invoices shall be submitted as proof of delivery.	

Questions to stakeholders

Q1. What would be the impact of an additional criterion excluding Mercury in lamps?

Q2. What are the additional challenges and costs for disposing of Mercury containing lamps compared to Mercury-free lamps?

9.3 ***Product lifetime***

9.3.1 Background research and supporting rationale

Apart from the potential to improve energy efficiency, one of the main advantages of LED lighting is the significantly longer lifetime of the light source compared to most other road lighting lamp technologies. Operation times of 100000 hours, equivalent to 20 years operation of road lighting, are commonly claimed.

Extension of the lifetime of luminaires and its components reduces the overall environmental impacts caused by shorter lifespans, raw material extraction and manufacturing processes. It also partly justifies the higher initial investment in more efficient road lighting installations. An extension of the warranty period would be an

[39] See IMERC factsheet: http://www.newmoa.org/prevention/mercury/imerc/factsheets/lighting_2015.pdf

addition to the requirements on lifetime and would decrease the frequency of early failures.

All lamp technologies suffer a decrease in lumen output for a given power consumption (i.e. a decrease in luminous efficacy) with time. This has been referred to as the factor of lamp lumen maintenance (F_{LLM}) and can be combined with potential losses of light output caused by dirt collecting on the luminaire (F_{LM}).

However, the lifetime of LED lighting is not so simple to guarantee. There are many different components that may contribute to the failure of an LED component, such as the driver, overheating, poor electrical connections etc. The reliability of a particular LED-based luminaire should be considered as the product of all the failure rates of the individual critical failure mechanisms.

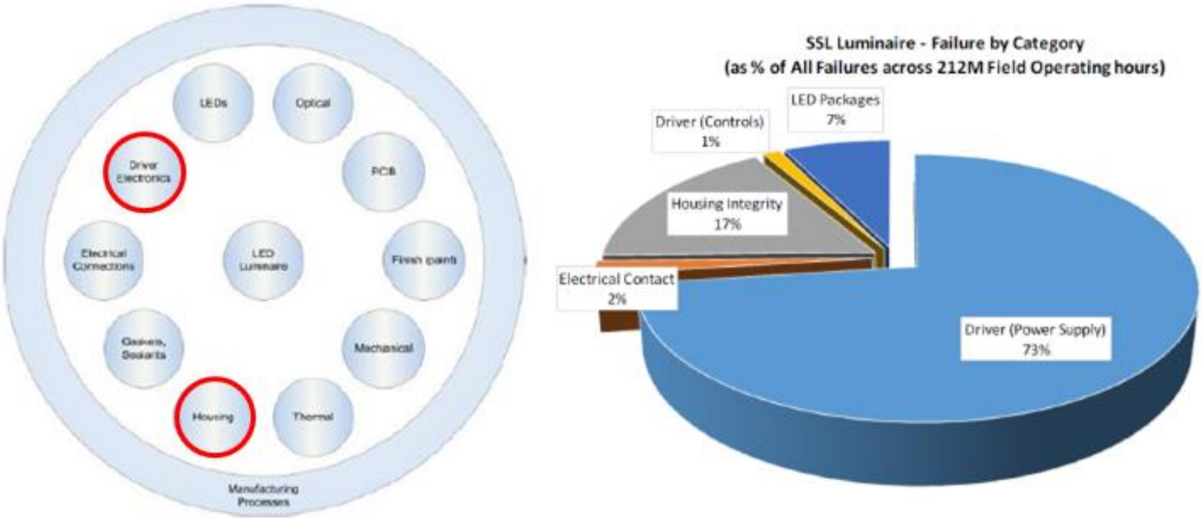

Figure 26. Examples of potential causes of LED failure (left) and statistics about the most common causes of failure (right)[40].

The relevant parameters relating to LED luminaire life times are LxCz and LxBy which are both defined in EIC 62717 and equivalent to the Lamp Survival Factor and Lamp Lumen Maintenance Factors for traditional HID lamps respectively. The former terms can be explained as follows:

- LxBy relates to gradual reductions in lumen output where x is the % of original lumen output still maintained after a defined operating time and y is the % of units that no longer meet the x % of original lumen output at that same time. For example, L70B10 at 50000 hours means that overall lumen output is at least 70% of the original output and less than 10% of the fixtures are <70%. It is common practice to term the "rated life" of an LED light source as the point when its luminous efficacy reaches 70% of the original efficacy.
- LxCz relates to abrupt failures at the end of rated life. Abrupt failures happen with no set pattern in time. Consequently, linking to the LxBy value above, a LxCz value of L0C10 at 50000 hours would mean 10% of the LED modules suffer abrupt

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[40] LSRSC, 2014. LED luminaire lifetime: recommendations for testing and reporting. Solid-state lighting product quality initiative, 3rd edition, September 2014, Next generation lighting industry alliance LED systems reliability consortium.

failure during the rated life – and that the failure rate is effectively 0.2% per 1000 hours operation.

Due to the long lifetimes involved and the rapid development of LED lighting technology, there is not a sufficient evidence base of long term test data to verify lifetime claims. Even if there was, it would be relatively obsolete since the technology would have evolved significantly in the meantime.

In the US, the Illuminating Engineering Society of North America (IESNA) has an approved method (TM-21-11) taking LM-80 data and making useful LED lifetime projections, according to what has been reported in the stakeholder meeting a European standard is under elaboration and will be based in that. In Europe, recent developments have been made in 2017 which are detailed in the stakeholder discussion session.

9.3.2 Stakeholder discussion

An initial proposal in TR 1.0 was made for lumen maintenance to be L92B50 at 16000 hours (core) and both L92B50 at 16000 hours <u>and</u> L80B50 at 50000 hours (comprehensive).

Most stakeholders were agreed about the importance of the criterion, especially to those responsible for maintenance of the lighting installation and especially in harsh environments with large temperature fluctuations. However, there was a split opinion about whether maintenance factor specifications should extend beyond 6000 or 16000 hours. Those against longer term maintenance factors cited the current uncertainty in Europe regarding the extrapolation of laboratory data for LED light sources to longer lifetime expectancy claims. However, since then "*IEC 63013:2017 LED packages - Long-term luminous and radiant flux maintenance projection*" has been officially published.

Stakeholders in favour of longer term lifetime projections being included in criteria generally felt that the ambition level should be raised. It was pointed out that luminaires that meet L92B50 at 16000 hours would also tend to meet L80B50 at 50000 hours – so there is no great distinction between the original proposals for core and comprehensive levels. One stakeholder proposed to increase the comprehensive requirement to L80B10 and L80C08 at 50000h. Lighting Europe are currently considering the application of LxBy values for 100000 hours (i.e. 20 years operation) and such an approach may be interesting for comprehensive level criteria.

Regarding standard methods for assessing LxBy and LxCz in the laboratory, one stakeholder opined that IEC 62722 should be used instead of a combination of IESNA LM80 and TM21. If abrupt failure is to be specifically addressed in lifetime criteria (i.e. LxCz values) then it would be worth referring to IEC 62861:2017, which will include optical materials, interconnectors, electronic subassemblies, cooling systems and construction materials used in LED light sources or luminaires. Another option is to simply have a criterion on the maximum acceptable failure rate for control gear (since this is the most common cause of failure as shown in Figure 26 above). However, any specific requirements for abrupt failure rates will always be questionable since they are based on predictions with a certain amount of statistical uncertainty and are not always published by manufacturers.

The truth is that long term performance can be estimated but never known for certain. For this reason, the idea of requesting extended warranties for LED light sources was raised. Mixed opinions from stakeholders were evident. While some stakeholders were against the idea of extended warranties, others felt that an example of 32000 hours operation (i.e. 8 years) would be a reasonable request and that reputable manufacturers would be more likely to commit to extended warranties. It was claimed that warranties of 3-5 years were already common practice and warranties up to 10 years could reasonably be requested but would likely have a cost impact for the procurer. However, longer warranties need to be backed up with clear CPCs otherwise they may simply represent a meaningless commitment.

9.3.3 Criteria proposals for product lifetime and warranty

Core criteria	**Comprehensive criteria**
TS11 – LED lamp product lifetime, spare parts and warranty	
Any LED-based light sources shall have a rated life of: • L92B50 at 16000 hours and • L80B10 at 60000 hours (projected) The repair or provision of relevant replacement parts of LED modules suffering abrupt failure shall be covered by a warranty for a period of 8 years from the date of installation. ***Verification:*** Test data regarding the maintained lumen output of the light sources shall be provided that is in accordance with IEC 62722 for actual data and IEC 63013 for projected data. The tenderer shall provide a copy of the minimum 8 year warranty that would be signed in case the tender should be successful. The contractor shall provide a copy of the warranty that would be applicable should the tender be successful and provide the necessary contact details (phone and email as a minimum) for dealing with any related queries or potential claims. For clarity, the warranty shall, as a minimum, cover the repair or replacement costs of faulty LED module parts within a reasonable time period after notification of the fault (to be defined by the procurer in the ITT) either directly or via other nominated agents. Replacement parts should be the same as the originals but if this is not possible, equivalent spare parts that perform the same function to the same or to a higher performance level may be used. The warranty shall not cover the following: a) Faulty operation due to vandalism,	Any LED-based light sources shall have a rated life of: • L92B50 at 16000 hours and • L90B10 at 60000 hours (projected) The repair or provision of relevant replacement parts of LED modules suffering abrupt failure shall be covered by a warranty for a period of 10 years from the date of installation. ***Verification:*** Test data regarding the maintained lumen output of the light sources shall be provided that is in accordance with IEC 62722 for actual data and IEC 63013 for projected data. The tenderer shall provide a copy of the minimum 10 year warranty that would be signed in case the tender should be successful. The contractor shall provide a copy of the warranty that would be applicable should the tender be successful and provide the necessary contact details (phone and email as a minimum) for dealing with any related queries or potential claims. For clarity, the warranty shall, as a minimum, cover the repair or replacement costs of faulty LED module parts within a reasonable time period after notification of the fault (to be defined by the procurer in the ITT) either directly or via other nominated agents. Replacement parts should be the same as the originals but if this is not possible, equivalent spare parts that perform the same function to the same or to a higher performance level may be used. The warranty shall not cover the following: a) Faulty operation due to vandalism,

<table>
<tr><td>accidents or other extreme weather events.

b) Lamps or luminaires that have been working for a significant time under abnormal conditions (e.g. used with the wrong line voltage) insofar that this can be proven by the contractor.</td><td>accidents or other extreme weather events.

b) Lamps or luminaires that have been working for a significant time under abnormal conditions (e.g. used with the wrong line voltage) insofar that this can be proven by the contractor.</td></tr>
<tr><td colspan="2">AC3 Extended Warranty</td></tr>
<tr><td colspan="2">X points shall be awarded to tenderers that are willing to provide initial warranties, whose cost is already included in the bid price, that go beyond the minimum warranty periods stated in TS10. Points shall be awarded in proportion to how long the warranty exceeds the minimum requirements as follows:
• Minimum +1 year: 0.5X points
• Minimum +2 years: 0.75X points
• Minimum +3 years or more: X points

Tenderers may also optionally provide quotations for extended warranties that are not included in the bid price, although points shall not be awarded for this. In such cases, it shall be made clear that no payment for any extended warranty is required until the final year of the initial warranty and then annual payments would be made by the procurer to the successful tenderer at the beginning of each year of the extended warranty.

It shall also be clear that the procurer has the option to initiate or leave the offer of the any extended warranty right up until the final year of the initial warranty and that the costs of the extended warranty would be those initially proposed plus any inflation.</td></tr>
</table>

Questions to stakeholders

Q1. Would an initial lifetime requirement at 6000 hours be preferable to 16000h (i.e. to shorten the time to market for new products)? If so, what would be a suitable LxBy at 6000 hours?

Q2. Should an equivalent minimum maintenance factor (F_{LLM}) also be specified here for HID lamps? If so, what should it be?

Q2. When a claim is made on a warranty, should the claim go to the contractor or to the original manufacturer?

9.4 *Reparability*

9.4.1 Background research and supporting rationale

Reparability is one of the key principles that products need to embrace to ensure the transition to a circular economy. In general, products that can be repaired will retain their residual value for the second-hand market and are set up to have extended product lives.

For road lighting, reparability is of particular value to the manufacturer when the products are under warranty in cases where repair due to a simple fault could prevent the need to replace the entire product. Reparability is also of value to the procuring authority if the installation is managed by an in-house maintenance team.

9.4.2 Stakeholder discussion

Stakeholders felt that reparability was an important issue and stated that it was already being considered in mid to high tier products. It was considered important that the LED module and ballast are designed so that they can be replaced independently. A series of 4 reparability classes for LED luminaires that has been established by Synergrid (specification C4/11-3) was described as follows:

- Class 1-LED module and auxiliaries can be removed and replaced in-situ at the luminaire mounting height;
- Class 2 – Auxiliaries can be removed and replaced in situ at the luminaire mounting height;
- Class 3 – luminaire has to demounted before removal and replacement of the LED module or auxiliaries;
- Class 4 – The luminaire is sealed and must be discarded in the case of failure of the LED module or any internal auxiliaries.

Another important aspect to consider in GPP criteria was that of "upgradeability" for LED light sources in existing luminaires. Upgrade could simply mean more energy efficient components, a lower energy consumption for a given photometric output or improved control and functionality. Upgradeable luminaires may offer significant economic and material savings when compared to the complete replacement of luminaires.

9.4.3 Criteria proposals for reparability

Core criteria	**Comprehensive criteria**
TS12 Reparability	
The tenderer shall make sure that the light source (lamp or LED module) and auxiliaries of the luminaire are easily accessible and replaceable and that the replacement can be performed on site (i.e. at luminaire mounting height) and with one of the following types of screwdrivers: - Standard - Pozidrive - Philips - Torx - Allen keys - Combination wrenches. ***Verification:*** A manual shall be provided by the tenderer which shall include an exploded diagram of the luminaire illustrating the parts that can be accessed and replaced. It shall also be confirmed which parts are covered by service agreements under the warranty. The tenderer shall provide a declaration that original or equivalent spare parts will be made available to the contracting authority or through a service provider. A spare part list with references shall be provided.	

9.5 ***Ingress Protection***

9.5.1 Background research and supporting rationale

The lifetime of the luminaire itself, i.e. the housing, cabling and optics, is usually not an issue, but the output of good quality light depends on design and maintenance. Light quality is in particular affected by the amount of dirt and water getting inside the luminaire and should be reduced as much as possible. This can be easily measured according to the IP rating system. According to CIE 154:2003, the IP rating (dust and moisture protection) has also a direct impact on the luminaire maintenance factors.

IP is a two digit code. The first digit indicates the level of protection that the enclosure provides against access to hazardous parts (e.g. electrical conductors, moving parts) and the ingress of solid foreign objects. The second digit indicates the protection of the equipment inside the enclosure against harmful ingress of water.

For all road lighting it is necessary that no ingress of dust is allowed and protection against water is guaranteed. This will help to maintain the promised lumen maintenance and will avoid failures because of external factors such as dust and water.

Benchmark values are provided in Ecodesign Regulation EC/245/2009:

- IP65 for road classes ME1 to ME6 and MEW1 to MEW6
- IP5x for road classes CE0 to CE5, S1 to S6, ES, EV and A

IP65 rating means "No ingress of dust; complete protection against contact" and "Water projected by a nozzle against enclosure from any direction shall have no harmful effects".

9.5.2 Stakeholder discussion

In TR 1.0, a technical specification was proposed for the ingress protection rating of luminaires in M or C class roads of 65 or 66 (depending on local conditions) and of 55 for luminaires used in P class roads.

Some stakeholders were against the imposition of minimum requirements for IP ratings for luminaires in GPP criteria. The main argument against this was that the correct application of IEC 60598-1 standard (specifically clause 9) is considered appropriate for deciding what IP rating is required. Any over specification of IP rating was claimed to simply add cost but no environmental benefits.

However, it was argued that a good IP rating is an essential component of ensuring a good product lifetime. A general requirement for IP 65 for all road lighting was proposed by one stakeholder. Another specific suggestion was to require IP66 for road classes M1 to M6 and IP55 for road classes C0 to C5, P1 to P6, ES, EV and A. Another stakeholder added that IP65 was the minimum requirement in Belgium.

9.5.3 Criteria proposals for Ingress Protection

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">TS13 Ingress Protection (IP rating)</td></tr>
<tr><td colspan="2">Luminaires for road classes M and C shall have an optical system that has an ingress protection rating of at least IP65 or IP66 depending on the local conditions.

Luminaires for road classes P shall be IP55 or higher depending on the local conditions

Verification:</td></tr>
</table>

The tenderer shall provide the technical specifications demonstrating this criterion is met according to IEC 60598-1 clause 9. *Note: The tests for the ingress of dust, solid objects and moisture specified in IEC 60598-1 are not all identical to the tests in IEC 60529 because of the technical characteristics of luminaires. An explanation of the IP numbering system is given in Annex J of the standard.*

9.6 ***Failure rate of control gear***

9.6.1 Background research and supporting rationale

The control gear is often a weak spot in the (LED) luminaire life time. This is typical for the potential weakness of complex electronic controls but it can also be applied to magnetic control gear that has proven its robustness.

As discussed in the Preliminary report (section 3.4.1.2.2) high-quality drivers provide a service life of more than 50000 hours with a failure rate of 0.2% per 1000 hours. Low-performance devices come with a service life of 30000 hours and failure rates of 0.5% per 1000 hours. Therefore, the core criteria are set at the standard for high quality drivers while the comprehensive criteria go a step further.

9.6.2 Stakeholder discussion

In TR 1.0, minimum technical specifications were made for maximum acceptable failure rates of 0.2 per 1000h and a 5 year warranty (core level) and 0.1 per 1000 with a 7 year warranty (comprehensive level).

Stakeholders accepted that the failure rates were well chosen although lower failure rates associated with better quality control gear would result in increased costs. Reputable suppliers will already have failure rate test data from industry quality control testing. Stakeholders were not aware of any international standards for assessing failure rates for control gear. When prompted about possible requirements in GPP criteria for higher protection levels in control gear due to dielectric strengths, stakeholders felt that this would be difficult to verify and should not be specified as it was still under discussion in the IEC technical committee.

9.6.3 Criteria proposals for control gear failure rates

Core criteria	**Comprehensive criteria**
TS14 Failure rate of control gear	
The specified control gear failure rate shall be lower than 0.2% per 1000 h. Specific warranty for control gear of 8 years ***Verification:*** The tenderer shall provide a declaration of compliance with the above failure rate for any control gear they intend to supply. The declaration shall be supported by relevant	The specified control gear failure rate shall be lower than 0.1% per 1000 h. Product warranty of 10 years ***Verification:*** The tenderer shall provide a declaration of compliance with the above failure rate for any control gear they intend to supply. The declaration shall be supported by relevant

industry standard testing procedures.	industry standard testing procedures.

10 Traffic signals

Although not strictly the same subject matter, criteria for traffic signals are included together with the broader criteria-set for road lighting. There is no other relevant EU GPP product group for traffic signals since it is not included within the scope for "*EU GPP Road Design, Construction and Maintenance*" and there is no stand-alone product group such as "*Traffic Management Systems*".

10.1 *Life Cycle Cost*

10.1.1 Background research and supporting rationale

The existing EU GPP criteria for traffic signals focus exclusively on energy efficiency and set maximum operating wattages of 9 to 12W (core) or 7 to 9.5W (comprehensive depending on the diameter of the roundel, the colour of the light and whether the display was a full ball or just an arrow.

The criteria proposed in TR 1.0 (October 2016) were identical to the comprehensive ambition level set in the 2012 criteria for energy efficiency. The only additional aspect was that a minimum lamp lumen maintenance factor (L92B50 at 16000 hours) and a minimum lamp survival factor of L92C08 at 16000 hours were set.

In both the existing EU GPP criteria and the TR 1.0 proposal, there is a lack of data about the energy consumption of pedestrian signals – which will also be highly relevant to the subject matter in the majority of intersections.

Energy efficiency and lifetime data can be quite neatly combined with a life cycle cost framework over a defined period. Better energy efficiency results in lower electricity costs and better lifetime results in reduced maintenance costs. An added advantage of longer life is that there will be less disruption to traffic caused by traffic signal maintenance.

It is uncertain whether the energy efficiency criteria are ambitious enough and what range of performance is available on the market. The market front-runner performance appears to be of the order of just 1-2W[41]. This performance can only be achieved by replacing load resistors and switching elements with digital LED driver modules.

Due to the fact that front-runner performance could be 4-9 times better that the EU GPP requirements and doubts about how widely available front-runner products are and how much more expensive such technology is, it is considered most appropriate to propose a criterion for traffic signals based on life cycle cost.

Chicago case study[42]

In 2011, the city of Chicago reported on an ambitious $32 million project, running from 2004-2014, to retrofit traffic signals with LED technology at 2900 intersections. The new LED traffic signals consume 85% less energy and save $2.55 million per year. It was unclear if the cost savings referred to once all 2900 intersections had been replaced or to the 1000 intersections that had been replaced at the time of the report. Regardless, the worst-case payback period was less than 13 years.

In terms of relative importance in Chicago, installed power for traffic signals was 6MW while road lighting was 70MW.

41 https://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2016/mobility/pr2016040225moen.htm

42 http://www.c40.org/case_studies/led-traffic-lights-reduce-energy-use-in-chicago-by-85

Graz case study[43]

Graz has around 260 traffic signal intersections and is promoting the replacement of traffic signals with LED technology whenever the existing lamp needs to be replaced. The assessment assumed an energy consumption of 75W for the traditional lamp and 10W for the replacement LED lamp. In terms of lifetime, the traditional lamps were replaced every 6 months as per a fixed maintenance schedule (an annual maintenance cost of €960,000). The replacement schedule can be extended by a factor of 6 (i.e. up to 3 years instead of every 6 months) when using LED lamps.

At the time of publication (year unknown), LED lamps for traffic signals were 2-3 times higher than traditional lamps but it could be realistically expected that this would be paid back within 2 years simply by the longer lifetime.

In terms of relative importance in Graz, electricity consumption for traffic signals was 1.7 million kWh/yr while (ca. €220,000) road lighting was 8.5million kWh/yr (ca. €1.1 million).

For comparison, the same document citing the Graz case study provided details of the 2001 retrofit of traffic signals in Stockholm in 2001 (530 intersections). A total additional LED-related investment of €3 million was paid back in 4-5 years thanks to annual savings in electricity (€471,000/yr) and maintenance (€243,000/yr).

Early US experience[44]

Even back in 2009, LED was the standard approach for any new traffic signal installations in the US. The replacement of traditional incandescent lamps with LED lamps results in energy savings of around 93%. In 2009 the reported difference in lamp costs was typically $3 for incandescent bulbs and $150 for LED bulbs – a factor of 50 difference!

Despite the major differences in capital costs, savings on electricity and maintenance are so high that payback periods of 0.5 to 3 years for retrofitting traffic signals with LEDs are the norm.

The energy saving potential of retrofitting an individual traffic signal will depend on the duty cycle (i.e. red-amber-green). The US study found that, in general, the retrofitting of red signals should be prioritised over green signals and that amber signals were of least potential energy savings.

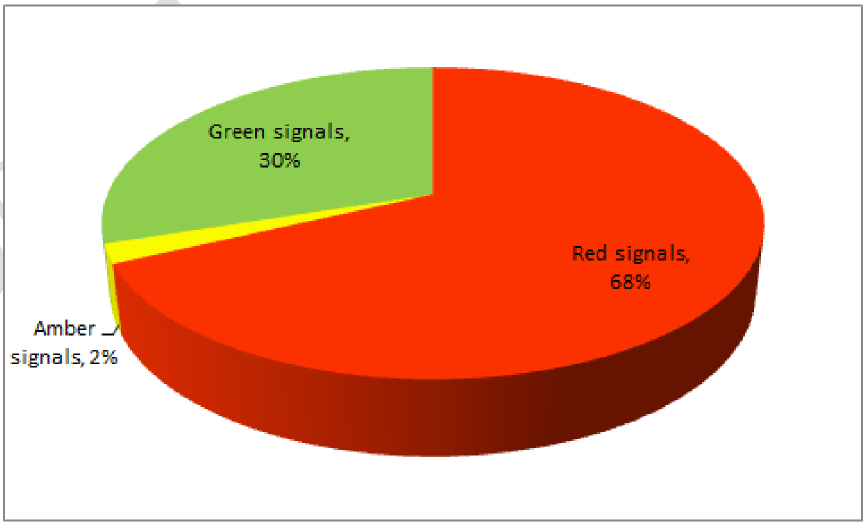

Figure 27. Energy saving potential for different lights in traffic signals (Source RPN, 2009)

[43] http://www.eltis.org/sites/eltis/files/Competence_reference_material_urbandesign_en_6.pdf

[44] Taken from the 2009 Responsible Purchasing Network (RPN) Guide to LED Exit Signs Street Lights and Traffic Signals. Accessed online: http://www.everglow.us/pdf/rpn-led-purchasing-guide.pdf

The authors of the 2009 RPN guide also illustrated the specific savings that are possible for different traffic light fixtures.

Table 14. Energy and cost savings of incandescent vs. LED traffic signals

	Incandescent wattage (Annual energy consumption, kWh)	LED Wattage (Annual energy consumption, kWh)	Annual electricity savings per LED*
12 inch red ball (55% duty cycle)	150 (723)	10 (48)	$67.50
12 inch red ball (90% duty cycle)	150 (1183)	7 (55)	$112.80
12 inch green ball (45% duty cycle)	150 (591)	11 (43)	$54.80
12 inch green arrow (10% duty cycle)	150 (131)	7 (6)	$12.50
Stop hand display	67 (528)	8 (63)	$46.50
Walking figure display	67 (59)	8 (7)	$5.20

*assuming an electricity cost of $0.10/kWh

Specific examples of municipalities implementing the replacement of traffic signals were provided:

- Denver, CO (1996): Replacement of >20,500 traffic signals (150W incandescent with 14W LED or 69W incandescent with 8W LED) saving $276,000 per year in electricity and $154,000 per year in maintenance. Payback period was less than 4 years.
- Salt Lake City, UT (2001-2007): Replaced red and green bulbs with LEDs and reduced electricity consumption by 70% (almost 2 million kWh/yr) and electricity costs by $115,000/yr.
- Portland, OR (2001): Replaced 6900 red and 6400 green incandescent bulbs with LEDs at a cost of $2.2 million and reduced electricity consumption by 4.9 million kWh/yr, reduced electricity costs by $335,000/yr and reduced maintenance costs by $45,000.

Considering the notable increases in electricity costs in the last 10-15 years and the simultaneous drastic decrease in the cost of LED lamps, it is clear that the financial benefits of investing in LED-based traffic signals has increased significantly and must today be the stand-out candidate in any ITT that considers lifetime costs. Today the main competition is likely to be between one LED-product and another LED-product.

There is clearly a lot of experience in calculating life cycle costs and payback periods for justifying investments in LED traffic signals although the precise details of how this is done are not well published and are likely to vary from one project to another and from one public authority to another. This could be due to factors such as the use of in-house or contracted maintenance staff and electricity tariffs.

10.1.2 Stakeholder discussion

Very little discussion took place about criteria relating to traffic signals. Some mixed comments were raised about the wattage requirements initially proposed in TR 1.0 with one stakeholder stating that the limits were already too ambitious and another stating that the ambition limits were acceptable.

Further doubts were raised about the 1W traffic signal front-running technology in terms of capital cost and the need for ancillary equipment that would rule out simple retrofits.

In general, support was expressed for lifetime criteria.

10.1.3 Criteria proposals for Life Cycle Cost

Core criteria	**Comprehensive criteria**

TS1 – Life Cycle Cost

A life cycle cost shall be calculated based on the specifications set by the procurer, which should include:

- Time period (e.g. 8 years).
- Inventory of traffic signals required (e.g. red ball signals, amber ball signals, green ball signals, green arrow signals, pedestrian stop signals and pedestrian go signals).
- Average duty cycle of each traffic signal (e.g. red signal 55%, amber signal 2%, green signal 43%).
- Electricity rate (e.g. €/kWh).

The tenderer shall provide the following details in order to complete the life cycle cost assessment:

- Period of time that bulbs are covered by warranty for abrupt failure.
- Rated lifetime of lamp (i.e. the time when lamp lumen output is expected to fall to 70% of original output.
- Purchase cost for lamps (both at the beginning and for any necessary replacement during the defined time period).
- Purchase cost for any ancillaries.
- Purchase cost for any poles, foundations and new electrical connections.
- Installation cost (hours of labour multiplied by labour rates plus any costs for lifting equipment etc.).

Verification:

The procurer shall provide the tenderers with a common spreadsheet-based Life Cycle Cost calculator in which the information required from the procurer has already been entered.

The tenderer shall submit a copy of the completed spreadsheet together with a declaration confirming that these costs are valid at least for a defined period that would cover the original timescale planned for the execution of the contract after selection of the successful tenderer.

AC1 Lowest Life Cycle Cost

A maximum of X points shall be awarded to the tenderer whose proposal is shown to have the lowest life cycle cost.

Points shall be awarded to other tenderers in proportion to how their life cycle cost compares to the lowest cost using the following formula:

$$Points\ awarded = X\ x \left(2 - \left(1 - \frac{lowest\ LCC\ \left(\frac{Euros}{yr}\right)}{actual\ LCC\ \left(\frac{Euros}{yr}\right)} \right) \right)$$

Negative points cannot be awarded. The lowest number of points awarded using the above formula shall be 0 (which would apply to any actual LCC that is at least twice as high as the lowest LCC).

Verification:

Once all tenders have been received, the procurer shall be able to determine which tender provides the lowest life cycle cost and use this to determine how many points (if any) should be applied to each tender.

Questions to stakeholders

Q1. Do you think a life cycle cost approach for traffic signals is more appropriate than criteria specifically for power consumption and lamp lumen maintenance factors?

Q2. Considering the shorter lifetime of lamps, what time scale would be suitable for a Life Cycle Cost assessment?

Q3. Do you have any other suggestions about how to calculate the points that should be awarded to tenderers based on the relative results of their LCCs?

10.2 *Warranty*

10.2.1 Background research and supporting rationale

The justification for a criterion relating to product warranty for traffic signals is broadly similar to the arguments presented for warranties for street lighting in section 9.3. The superior longevity of LED lamps and their lower incidence of abrupt failure when compared to incandescent lamps results in less frequent replacement cycles and maintenance interventions.

One notable difference between traffic signals and street lights is that the former are constantly switching running through short duty cycles of the order of seconds while the latter tend to have one signal and continuous duty cycle for 10-12 hours per day and then are switched off. As a result, lamps used in traffic signals need to be replaced more frequently than lamps based on the same technology when used in street lighting. This fact should also be reflected in shorter warranty periods for traffic signals.

Despite the superior longevity of LED-based lamps compared to incandescent lamps, there is a range of performance within LED technology alone. As illustrated in Figure 26 in section 9.3.1, a number of factors can contribute to a reduced lifetime of LED lamps. A sufficiently long warranty is an indirect way of ensuring that the contractor will take extra care to minimise the possible factors that could shorten lamp lifetime. Such factors include:

- overheating of electronics due to inadequate heat sinks/cooling mechanisms,
- the use of good quality LED chips,
- the use of durable capacitors and drivers that can accurately regulate currents within design specifications.

The need for a warranty going beyond the standard 2 year period is also necessary in order to back up claims and assumptions made in the life cycle cost assessment.

10.2.2 Stakeholder discussion

Since this is a new proposal, no previous stakeholder discussion has taken place about this criterion in particular for street lighting.

The main motivation for including such a criterion is that if it is relevant for street lighting it should be even more relevant for traffic signals, given the more acute potential safety impact.

10.2.3 Criteria proposals for traffic signal warranty

Core criteria	Comprehensive criteria
TS2 – LED lamp product lifetime, spare parts and warranty	
Any LED-based light sources shall have a rated life of: • L92B50 at 16000 hours and • L80B10 at 60000 hours (projected) The repair or provision of relevant replacement parts of LED modules suffering abrupt failure shall be covered by a warranty for a period of 5 years from the date of installation. ***Verification:*** Test data regarding the maintained lumen output of the light sources shall be provided that is in accordance with IEC 62722 for actual data and IEC 63013 for projected data. The tenderer shall provide a copy of the minimum 5 year warranty that would be signed in case the tender should be successful. The contractor shall provide a copy of the warranty that would be applicable should the tender be successful and provide the necessary contact details (phone and email as a minimum) for dealing with any related queries or potential claims. For clarity, the warranty shall, as a minimum, cover the repair or replacement costs of faulty LED module parts within a reasonable time period after notification of the fault (to be defined by the procurer in the ITT) either directly or via other nominated agents. Replacement parts should be the same as the originals but if this is not possible, equivalent spare parts that perform the same function to the same or to a higher performance level may be used.	Any LED-based light sources shall have a rated life of: • L92B50 at 16000 hours and • L90B10 at 60000 hours (projected) The repair or provision of relevant replacement parts of LED modules suffering abrupt failure shall be covered by a warranty for a period of 7 years from the date of installation. ***Verification:*** Test data regarding the maintained lumen output of the light sources shall be provided that is in accordance with IEC 62722 for actual data and IEC 63013 for projected data. The tenderer shall provide a copy of the minimum 7 year warranty that would be signed in case the tender should be successful. The contractor shall provide a copy of the warranty that would be applicable should the tender be successful and provide the necessary contact details (phone and email as a minimum) for dealing with any related queries or potential claims. For clarity, the warranty shall, as a minimum, cover the repair or replacement costs of faulty LED module parts within a reasonable time period after notification of the fault (to be defined by the procurer in the ITT) either directly or via other nominated agents. Replacement parts should be the same as the originals but if this is not possible, equivalent spare parts that perform the same function to the same or to a higher performance level may be used.

The warranty shall not cover the following: a) Faulty operation due to vandalism, accidents or other extreme weather events. b) Lamps or luminaires that have been working for a significant time under abnormal conditions (e.g. used with the wrong line voltage) insofar that this can be proven by the contractor.	The warranty shall not cover the following: a) Faulty operation due to vandalism, accidents or other extreme weather events. b) Lamps or luminaires that have been working for a significant time under abnormal conditions (e.g. used with the wrong line voltage) insofar that this can be proven by the contractor.

AC4 Extended Warranty

X points shall be awarded to tenderers that are willing to provide initial warranties, whose cost is already included in the bid price, that go beyond the minimum warranty periods stated in TS10. Points shall be awarded in proportion to how long the warranty exceeds the minimum requirements as follows:

- Minimum +1 year: 0.5X points
- Minimum +2 years: 0.75X points
- Minimum +3 years or more: X points

Tenderers may also optionally provide quotations for extended warranties that are not included in the bid price, although points shall not be awarded for this. In such cases, it shall be made clear that no payment for any extended warranty is required until the final year of the initial warranty and then annual payments would be made by the procurer to the successful tenderer at the beginning of each year of the extended warranty.

It shall also be clear that the procurer has the option to initiate or leave the offer of the any extended warranty right up until the final year of the initial warranty and that the costs of the extended warranty would be those initially proposed plus any inflation.

Questions to stakeholders

Q1. The same warranty criteria have been proposed for traffic signals as for road lighting. The only difference is that the periods are shorter for traffic signals (5 and 7 years instead of 8 and 10 years). Do you agree with this? Please also state why.

11 Potential other criteria not previously proposed

During the research and consultation exercises, certain issues that are directly or indirectly related to the environmental performance of road lighting and traffic signals have arisen. These issues are presented here and stakeholders are invited to communicate any thoughts they may have on the matter at the 2nd AHWG meeting and during the subsequent period for submitting comments.

11.1 *Labelling of LED luminaires*

This potential criterion is of direct relevance to road lighting in particular. If metering is not in place, which is currently a common situation according to stakeholder feedback, it is extremely difficult to estimate the current electricity consumption of the lighting installation. When it comes to replacing lamps, it is extremely important to know the relevant input voltages. These issues are also relevant to traditional lamp technologies, as illustrated by the labelling scheme that provided in Finnish Transport Agency guidelines.

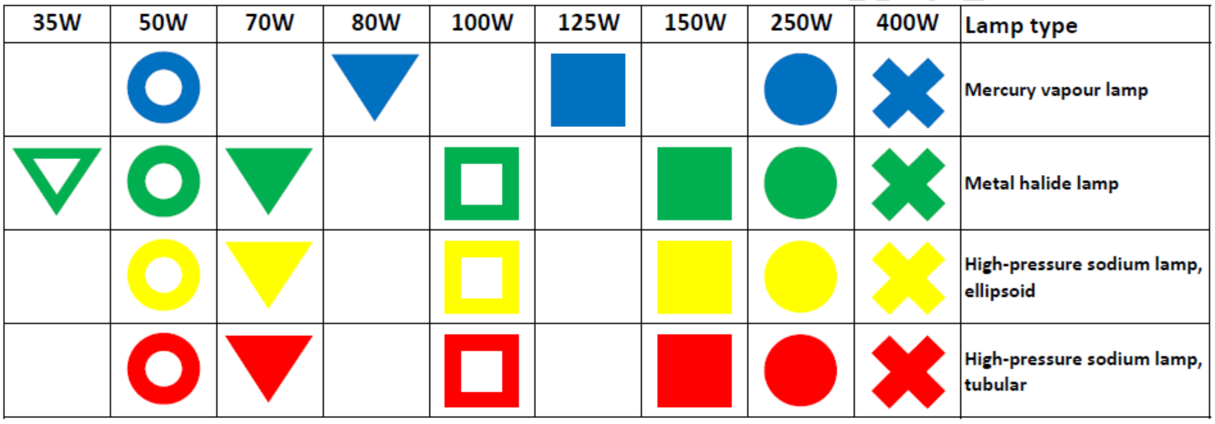

Figure 28. Example of labelling system recommended in Finland for traditional lamp technologies[45].

With traditional lamp technologies, labelling was to some extent simpler because the lamps were only supplied with certain standard power ratings (e.g. 35W, 50W, 100W, 250W etc.). However, with LED lamps, the rate of technological advance is so fast that there is not yet any industry standard power rating that can apply. This fact, coupled with the possibilities for dimming, make it extremely difficult to assess the actual energy performance of existing road lighting installations, which in turn makes it more difficult to accurately assess the potential for energy savings by retrofitting the installation with new and more efficient lamps.

An example of labelling requirements specifically for LED installations is provided in the Synergrid technical specification used in Belgium[46]. The specifications for labelling include the following:

- Wiring diagram.
- Manufacturer's name, code, serial number and date of manufacture.
- Type of lighting appliance.
- Nominal input voltage (or range).

[45] Finnish Transport Agency Guidelines, 2016. Quality requirements of road luminaires and lighting fixtures.
[46] Synergrid technical specification 005. C4/11-3 specification s for luminaires equipped with LED technology.

- Nominal input current (or range).
- Total input power (or range).
- Light flux emitted at ambient temperature (25°C).
- LED current in mA.
- Colour temperature and colour rendering index.
- Indication of the dimming control technology (if applicable).
- CE marking and, if appropriate, ENEC compliance marking.

Questions to stakeholders

Q1. Do you support a requirement for labelling of luminaires in EU GPP criteria for road lighting and traffic signals?

Q2. Are there any other criteria that you think should be considered that have not previously been discussed in the project?

12 Table of Comments: Stakeholder feedback following 1st AHWG meeting

Topic	Comment	JRC Response
General: HID versus LED	Taking in account the figures of the studies proposed for lighting renewal projects, in Brussels, over the past five years, HID projects can be seen to shift from an installed capacity of 2,085.75 kW to 1,264.95 kW, this is a 40% reduction in installed power, while Belgian road lighting has historically a very rational use of energy for road lighting. It is therefore abusive to say that the renewal by means of HID technology does not bring any gain on the energy consumption.	Not all HID is equal that is true, e.g. replacing HPM with HPS would show a large benefit. But what is important now is to think about where are the potential FUTURE improvements in energy efficiency – and the market points towards LED.
General: Luminaire lock-in effect	The meaning of the so-called luminaire lock-in effect may be different from what is written in the report. It is valid if an inefficient discharge lamp on an existing ballast is replaced by a more efficient discharge lamp. The higher efficiency would play out rather in more lumens with using only marginally less energy than producing the same amount of light with consuming much less energy. The case with LED retrofit lamps is different. Here, either the ballast (and ignitor) has to be removed anyway or the LED lamp is able to run on the existing ballast and it would still be able to consume much less energy.	Accepted.
General: Urban amenity lighting	If it were possible to narrow down the problem of road lighting to street lighting there would not be too much to say: nowadays street LED luminaires always have near-zero ULOR and could easily provide a luminaire efficacy higher than 105 lm/W. Nevertheless LED streetlights usually produce very directional light rather than a “diffused light” (as in HID luminaires): This creates a specific, well-lit area while avoiding light trespass and wasting flux outside the area to be lit. LED technology could also turn on and off almost immediately and can provide dimming capability from 0% to 100%. Yet road lighting encompasses so much more than street lighting. Parks, monuments, urban landmarks, pedestrian and entertainment areas but also parking lots and cycle lanes, they all require “ad hoc” design that cannot rely solely on ground illuminance. For example, the beneficial effects of artificial lighting in pedestrian areas can be related to the subjective aspects of social safety and amenity. For feeling secure and have an agreeable situation, citizens must be provided with good vertical illuminance, uniformity and face recognition – and with luminaires pleasant to the eyes if possible. With a near-zero ULOR it is almost impossible to achieve good vertical illuminance (if we don’t want to use extremely high mounting height). The problem is more pronounced among urban amenity lighting, with low mounting height: With near zero ULOR, the luminaire’s throw angle is not high enough to provide good vertical illuminance. If we focus only on CCT or ULOR we could miss some important aspects of lighting design process and we could neglect the needs of people living in the cities: there is no “easy way” to limiting light pollution and some proposed criteria, such as “no flux over 90°” or “CCT less than 3000K” are too simplistic, in most cases ineffectual (i.e. inside city limits) and they could be seen as unnecessary limiting constraints for luminaires market. I propose 2 different solutions: A) Narrow down criteria to street lighting B) Criteria must discriminate among different applications: i.e. Italian GPP criteria distinguish between 1) street lighting 2) big area, roundabout, parking lighting 3) pedestrian areas 4) green areas 5) artistic lanterns	The scope for the product group "road lighting" defines the uses for which the criteria can be applied to. Please bear in mind that the GPP criteria are voluntary and the procurer can directly adopt all of the criteria for one particular ITT, only adopt some of the criteria or modify the criteria according to the site specific constraints and requirements for their road. So it may be that the procurer may wish to deviate from the criteria in certain cases, e.g. >0% ULOR for low mounting height luminaires where vertical lighting is required. Higher CCT if facial recognition is v.important.
General: acrynoms and abbreviations	You have to distinguish between abbreviation/acronyms AND symbols. This should be done on MF, LMF, LLMF and LSF in this document and in the preliminary report When you are using symbol for "factor" built on abbreviations and acronyms start with curved italic lowercase letter f followed with upper letters e.g. f LM (see EN 13201-3)	Accepted. Although all the technical committees and standards have not yet updated to the recently agreed rules (EN 12665), the EU GPP criteria will follow the abbreviation rules set out therein.

	OR use only abbreviations and acronyms: LMF	
General: definitions	In the prEN13032-2: LLMF is defined as luminaire lumen maintenance factor, LSF is defined as luminaire survival factor,	We do not find these definitions in the mentioned standard…
General: LED lifetime	At this moment the lifetime of LED technology in real application on the grid is only based on data and extrapolation publish by manufacturers. Bad constructions of luminaires, not taken in account the LED technology and his requirements concerning heat problematic will have negative impact on the lifetime of the luminaires. So quality luminaires are a must.	Accepted in principle, but what criteria could be used to distinguish between a luminaire of "good" or "bad" quality?
General: Maintenance activities	Despite what manufacturers claims maintenance operations will still be necessary during the lifetime of the luminaires. Led technology will not impact the environment in which the luminaires are functioning. Impact of dust, liquids, pollution will still impact the maintenance factor (MF) of the luminaire. So to maintain a correct light output and MF the luminaires had to be cleaned during some periods of their lifetime. Each EU country has different policy's concerning the MF and maintenance.	Accepted. In TS4, for the reference PDI calculation, we suggest that the procurer chooses a factor of 0.85 but they are free to choose a different one based on the minimum IP rating they request, the local environment and the cleaning frequency they envisage.
General:	First, it must be said that the two JRC technical reports "Revision of the EU Green Public Procurement Criteria for Street Lighting and Traffic Signals": Draft preliminary report, and, Technical report and criteria proposal (1st draft) are remarkable documents giving a very comprehensive view on public lighting policies and state of the art, giving rise to very well-argued proposals. Their authors have accomplished an exceptional work and must be prized for that. That being said, this GPP project promotes standard EN-13201 and its average maintained illuminance E,m, thus, the current excessive levels of light pollution will comply with the GPP project. It should not be the aim and the ambition of a GPP. A GPP should not comply with EN-13201, but should establish new policies for lighting. ANPCEN opposes the citation of EN-13201 as reference in public orders (Press release: Paris, June 30th, 2016 https://www.anpcen.fr/docs/20160630205641_kn7ixi_doc190.pdf) More over, this GPP does not address the aims of three French major environmental bills requiring the nightly environment pollution of lighting installations to be reduced: Décret 2011-831 Art. R 583-4 (called "Grenelle Law" -see attachment for links): (...) Requirements may include lighting levels (lux), luminous and energetic efficiency of the installations (in watts per lux per square meter) and the luminous efficacy of the lamps (in lumens per watt), the average light flux of the installations (total light flux of the sources divided by the surface to be lit, in lumens per square meter), the luminance (in candelas per square meter), the limitation of glare, the spectral distribution of light emissions and the quantities that characterize the spatial distribution of light; (...) Loi 2015-992 Art. 189 (called "Energetic Transition Law"): (...)The new public lighting installations under the control of the State (...) and local authorities show energetic and environmental exemplarity in accordance to Article L. 583-1 (i.e. Décret 2011-831 above) of the Environment Code. Loi 2016-1087 (called "Biodiversity Law"). Art. 1 - Terrestrial and marine areas, resources and natural environments, sites, diurnal and nocturnal landscapes, air quality, living things and biodiversity are part of the common heritage of the nation (...) Art. 5 - It is the duty of everyone to ensure safeguarding and to contribute to the protection of the environment, including night-time. The GPP should focus on environmental criteria only, such as AECI, CCT, ULOR and CIE flux codes, and define its own levels. Photometric performance brought by the compliance to EN-13201 should not be in the scope of the GPP. As a summary of the argued proposals given in the following comments on the GPP draft: No reference or compliance to the standard EN-13201	Accepted in principle. We have attempted to make it clear that EU GPP criteria play no role in the decision of whether or not to light a road and if so, to what level. This is most clearly illustrated in the intro to chapter 6 (Figure 16). Controls on the decisions to light roads and to what level must be dealt with in national or regional planning legislation – where the comment itself provides a good example of France. Regarding the AECI proposal, we have broken down the calculation so that it is more transparent and we no longer refer to RW but instead U, which is related to RW. The ambition level for a given road is generally linked to the luminaire efficacy that is possible. But it is not practical to set a single AECI value for all types of roads covered in this product group. We now have proposals for CCT and we have mentioned flux codes in the background research to ULOR because it may be relevant in some

	Core criteria AECI < 1,5 x RW MWh/km/y CCT < 3000K CIE flux codes: N3 > 97; N4 = 100 (ULOR = 0) Comprehensive criteria AECI < 1,0 x RW MWh/km/y CCT < 2500K CIE flux codes: N3 > 99; N4 = 100 (ULOR = 0)	situations but problematic in others.
General:	The EEB agrees with the JRC's general conclusion after reviewing Life Cycle Assessment (LCA) studies that energy-in-use should remain the main focal point of the revised GPP criteria set for street lighting (see technical report, page 8). The second most important LCA aspect is manufacturing, which is expected to increase in relative importance as LED technology already lasts longer and is more efficient than any high-intensity discharge (HID) light source available. Thus, the most important parameters that have to be considered in the GPP criteria set have to be related to system efficacy, energy efficiency and lifetime for both street lighting and traffic signals. Two ideas were raised by EEB during the first AHWG meeting in Seville that are not reflected accurately in the meeting minutes, and which we believe could benefit public procurers and achieve the objectives of the GPP scheme overall. These two ideas are discussed below and the EEB offers to make itself and its experts available for further consultation and discussion to more fully explore these ideas and perhaps identify approaches whereby they could be implemented effectively: The EEB recommends that the JRC investigate mechanisms and implementing agents that could enable the creation of a facility to combine orders from multiple public procurers and thus achieve 'bulk' procurement status (and pricing) from the suppliers. During the Seville workshop, several municipalities expressed concern over capital costs and that budgets were a constraint to purchasing street lights. We suggest that the Commission engages with stakeholders (manufacturers, municipalities, energy service companies, environmental non-profit organisations (like Les Eco Maires, or ICLEI – the International Council on Local Environmental Initiatives, etc.) to discuss and explore possible ways to develop a bulk procurement facility that would offer discounted prices if purchase orders could be merged and/or delayed for a limited period of time while sufficient orders are built up. The GPP Advisory Group could collect best practices and provide expertise/ guidance how such an entity could be set up exclusively national or perhaps regional, and would accelerate take-up of the EU GPP criteria by lowering first-cost barriers for municipalities. The EEB recommends that the JRC develops concept for a GPP street lighting qualification / certification system for organisations that design, procure and install LED street lighting systems with demonstrated high competency and that meet the EU GPP core criteria as a minimum standard. With such a GPP street lighting certification, these entities could offer municipalities turn-key solutions which meet the GPP core or even comprehensive criteria. This certification would also help to achieve the goals of high-quality GPP, and the entities would directly market the EU GPP criteria to municipalities and other public procurers, highlighting the benefits of green procurement and accelerating its take-up. Thus, GPP criteria for lighting design are important, but some kind of official scheme for accreditation or certification to these criteria would accelerate take-up and increase the impact. During the 1st AHWG meeting in Seville, some participants called for the GPP criteria to require illumination levels in the industry standard document EN 13201. The EEB however recommends that this should not (!) be included as a requirement of the GPP scheme because the standard calls for levels of illumination that are significantly higher than can be found in many existing installations across Europe (and indeed, elsewhere in the world). In addition to exacerbating the problem of light pollution, municipalities that significantly increase lighting levels when meeting the EU GPP criteria could end up with many complaints from residents and road-users due to the increased light level. The standard, largely drafted by industry representatives, calls for levels of illumination levels that would require more equipment and higher-output installations, and current practice / field experience has shown that these higher levels of illumination recommended in the standard may not be so critical. Therefore, the EEB recommends that the JRC investigates and compares the typical practice for illumination levels in a small sample of European cities with the levels	Accepted – this is why we will continue to have TS for energy efficiency and AC to promote even better energy efficiency. And also a TS for dimming controls. Regarding possible mechanisms such as "bulk procurement" and centres of expertise to aid procurers – this is an interesting idea but is not within the scope of this project. This idea should be raised with DG ENV or DG ENER but would essentially be a separate project. Likewise, regarding the certification scheme, this is very interesting and relevant, but unfortunately outside of the scope of this particular project. Regarding the reference to EN 13201 illumination levels – we have modified the text in several places in TR 2.0 with the aim of clarifying that the JRC is not recommending any particular lighting level to be used but that this is to be defined by the procurer and by local, regional or national planning requirements.

	recommended in the industry standard to better understand this potential problem.	
General LED Operation costs	Not sure that LED-lighting fixtures will reduce the operational expenditures. What with Cleaning? HID: Replacement of Lamp each 4 years + cleaning at that moment. LED: Outside cleaning of lighting fixture will be needed to have an high maintenance factor	Rejected. What is cheaper: cleaning and buying a new lamp every 4 years or just cleaning every 4 years?
General: LED promotion	LED is BAT and the purpose of GPP is especially to help purchaser to buy energy efficient.	We have set ambitious minimum energy efficiency requirements and will reward any lighting technology that goes beyond them with AC1.
General: references	Related references to be added: Buy Smart and Buy Smart + Project - www.buy-smart.info Green ProcA – Green Public Procurement in Action - http://gpp-proca.eu GPP2020 Procurement for a low-carbon economy http://www.gpp2020.eu	Accepted. References now included in the introduction section.
General: Light Pollution	I am Chris Baddiley, scientific adviser to the British astronomical Association commission for dark skies. I am a retired physicist and mathematical modeller, currently building a database 2012 to current of dark sky light pollution at the Malvern hills area of outstanding natural beauty . This is now continuous measurement photometry in all-weathers, also with extensive samples from imaging horizon to horizon. I have Written a program for Analysing the sky illumination changes due to the introduction of blue rich LEDs in Herefordshire, which occurred during this period. This proposed document does not discuss the effect of light pollution on the sky. If an increase in light levels was implemented and infill of additional polls to increase uniformity than the total increase in light level to the sky could be devastating to the visibility of the Milky Way in rural areas, never mind suburban areas. There are nearly always towns on the horizon and cities beyond, these dominate in total contribution to the light pollution. Reducing the contrast, on clear nights for the Milky Way. At present it is a critical levels, With very few people being able to see the Milky Way, while it should be a right. Any light near horizontal is unimpeded and has an effect on the night sky of up to several hundred kilometres. That from particle water droplets scattering is predominantly forwards and backwards and not so colour dependent all that overhead is from molecular scattering which is very colour dependent, and caused by cities, even beyond the horizon. The angular cut-off is absolutely critical as the ground axis of filter reflection cutting out a lot of the blue content which otherwise has huge scattering. An upward light ratio of 1% would be disastrous. There is no need to have any light above 30° below the horizontal, as it would not be effectively eliminating the roads. Through the horizontal, a change of cut off as an exponential affect on light to the sky, doubling for every 5°. Highways England have used my modelling previously to set road lighting standards originally flat glass, but now with strict brightness versus illumination angle criteria to minimise the impact of LED lighting etc. A reduction in blue content lower CCT, especially for undirected and uncontrolled general persons commercial lighting, where much of it goes directly into the sky. We recommend the attachment above as a criteria for light levels, but has been advised by experts in modelling and measurements within Europe. I have also attached a paper in preparation concerning my data analysis of the Malvern Hills AONB of which the analysis and are very relevant and form a severe warning. In summary see the third attachment from an article Bob Mizon (commission coordinator) and myself wrote in astronomy and geophysics, just published....	Partially accepted. We are now promoting 0% upward light in any new luminaires installed. However, any requirements to restrict light in angles less than 30 degrees to the horizontal could have significant impacts on other aspects such as cost (more light poles) energy efficiency and glare – this would need to be discussed with lighting design stakeholders.
General Light pollution and energy efficiency	The EEB acknowledges environmental and health concerns over light pollution in general and blue light content of LED lamps in particular. This caused EEB to conduct analysis on commercially available 2016 street light models. Our analysis of 2016 street light luminaires shows that the relationship between efficacy and correlated colour temperature (CCT) is only 3 lm/W per 1000K CCT. Please see for more details below in the relevant section on lighting equipment. Because highly efficient warm-white LED luminaires are already available, we can conclude that GPP should push the market for street	Accepted. The evidence provided supports the claims made and we refer to the same in TR 2.0.

	lighting solutions further into that direction. In the future there should be no reason to compromise between further increasing lighting efficacy and limiting blue light content compared to existing installations. If adequate luminaires are installed and excessive lighting levels are avoided, functional/ directional street lighting should not cause a major contribution to light pollution with potentially negative effects on humans or natural ecosystems. It is up to municipalities to ensure that also private or commercial outside lighting installations or illumination of buildings and sites are designed to limit light pollution and might be completely banned in ecologically sensitive areas. We encourage decision makers to carefully analyse potential impacts of their choices for street lighting on light pollution and consider additional criteria for their respective situations, going beyond what can be captured by GPP.	
General: Light Pollution	Comments on: "The main known non covered impact from road lighting is related to light pollution. Light pollution is defined in guideline CIE 126:1997 as a generic term indicating the sum-total of all adverse effects of artificial light. The light pollution discussed in the report are sky glow, obtrusive light, and ecological impact from outdoor lighting. These kinds of light pollution can be reduces through for example a combination of a correct luminaire with a correct installation and a correct light (lumen) output." (P.10) CIE is industry driven, JRC should not leave the definition of light pollution to the originators. JRC should use instead the definitions of UNESCO, IAU and Institudo Astrofisica Canarias "Light pollution is the introduction by humans, directly or indirectly, of artificial light into the environment." and of Istituto di Scienza e Tecnologia dell'Inquinamento Luminoso (Light Pollution Science and Technology Institute) "Light pollution is the alteration of night natural lighting levels caused by anthropogenic sources of light" for example, which provide neutral and profit independent definitions.	Accepted. Multiple definitions for light pollution have now been included.
General: Light pollution	CieloBuio is very critical of the proposal, because the regulation does not address the environmental concerns of artificial light at night (ALAN) but will conduce to an increased emission of harmful light and night. We work on a voluntary basis only, and so we are using our free time to protect Europeans from the deleterious effects of light pollution. You'll excuse us if we comment the document as a whole and not in specific points.	Rejected. The purpose of this GPP project is not to influence the decision on whether or not to light a road or to what level – that must be defined by the procurer and be in line with relevant planning regulations. The GPP criteria simply focus on how to reduce the environmental impact once a lighting installation is to be installed or renovated.
General, especially focussed on Light Pollution	"The development of EU GPP criteria aims to help public authorities ensure that the goods, services and works they require are procured and executed in a way that reduces their associated environmental impacts." (P 5) The Light Pollution Expert Coalition (LPEC) Germany, Italy and Slovenia (Licht und Natur e.V., CieloBuio and Dark-Sky Slovenia) decline the current GPP proposal, because the regulations do not address the environmental concerns of artificial light at night (ALAN) but will conduce to an increased emission of harmful light and night. JRC should use following requirements for GPP: Luminaires and lighting installations can only be qualified for the EU Green Public Procurement Criteria for Street Lighting and Traffic Signals (GPP) if all of the following 12 requirements are fulfilled. 1. Energy Consumption Lighting installation can only be qualified for GPP if the target energy consumption in a given municipality per capita per year is lower than 15 kWh. This target value includes all losses on cables and also includes all outdoor public illumination (also facade illumination). 2. Blue-Light Content Correlated Colour Temperature (CCT) of all luminaires must be equal or lower than 2200 K AND must emit under 500 nm energy flux lower than 6% of the total emitted in the entire visible range. In case of an average illumination level below 5 lx it is allowed to use luminaires with CCT from 2200 K up to 2700 K AND energy flux must be lower than 10% of the total	Energy consumption: rejected because this is not an adequate single metric for all the different types of roads that may need to be lit. PDI and AECI are considered more suitable. Blue light: partially accepted, we have proposed some criteria on CCT and blue light but not in an identical way. ULOR: accepted. We now propose 0% ULOR in both core and comprehensive technical specifications Prohibitive rules: rejected – this is a planning and safety issue to be decided by road authorities, not

	emitted in the entire visible range under 500 nm. 3. Upward Light Output Ratio The Upward Light Output Ratio (ULOR) of a luminaire must be 0.0%. This needs to be valid during the whole lifetime of the luminaire and also when the luminaire is dirty. 4. Prohibitive Rules It is not allowed to illuminate highways and motorways, including their exits and junctions, roads allowed for motorized traffic only, roads outside settlements, junctions and roundabouts outside settlements. 5. Pole Distance The distance between poles must be at least 3.7 times greater than the pole height. 6. Maximum Luminance The luminance of the main roads in cities and towns is not allowed to exceed 0.5 cd/m2. 7. Curfew For all luminaires there must be implemented a curfew (reduction of power and lumen output in late hours, i.e. outside peak traffic hours) from 100% down to 10% or less in case of adaptive lighting systems, or at least 50% reduction in absence of adaptive lighting. 8. Standards EN 13201 or national standards which are adopted from EN 13201 must not be implemented. 9. Lifetime The Lifetime (MTBF-mean time between failure) of luminaires must be at least 100.000 hours or 25 years. 10. Luminaire Efficacy The minimum efficacy of a luminaire at full power needs to be at least: luminaire below 1900K (like amber) 50 lm/W luminaire below 2200K (like PC amber) 95 lm/W luminaire between 2200K and 2700K 100 lm/W A lower luminaire efficacy is allowed when the pole-distance: pole-height ratio exceeds 6:1 or when a mechanical shielding is necessary in order to reduce unwanted illumination of nearby houses or natural environment. 11. Illumination Utilisation Factor At least 70 % of the lumen output must target the road/street/walking area. Lower utilisation factor down to 40 % is allowed in following cases: narrow paved bicycle path narrow paved pedestrian path 12. Protection of People To secure the basic human right to sleep in a dark environment, which is important for good sleep, the maximum allowed illumination on windows after 22:00 o'clock (standard time) is: 0.01 lx when window is at least 20 m from illuminated public place 0.02 lx when window is at least 10 m from illuminated public place	GPP. Pole distance: to be discussed further but in principle rejected if this cannot be applied reasonably to all road types. Maybe it can be guaranteed for certain road types though? Maximum luminance: rejected, again this is a planning and safety issue beyond the control of GPP. Curfew: accepted, a TS for dimming controls capable of curfew dimming to at least 50% has been introduced. Standards: rejected – this is the choice of the procurer. Lifetime: rejected, too ambitious and uncertainty with extrapolating test data that far. Luminaire efficacy: these are very unambitious values for the lower CCT luminaires. Utilisation factor: to be discussed further, but it is technically very challenging to exceed 70% and even more so as the road narrows. Protection of people: this could become extremely complicated to address in some designs. Parking places: this is not going to be included in the GPP scope.

	0.05 lx when window is at least 5 m from illuminated public place 0.10 lx when window is at least 2 m from illuminated public place 0.50 lx when window is less than 2 m from illuminated public place Parking places on highways and other roads which are used for car drivers and truck drivers and where drivers may sleep in their vehicles may be illuminated but with the following limitations: CCT must be below 2200 K Illumination levels must be below 1 lx	
General: EN 13201 reference	Comment on: "EN 13201 clearly describes the selection of the road lighting classes and the corresponding performance requirements." (P 9) Compliance to EN 13201 is counterproductive for GPP.	Accepted in terms of 13201-1 only, because this would affect the choice of lighting level, which JRC agrees should be the choice of the procurer.
General: similar rationale to Italian approach	I couldn't help noticing that, while here we are talking about a "combination of a correct luminaire with a correct installation and a correct light output", further on (par. 4.2.3.2) everything is cutted down to ULOR and CCT limiting criteria. I think we must truly assess the combination of the correct luminaire with the correct installation and the correct light output - as we already have done in Italian GPP criteria. 1) Define a concise rationale for light pollution. I would like to submit our definition: "Light Pollution is the sum of all adverse impacts of artificial light on the environment due to any part of the light from a light installation that: 1) is misdirected or that is directed on surfaces where no lighting is required 2) is excessive with respect to the actual needs 3) can cause overt adverse effects on human beings and environment" 2) Use a combination of zoning and upward lumen limits 3) Forget about ULOR (relative criteria are not equal to all luminaires) and CCT (that doesn't have a direct connection with light pollution)	1 – Accepted. 2 – Rejected. We are promoted 0% ULOR everywhere. 3 – Rejected. CCT does have a connection with the fraction of blue light output and blue light output can have an effect on increased sky glow, attraction of insects or annoyance in certain areas. Even if CCT is not perfectly proportional to blue light output, it does reflect the appearance of light to humans and is particularly relevant for the "annoyance" factor.
General: Scope	Comments on GPP document "StreetLightingPrelReporD" This document proposed a new definition for a revised scope. This revised scope proposal is derived from EN 13201 and includes car parks of commercial or industrial outdoor sites and traffic routes in recreational sports or leisure facilities. From our point of view this proposal is not acceptable. Reason: The applications: car parks of buildings, commercial or industrial outdoor sites and traffic (circulation) routes in recreational sports or leisure facilities are part of standard EN 12464-2:Lighting of work places - Part 2: Outdoor work places. Lighting levels are higher than road lighting as the task is different, this will create some confusion. How can DPI and AECI requirements be applied to these applications?	Accepted: parking lots and recreational sports facilities are specifically excluded from the scope.
General: HID versus LED	On base of laboratory photometric measurements and calculations, according to EN 13201, this conclusion is not always reached in terms of efficiency. Currently, according to the site configurations, LED technology is more or less efficient than the High Intensity Discharge lamps type ceramic white light (Philips Cosmo HID lamps) solutions with electronic ballast. Regular cleaning is required for LED luminaires. Currently today, HID lamps are replaced and the fixtures are cleaned every 4 years. Ultimately, LED luminaires should be cleaned approximatively every 4 years. Contractor costs will be equal ... and lamp costs of the lamp varies between 8 and 20 €. As regards to defaults, Brussels-Capital is obliged to repair thes within a delay of 5 working days.	Partially accepted. The luminaire efficacy criteria have been set to be technology neutral – a single value should apply for all types of lamps. If HID lamps can meet it, they shall be accepted, if some LED lamps cannot meet it, then they shall be excluded. Regarding the lack of standardised fittings for LED, this is a valid point

	As lamps and ballasts are available and standardized, repair can be done immediately. In case of a fault on an LED luminaire, the operator will not have LED modules available (too many models, too rapid evolution), so he will have to remove the fixture and temporarily replace it with another one, have the fixture repaired and return on site later to remove the temporary luminaire and reinstall the repaired luminaire. So there will be needed2 interventions, on site, needing an elevator including a replacement of luminaire. There where there was 1 intervention in elevator with replacement of components. So operating costs will therefore not be lower.	but we attempt to address this by having luminaires that can be opened and repaired etc. at the mounting height.
Guidance: reasonable estimate of LED luminaire installation per km?	LED luminaires' efficacy is unclear at this time (2016), for lumen output isn't always available in manufacturer catalogues, and it is unclear if the power consumption covers all attached electronic devices. Up to now (2016), it seems that the sole, but important, advantage of LED luminaires is an improved control of the light emission orientation; LED luminaires show less spill light. This may be the only reason why some LED installations show a lower consumption for similar illuminance. A reference value for LED luminaire should be the lumen/euro ratio of an HPS luminaire, or possibly, of a reference warm LED luminaire, with considering the whole life cycle. White LED luminaires should not be promoted as a reference for their adverse environmental impacts [7], increased halo intensity and blue content [1-3], health effect [4-6]). For this kind of reasons, January 2017, Montreal decides on warm LED lighting: http://www.rcinet.ca/en/2017/01/19/montreal-decides-on-warmer-led-lighting/ (see attachments for links) [1] Christian B. Luginbuhl, Constance E. Walker, Richard J. Wainscoat. Lighting and astronomy. Physics Today, December 2009. [2] Christian B. Luginbuhl, Paul A. Boley, Donald R. Davis. The impact of light source spectral power distribution on sky glow. Journal of Quantitative Spectroscopy & Radiative Transfer, 2014. [3] Fabio Falchi, Pierantonio Cinzano, Dan Duriscoe, Christopher C. M. Kyba, Christopher D. Elvidge, Kimberly Baugh, Boris A. Portnov, Nataliya A. Rybnikova, Riccardo Furgoni. The new world atlas of artificial night sky brightness. Science Advances, June 2016. [4] Effets sanitaires des systèmes d'éclairage utilisant des diodes électroluminescentes. ANSES, octobre 2010. [5] LED - Diodes électroluminescentes. Effets sanitaires des systèmes d'éclairage utilisant des diodes électroluminescentes. ANSES, 21/09/2016. [6] Louis J. Kraus. Human alampshnd Environmental Effects of Light Emitting Diode (LED) Community Lighting. Report of the council on science and public health, 2016 American Medical Associatio. [7] LED Practical Guide. International Dark-Sky Association, 2016.	Some interesting points. Setting a criterion based on Euros/lumen could be criticised as counting cost twice – because tenders are generally awarded to the lowest cost tender already or to the Most Economically Advantageous Tender. In TR 2.0 we set some criteria for CCT and, at the comprehensive level, for blue light.
Guidance: Should the ballast loss be included when calculating the installed power per km?	Appropriate, for with new unknown technologies (LEDs), the whole of the energy consumption of the installation must be taken into account	Accepted.
	Yes, the ballast (driver) loss AND every other devices for a good working of the fixtures must be included when calculating the installed power per km.	
	The power value given by the manufacturer should be the luminaire power including all losses within the product. Note: for old systems, this information could not be available; in this case, a conventional value should be used.	
	Yes	
	The power value given by the manufacturer should be the luminaire power including all losses within the product. Therefore the ballast losses should be defined by default and additional inclusion could result in double accounting.	True, any values submitted by the manufacturer must be clear on this point.
	Whatever the calculation is executed, the loss of the ballast must be integrated. The only loss on which, according to the model, one could make the impasse is the loss by Joule effect on the network. To have realistic numbers the total system power (light source + auxiliaries) must be included for the calculation. As today	Accepted.

	more electronics are included in the luminaires permitting the elaboration of "smart grids and city's", and these electronic components are consuming energy it's a must to take also their consumption in account for the calculations.	
Guidance: Is the reference power per km well defined?	Not appropriate, due to the two cons here after, Pros the low coefficient 0,161 requires the light output to be correctly aimed at the target, with no spill of light (achieved through ULOR = 0 and highest possible value of the CIE flux code N3) Cons taking minimum average maintained illuminance E,m from standard EN-13201 will lead to maintaining the current light pollution level the low coefficient 0,161 is compatible with high efficacy installations only, based on white LED or high wattage HID, but incompatible with warm LED and low wattage HPS, banning environment friendly light colour and low wattage installations. Thus, this criterion is counter productive, favouring white LED and high wattage HPS installations. The 0.161 figure is a key point to insure compatibility of the GPP with warm LED and low wattage installations. Point #3 should be replaced by the alternative writing with E,av introduced in Point#2: The installed power P [kW/km] has to be compared with a medium wattage HPS clear reference Pref [kW/km], i.e Pref[kW/km] = 0.035 x E,av[lx] x RW[m] This alternative writing, assess the lighting installation efficacy without invoking the E,m specification of EN-13201, sets a 0.035 W/lx/m2 PDI compatible with medium wattage HPS clear, derived from the figures of Table 4.1, sets a 0.035 W/lx/m2 PDI compatible with warm LED. introduces RW whatever the road width to incite to a better design of lighting installations of small width roads (<10 m). The introduction of RW is all the more relevant since the replacement technology would be based on LEDs, with an improved emission orientation control.	A new approach to the assessment of a road lighting installation will be proposed in a separate guidance document that is not included in TR 2.0. Nonetheless, this preliminary assessment is indicated in the diagram in section 4.1 of TR 2.0. It is a two-step assessment, The first step is simply to compare the luminaire efficacy to those that are currently available on the market. If the market shows that luminaires with much higher efficacies .are widely available, then it is justified to consult on capital costs and calculate the estimated operating costs in a simplified LCC study. Depending on the results, different options could be considered in terms of the subject matter of the procurement exercise (e.g: relamping only, installation of dimming controls and control gear only, installation of new lamps and control gear in existing luminaires or new luminaires, lamps, dimming controls and control gear).
	Not at all. The light is dimensioned taking in account a surface. So it is necessary to keep calculations per km² or m² (besides the document tries to do it simplifying to <10 m and> 10 m). Also, without m², how are we going to treat the squares and the parks? If the Pref is used with his actual value, it will be resulting in the fact that installations based on HID technology will not fulfil the requirements anymore. This will have as consequent that installed HID technology during the last 5 years (think at Philips Comopolis technology) will not comply anymore. It's financially not reasonable even possible to oblige municipalities to renew those installations.	Valid point. This also helps justify the move towards a luminaire efficacy and LCC based approach.
	The calculation method is well-defined, but the reason for its existence is not given. The PDI and AECI are defined within the EN 13201-5 standard. In addition, with the existence of PDI and AECI, including guiding which to use where, Pref may be a useful parameter only if its formula could be adjusted in respect of any national rule or condition/need.	Now with the PDI and AECI calculations broken down, if desired, the current PDI and AECI can be calculated if the luminaire efficacy and dimming scenarios are known. Then it is a case of substituting the

		current luminaire efficacy for the potential new luminaire efficacy.
	If we go beyond street lighting and we would like to consider the design of “road” lighting (as intended in EN 13201), the proposed criteria might appear too simplistic in its form and application. We would suggest to use Italian IPEA* and IPEI* values as benchmarks.	In the new approach to be published in a separate guidance document – the reference value shall be based on the luminaire efficacy of the existing installation. If this is way below the efficacies of products on the market then it is worthwhile to look at reference PDI and reference AECI and consider what potential cost savings there may be (on a LCC basis).
	The calculation method is well-defined but the reason for its existence is not given the PDI and AECI are defined within the EN 13201-5 standard.	
	Pref is very low. Every HID solution will not fulfill these value. Even installations made 5 years ago with up to date HID fixtures -> Replace all these HID installations�? Calculations in annexe: HID Saphire 2 on a M3 -> so 15 lux class: P = 119W (lamp + Use PDI and AECI for criteria for replacement and not to strict. See that 5-years old HID installations fullfil the requirements, no need (and no money) to replace already these HID installations with LED.	
Guidance: Do you think that the guidance provided above is appropriate?	Yes, but it is incomplete. Road lighting encompasses not only street lighting, but also pedestrian, bike, entertainment areas. In these areas, people needs are different and so it is nearly impossible to apply criteria tailored for street light.	Please see references above about new approach.
	No. There is a general confusion between the use of PDI, AECI and Pref. The basic requirements are does the proposed design achieve the required design criteria specified in EN 13201 (without significant over-lighting) and is this achieved in an energy efficient manner? As AECI calculates energy this is the critical value, especially considering AECI is also more comprehensive in the accounting of the benefits of controls and technologies such as CLO. If all three values are to be promoted there has to be better guidance on how they fit together and should be used as there is evident overlap in that the three values are effectively derived from each other. Currently this seems to add design and administrative costs with no clearly defined benefit.	Please see references above about new approach.
	Yes: As a proposal ... even if this text does not add much to the existing normative documents. Just pivot values are added to existing documents. No: The actual document is exclusively focused on the environment. It is excluding important urban planning features of lighting: Quality performance [example: duration time of defects]; Visual comfort; Total Cost of Ownership; Compliance with light plans (height, installation implementation parameters, color temperature); Model. These parameters are equally important, especially in urban areas. Even, the environmental assessment is based only on the installation and exploitation of the product, but not on a Real Life Cycle Analysis (LCA), including the cost of production and dismantling / recycling of the product. A guidance is necessary. But are the proposed PDI and AECI methods not the best methods for evaluation. Why creating a supplementary parameter. It is already difficult enough for a civil servant to understand how to take a decision.	These are important points. While the new approach also focuses on environmental performance and cost saving potential, it can be used to respect minimum luminance requirements set out for a reference or potential PDI and incorporate dimming scenarios in a reference and potential AECI.
Guidance: general comments	This must be analysed in relation to the remaining lifetime of the installation. If an installation does not meet the GPP criteria but can still run for 10 years, it is not necessarily better for the environment to dismantle it prematurely. Moreover, other factors must be taken into account when determining investment priorities (age of the installation, history and type of defaults of the installation, etc.)	The underlying decision should be based on life cycle costs and the potential for cost savings.
	HID technology installations currently have a lifetime of about 25 years.	The procurer can vary the period for

	Those with LED technology are announced 15-year ... unless under-powering the LEDs (and so installation of more luminaires is necessary to comply to the lighting level values required by the standards); Or Pay more for the warranty. The verification step must therefore be done over the estimated life of the new installation, which is not systematically 20 years.	LCC as they see fit. Other stakeholders felt that 15 or 20 years would be appropriate.
	The meaning of the so-called luminaire lock-in effect may be different from what is written in the report. It is valid if an inefficient discharge lamp on an existing ballast is replaced by a more efficient discharge lamp. The higher efficiency would play out rather in more lumens with using only marginally less energy than producing the same amount of light with consuming much less energy. The case with LED retrofit lamps is different. Here, either the ballast (and ignitor) has to be removed anyway or the LED lamp is able to run on the existing ballast and it would still be able to consume much less energy.	Accepted. This should be reflected by changes in the text of TR 2.0.
	Good to have a guidance, but reference power is an extra parameter. Why not working with PDI and AECI?	OK – with the new proposal, it can fit in with PDI and AECI.
	Pref is not applied in Italy	OK – thanks for the feedback.
	We appreciate this guidance, but it seems quite arbitrary.	Please see responses above about new approach.
Guidance: what would be a good reference value for LED luminaire installation cost/km?	For the moment, there is no difference in luminaire installation cost/km between LED and HID. In future it is possible that more time (so more cost) is needed to install LED because IoT (Internet of Things). But may be we win time (so less cost) on other	It is understood that costs relating to new installations are highly variable depending on site specific factors. Column heights, spacings and infrastructure will all have a significant influence. It is much simpler to only consider the cost of luminaire installation – although this also has it's nuances.
	No, the price is different in different countries and are not stable, is likely to decline.	
	This is a very Member State specific issue and can even be specific to an administrative region within an MS.	
	The LED luminaire installation cost per km depends on the road and lighting characteristics.	
	Installation costs per km may vary by site features (such as area size and complexity, lighting requirements, etc.), by design adopted (such as pole distance and arrangement, luminaires height, etc.), by boundary constraints (such as trees, buffer zones, etc.). Moreover, if construction works are required (such as new lighting ducts, poles, etc.), costs might triple or more. We can provide more infos about costs, but we need time and some more clues about the lighting systems you need to assess.	
	This is very MS specific and can even be specific to an administrative region within an MS. Indicative costings would be 5-6m column approximately £1200 per column, 10-12m column approximately £2000 per column. Complex junctions/inter-sections will be more expensive. Therefore cost per kilometre is related to the number of columns in that distance.	
	If we consider only the cost of LED luminaires (not the cost of replacement of the pole, the wiring …): Average price LED luminaire without fuses (in the framework of a public tendering contract): 695 € without fuse (without administrative costs of purchase, storage, logistics, ...) = purchase price Average cost contractor for replacement of a fixture: € 49.55 (direct purchase cost) Inter distance: in urban area, approximately 1 luminaire every 18 meters Per km, 56 LED luminaires - 56 x (695 + 49.55) = 41.694 € so we can consider 40 k € per km in direct costs in urban areas (this without modification of the installation) As “smart technology” is introduced in the luminaires the cost for installation of a LED luminaire can rise (ex. Communication devices must be installed in the cabinet, supplementary wiring may be necessary between luminaire and control module outside of the luminaire for decorative luminaires fixed on facades …). As future applications like Lifi, IOT	Thank you very much for providing these numbers and the assumptions behind them. It is clear that there is still a significant range in prices even when just looking at the luminaire (e.g. 350 versus 695 EUR/luminaire) translating into 16,000 or 40,000 EUR per km.

	are in full development they will surely impact on the cost per km. + It's difficult because it really depends of the situation (center of a city? Prescription about height of the luminous point ? If it's only for the luminaire (not counting the cable, the pole, etc.), 350€ (average price considering classic road lighting and urban lighting), one every 25m (average between cities and countryside), 45€/luminaires for labour (only to mount a new luminaire. If it's a replacement, you need to take off the old one à extra cost of 26€/luminaires). à It's more like 16.000€/km	
Guidance: Can you suggest any tool for LCC of road lighting?	Yes, we can suggest a tool. The Swedish LCC tool is very useful and easy to use, it's a version avalible in English (attached). The LCC tool example from EU has been evaluated by the Swedish National Agency for Public Procurement (attached). There are comments like "not user friendly", "not transperency", "lack of information how to use"	Thank for providing this – it appears to be a very specifically designed and useful example of a LCC tool for road lighting.
	No. Many LCC calculation programmes are commercial or manufacturer specific. It would perhaps be useful to give guidance on the standard calculation methodologies to be used within LCC software to ensure quality of results. The calculation tool should be easy to use and, as far as possible, self-explanatory. It is important that dimming and the selection of the right maintenance factor (MF) is taken into account. Many planners just use 0.8 or 0.5 as MF. It has to be verified that the quality of lighting design respecting the requirements of the standards are still fulfilled.	We will try to break down the calculation in the new guidance document to be published.
	No clue. A guidance to correct LCC calculation should be given - otherwise results may vary according to different "interpretations" of LCC	
	No. Many LCC calculation programs are commercial or manufacturer specific. It would perhaps be useful to give guidance on the standard calculation methodologies to be used within LCC software to ensure quality of results.	
Guidance: Should we use PDI instead of Pref for the preliminary assessment?	Not appropriate, due to the cons here after, Pros good criterion of the energy efficacy of the installation Cons It is a technically difficult criterion to handle by authorities (procurers) and citizens (NGO): illuminance is not uniform, what value to consider? Average illuminance value? even more difficult when the installation design is based on luminance, needing the additional use of conversion formulas from luminance to illuminance under various complex assumptions (hemispherical illuminance...), designing the future installation requires costly computational modelling and access to the luminary photometric database assessing existing installations requires costly measures in the fields only experienced technicians are able to handle this criterion the complexity of the PDI criterion is flagrant in the Table 4-1 from Annex A of EN 13201-5: how these table was established? the discrepancies in values given for HPS appears extremely narrow compared to what can be observed in the field The " 0.161/RW " factor within the Pref formula, stands for a reference PDI. That is, there is no need to introduce the complex PDI concept.And the Pref criterion is a more friendly holistic criterion, for it is expressed in terms of wattage per km. As argued in the comment of the Point #3 of the guidance, a " 0.035 " factor instead of " 0.161/RW ", should be preferred.	Now that the PDI calculation has been broken down, surely it will be much easier for procurers to use now?
	As less possible different indicators is best. So why introducing a new one, while we can use PDI and AECI� Better to put limits on these values (PDI and AECI) than introducing a new Pref with new calculation methods and new limited values�	The new approach will allow reference PDI and AECI to be calculated based on the existing and potential new luminaire efficacies.
	Yes, I think it's a good idea.	
	Yes. Preference is not a standardised calculation, and standard methodologies should always be used in preference.	
	We approve the choice of PDI. The actual version of the Italian CAM (minimum environmental criteria), which is under	

	updating, adopts the IPEI to verify the efficiency of lighting installations (IPEI = Dp/Dp,R. Dp = Design Power Density. Dp,R = Reference Power Density).	
	If we go beyond street lighting and we would like to consider the design of "road" lighting (as intended in EN 13201), the proposed criteria might appear too simplistic in its form and application. We would suggest to use Italian IPEA* and IPEI* values as benchmarks.	
	Yes. Pref is not a standardised calculation and standard methodologies should always be used in preference	
	Yes. There is a existing European standard that provides energy characteristics to characterize a lighting installation. Why introduce something else and force the design offices to work on other new references that are not used at this stage? Are the proposed PDI and AECI methods not the best methods for evaluation? Why creating a supplementary parameter. It is already difficult enough for a civil servant to understand how to take a decision. It is preferable to introduce values for PDI and AECI methods.	
	The calculation method is well-defined, but the reason for its existence is not given. The PDI and AECI are defined within the EN 13201-5 standard. In addition, with the existence of PDI and AECI, including guiding which to use where, Pref may be a useful parameter only if its formula could be adjusted in respect of any national rule or condition/need.	
	If we go beyond street lighting and we would like to consider the design of "road" lighting (as intended in EN 13201), the proposed criteria might appear too simplistic in its form and application. We would suggest to use Italian IPEA* and IPEI* values as benchmarks.	
Guidance: LCC	We recommend that the JRC develops and provides a generic template for the LCC calculation which applicants can use when submitting their proposals for consideration under GPP. The verification criteria for AW1 include LCC calculations to be clearly presented in a spreadsheet – however, the term 'clear' is subjective and may cause confusion and/or additional work during the implementation of the GPP criteria due to this ambiguity and lack of a starting point. Applicants should still be allowed to submit their own LCC calculation spreadsheets (note: some may already have them and not want to adapt to a new approach). However, the JRC should also provide a working template that includes all the input parameters and thus would standardise applications that use this template, greatly facilitating the review and award procedure.	We will produce a separate guidance document with a breakdown of LCC calculations although in terms of a tool, the Swedish example is currently much more superior that the generic Commission LCC tool.
Energy efficiency: Simplified formula – pros and cons	Never calculate E,m or L,m with a simple formula (eg: E,m = L,m/0,7). The only correct way is calculation with a good lighting program! Lm is highly depending on road surface and lighting distribution. There are LED lenses specialy developed to give high Calculation of both values (Lm en Em) is needed! Also take into account the calculated value for Lm and Em in formulas and not the reference Lm or Em for the lighting class.	Accepted. Although the general rule of thumb for asphalt of 0.07 has still been mentioned to give readers a general idea of how the numbers vary.
	These values cannot reflect the complexity of real public lighting design. One formula for all road classes can surely offer an easy calculation and therefore it is more likely to be used, but it does not reflect the complexity of real public lighting design. If we go beyond street lighting and we would like to consider the design of urban lighting, the proposed criteria might appear too simplistic in its form and application. We would like to suggest to use IPEA* and IPEI* indexes both to assess existing and new luminaires and lighting systems.	Rejected: EU GPP criteria cannot fully align with IPEA and IPEI approach in terms of labels involved. But perhaps it is possible to make the same distinctions for ambition levels for different road classes. Further discussion welcomed on this.
	Pros Simplified rules are the best path towards better practices. GPP requirements will be widely shared if they state simple goals: a simplification into one formula is a valuable thing. It is then up to the professional to implement complex (if needed) professional rules in order to satisfy the GPP requirements. Cons None	Accepted. Now we have moved to a PDI and AECI approach which hopefully remains simple because we break down the calculation into simple components.

	Pros – simple method allowing easy calculation and therefore more likely to be used. Cons – simple method which does not reflect the complexity of real road geometries and therefore requires interpretation to understand real application.	
	2) Pros: simple method. Cons: it could result too simplistic in many cases, with a scale that is too broad.It seems impossible to apply in some areas (such as parking lots, wide areas, roundabouts, green areas, and so on).	
	Pros – simple method allowing easy calculation and therefore more likely to be used. Cons – simple method which does not reflect the complexity of real road geometries and therefore requires interpretation to understand real application.	
	For Belgium Synergrid published its own specification based on the standard EN 13201 series. This is due to the fact that: A simplified rule is in Synergrid view not accurate, to have realistic numbers, Luminance is depending on the road surface and the photometrical lighting distribution characteristics of the luminaire, Evolution of the technology of lenses. Today specially developed lenses are at disposal that result in high levels of luminance for less illuminance. So accurate calculations are needed. In annex the draft of the English version of the Synergrid specification is joined.	Accepted. To be further discussed if there are any outstanding issues based on the new PDI and AECI criteria proposed in TR 2.0.
	Cons: Simplification has as consequence: The exclusion of existing roads (2m trails, 3m roads in urban centres, much wider roads in the periphery - ring roads, motorways.) And thus promote LED technology	Accepted. We have now moved towards a PDI and AECI based approach.
	To assess JRC's PDI limits, we made a comparison between 161/RW formula and IPEI* on a base of more than 700 road lighting designs (following what we have said before, 161/RW formula cannot be applied satisfyingly to Cx and Px classes), using both HID and LED luminaires (see Annex A). We find out that using PDI limits (based on a fitting of 161/RW) could result too simplistic in some cases, with a scale that is too broad. We would suggest to use IPEA* and IPEI* system, whic is a simple, but versatile, approach to Public Lighting Energy Criteria.	
	The Synergrid experts asks: If it is possible to have detailed information of the configurations used for the calculations. More time for examination of the proposed numbers by the synergrid experts. They need to compare them to their database	Accepted. Our consultant has been available for further discussion on this matter.
Energy efficiency: AECI, PDI and any additional criteria?	The more criteria are fixed, the less interpration and discussion are possible. BIV (Belgian institute for lighting) is preparing a method for calculating MF for LED fixtures. Document not yet available.	Please share this document once available.
	It is too little information/studies to give numbers on LLMF and cleaning cycle	We would welcome further background information about suitable default values and rules for setting maintenance factors. The aim is to set a default MF (composed of LMF and LLMF) to use in the calculation of PDIref. However, when calculating the actual PDI of the tender, a
	The lighting design correlate with the atmospheric pollution and cleaning cycle to prevent a designer assuming a more stringent cleaning cycle to reduce over lighting and therefore luminaire numbers. These would be specified within the tender document. However, a standard maintenance factor cannot be used as this would discriminate against luminaires using LED with better performing characteristics through life. In addition, the LMF can be given based on fixed environmental and cleaning regimes, but the LLMF shall be based on the LED based luminaire lumen maintenance quality. Note: the abbreviation for luminaire maintenance factor should be LMF and not FLLM.	
	The criteria that should be added are: luminaire maintenance factor (FLLM), failure rate and cleaning factor.	

	10) Having LMF (not LLMF) would be great for lighting designers. Why not asking for a comprehensive criterion about LMF?	different MF may potentially be used if this can be justified according to a set of rules that we should define (if possible).
	The lighting design should be to defined atmospheric pollution and cleaning cycle to prevent a designer assuming a more stringent cleaning cycle to reduce over lighting and therefore luminaire numbers. These would be specified within the tender document. However a standard maintenance factor cannot be used as this would discriminate against luminaires using LED with better performing characteristics through life.	
	They should not be added as criteria but defined in the project. The FLLM must be established according to the maintenance policy. To ovoid discussions and interpretations a maximum of parameters had to be defined clearly. At Belgium national level the Belgian Lighting Institute (IBE-BIV) is working on a national document concerning maintenance factors to use with LED technology. This document is in progress for the moment but not yet available.	Accepted that the procurer should set the FLLM requirement but we would also like to provide background information that can help procurers know what is a reasonable LLMF to ask for and how this relates to cleaning cycles.
	FLLM is already introduced in the controversial E,m due of the "maintained" requirement (controversial for the professional EN-13201 should not be mentioned in the GPP). Instead of the complex PDI criterion, an average light flux Flux_av[lumen/m2] criterion should have been preferred. With Flux_av[lumen/m2] being the rated flux from the lamps divided by the area intended to be lit. The light flux efficacy of the installation would be given: Installation lighting efficacy = Flux_av[lm/m2]/E_av[lx/m2] This holistic and easy to handle criterion is mentioned in the French "Grenelle Law" Décret 2011-831 Art. R 583-4 (see attachment for link).	Rejected. We have opted to go for transparent PDI and AECI criteria which are hopefully quite easy to understand.
Energy efficiency: Is PDI redundant when AECI is specified?	The two criteria PDI and AECI are redundant for they both account for the energy efficacy of the installation in order to achieve some given illuminance level. They differ only by the dimming/extinction taken into account within the AECI. Thus the latter is a more comprehensive criterion. In the end, from both the environmental point of view and the ease of implementation, the sole AECI criterion should be retained. Some reference AECI should derive directly from the Pref expression, for instance: AECI[kWh/(m2.y)] < "some factor close to 1" x 0.000035 x 4000 x E,av_GPP With an average illuminance E,av_GPP to be defined and set by the GPP, and not issued from the professional EN-13201 standard. Meeting the EN-13201 standard is leading to ensuring the current level of light pollution with no improvement perspective. The GPP should promote lighting moderation (in compliance with the three French "Grenelle', "Transition énergétique" and "Biodiversité" laws). As a reminder (see attachment for links), Through European Energy Awards, since 2006, Besançon (France), 125,000 p., is aiming at a street lighting consumption of 15,000 kWh/(km.y), that is an AECI below 2,.0 kWh/(m2.y). The goal is achieved by the deployment of 70W HPS lamps. It is a common practice in Switzerland to devote less than 10,000 kWh/(km.y) in street lighting, thus an AECI about 1.2 kWh/(m2.y). PDI is a complex criterion that shouldn't appear in a GPP intended to procurers (public authorities) as to citizens (NGO).As a matter of fact, the relevance of the figures of Table 4-1 is very difficult to verify. Then it may be objected that the GPP requirements be based on these unverifiable figures. The possible conversion between Pref and PDI shows that the PDI criterion could be advantageously replaced by a similar and easy to handle Pref criterion.	Accepted in principle so long as the procurer is not interested in guaranteeing a minimum level of illumination on roads – which may be the case. However, for the sake of procurers in Europe who do want to guarantee a certain minimum level of light in the road, we will also provide a criterion for PDI in the EU GPP criteria.

	AECI is an excellent criterion, easy to understand and handle, directly correlated to the energy efficacy of the lighting installation environmental impact.	
Energy efficiency: Do operating hours vary much from country to country?	What operating strategies, LED luminaires type and maintenance factor were taken into account for calculations made in Q2 / 2016? Attention to the annual operating hours ... They depend from one country to another, in particular according to the sunshine. Brussels= 4190 hours. So these 190 additional hours corresponds to a difference of almost 5%. Imposing values on the basis of 4,000 hours per year can be detrimental to the intrinsic efficiency of the installation.	Now that the AECI calculation is more transparent, the procurer is free to change the "T" term of the equation as they see fit. The default value is 4000 and whatever value is chosen, it should be the same for all tenderers.
Energy efficiency: Dimming in AECI by means of AECI	As previously stated, no reference to the standard EN-13201 should be mentioned. AECI is an excellent criterion, easy to understand and handle, directly correlated to some aspect of the lighting installation environmental impact. It is inappropriate to express it as complex functions of the complex PDI criterion... The easy and understandable Pref concept is a straightforward mean to set AECI references. It is appropriate that the GPP promote dimming and extinction (an affordable and common practice in France for instance). It is appropriate that dimming and extinction are already being taken into account in the AECI criterion values. Again, these goals are all the more reachable as long as the standard EN-13201 hasn't to be met. It would be appropriate to base AECI on the easy to handle Pref concept: AECIref[kWh/m2/y] = Pref[kW/m2] x 4000[h] and then modulate it toward the best practice intended to promote, for instance, AECI[kWh/m2/y] < 1.1 x AECIref for core criteria AECI[kWh/m2/y] < 0.8 x AECIref for comprehensive criteria (achieved through dimming and/or extinction)	We have significantly modified the approach to the energy efficiency criteria – respecting the basis of PDI and AECI but trying to make the calculations as simple and transparent a possible.
	Simple standalone dimming solutions now exist that allow dimming over the middle of the night based upon an astronomical clock. Therefore, having dimming as part of the core criteria is reasonable. Increasing the level of expected control for the comprehensive criteria is also acceptable and should remain. In addition, it is recommended to set a more ambitious target for CL as comprehensive criteria and to recommend a light management system.	Accepted. We have now introduced a TS for dimming controls.
	Dimming shall be taken into account.	Accepted.
	LEDs already incorporate stand-alone technologies, so dimming could also be a part of comprehensive criteria	Accepted. Now included at core level as well.
	Simple standalone dimming solutions now exist that allow dimming over the middle of the night based upon an astronomical clock. Therefore having dimming as part of the core criteria is reasonable. Increasing the level of expected control for the comprehensive criteria is also acceptable and should remain.	Accepted.
	There is thus a change from 1.3 / 1.1 to 0.85, or a permanent dimming between 23 and 35% during the entire operating time. It's illusory! In urban areas, the permitted dimming (for the security feeling of pedestrian) is about 30% -35% during half the night thus 15% to 18%. Ideally, as it is not sure that the expected dimming will be maintained throughout the lifetime of the installation, it would be better to provide both values with and without dimming. For Question 1 to 6 more time is needed for examination by Synergrid experts	Accepted in principle. Now that the AECI calculation has been broken down in the TR 2.0 proposal – it should be easy to see both values because the only difference will be the dimming factor.

Energy efficiency: Luminaire efficacy requirements	The EEB supports the use of both the power density indicator (PDI) and the annual energy consumption indicator (AECI) in TS1. Because of the fast moving development of the technology for street lighting, the efficacy values in the revised GPP criteria set cannot be static and must continue to be strengthened further over the six year cycle of these criteria. The EEB has prepared some analysis which presents our findings, using published performance data from street lighting systems spanning the years 2011, 2012, 2013, 2014, 2015 and 2016. Therefore, we suggest increasing the efficacy requirement for GPP in form of a tiered approach by approximately 17 lm/W every two years (see graphs and data later in these comments). The EEB is willing to make its analysis and experts available for further consultation if this would be helpful to the JRC team. The EEB believes that the new GPP criteria – both core and comprehensive – should only be allowed to be applied to LED technology. The market is already shifting significantly over to LED because they offer better system efficacies, longer lifetimes and can be more easily controlled than HID sources. Thus, the GPP criteria taking effect only in 2018 and running for six years should be exclusively tied to LED, and incentivise public procurers towards the better LED products in the market. We suggest targeting the top 75% of the models on the market for the core criteria and top 50% of the market for the comprehensive criteria. Additional criteria to be set on light pollution would further differentiate the market towards better quality street lighting. However, EEB is concerned that the point values for PDI discussed in section 4.2.3.1.1 (Rationale) fail to take into account the range of efficacies and CCT of existing 2016 street lighting systems. Due to the fact that LED technology has advanced considerably between 2014 and 2016, we find it concerning that for the seven roads analysed, core criteria values are being suggested which are less ambitious than the LED values reported in the standard (Annex A of EN 13201-5:2016). Therefore, we recommend that the JRC adds an efficacy dimension to the core and comprehensive criteria evaluation for the PDI values recommended, whereby the core criteria should remove 25% of the products on the market (i.e., only be available to the top 75% of models) and the comprehensive criteria should remove 50% of the market (i.e., only be available to the top half of models offered). As suggested in the general comments, these PDI values would need to change over the time period of performance, assuming an evolution in efficacy as outlined in our analysis presented in these comments: i.e., 17 lm/W every two years – 2018, 2020 and 2022 (see Tables 1 and 2 below). For AECI, the EEB is unclear on the basis for the setting of the CL factor. We understand that in the standard, CL is set to 1.1 for LED technology, but then it is proposed that the core CL factor should be 0.85 and the comprehensive CL factor be should 0.75 in order to require that the systems incorporate some energy savings from dimming. This seems to be a reasonable approach, however it is unclear how these two values were selected and we wonder what is actually typically used in the best-in-class LED systems installed today? We request that the JRC includes one or two case studies from recent LED installations and/or provide more explanation around the derivation of these values. It is also unclear to us how the efficacy (lumens/watt) of the LED system is taken into account in this metric of AECI. Due to the fact that the AECI is kWh/m2.y, this metric will be highly dependent on efficacy and we do not support using only one efficacy value for LED systems for all six years of the GPP criteria. The EEB requests that JRC provide some analysis around efficacy and its relationship to the AECI and we recommend that three levels of AECI be offered, taking effect in three tiers - 2018, 2020 and 2022 – which correspond to the efficacy values in our Tables 1 and 2 in these comments.	Accepted. The research behind the proposal is very much appreciated and we have incorporated this into our TR 2.0.
	There should not be criteria on the light source efficacy for the notion is very unclear. What is considered, the chip, the LED package? Is the electronics included? How this efficacy can be compared with HPS sources? There is only one clear efficacy criterion, the luminaire efficacy: lumen output versus power wattage. The luminaire efficacy is available in luminaire rated data. Then, as previously said, the efficacy requirement is not needed at the luminaire scale for it is already included at the installation scale (AECI).	Light source efficacy was only considered in cases when relamping is to be carried out.
Energy Efficiency:	If GPP requirements can not be met due to particular constraints, let's just act they can not be met in that particular case.	The GPP criteria are voluntary –

Are there cases when exemptions from normal PDI and AECI limits.	Yes, local and particular needs can justify higher values of PDI and AECI.	the procurer is free to use them, modify them or ignore them.
	Yes, it is essential, but without clear guidelines this will be applied with widely varying outcomes. Both PDI and AECI are important. EN 13201-5 states: Power density indicator (DP) demonstrates the energy needed for a road lighting installation, while it is fulfilling the relevant lighting requirements specified in EN 13201-2. The annual energy consumption indicator (DE) determines the power consumption during the year, even if the relevant lighting requirements change during the night or seasons. However, the following needs to be taken into account. AECI cannot detect a poor lighting design. We have to distinguish two different GPP scenarios: a) 'fixed design parameters' and b) 'free design parameters. Where the design parameters (e.g. lighting class, road layout, use of controls) are fixed, only AECI will do. In case the design parameters are free, it is recommended to first use the PDI before switching to AECI calculations. This method helps to check the quality of the lighting design in combination with the luminaire selected (i.e.: How energy efficient is the luminaire used to fulfil the lighting requirements for the useful area?). Also, clear criteria have to be specified in case of the GPP scenario 'free design parameter.' Moreover, weighing criteria shall be clear and will influence this. Note: A further check in table 4-1 should be done: the 'lot 37 BAT' value is the same as the 'Best EN standard' for M3 class with 7m road width. We should expect that it reflects technology improvement from Q1/2014 to Q2/2016.	Accepted. We welcome any input from stakeholders about specific situations where higher PDI or AECI values would be justified.
	Yes.	
	Yes	
	Yes it is essential, but without clear guidelines this will be applied with widely varying outcomes.	
	Yes, it is clear that particular constraints, can require higher values for both parameters.	
Energy efficiency: Factors that only LED can comply with.	Factors 1.1 and 1.3 are fair values to measure the proximity to a reference value. But the matter is the reference value: white LED sources should not be the only light sources compliant with the GPP criteria.	Rejected. The values apply equally to all technology – high power and energy efficient HPS lamps can meet the criteria today but must improve to meet future ambition levels.
	The problem with this approach is it assumes that the lighting is purely functional. See point (1)	Please expand upon this point.
	The problem with this approach is it assumes that the lighting is purely functional and for straight sections of road with no junctions. Therefore applying these to real life situations will be difficult and either clear guidelines on adjusting the figures for different road conditions and possible amenity function will be needed or they should be relaxed slightly to account for real world roads	
	No! The CL must be determined based on the initial over-sizing, which depends on the exploitation strategy. Moreover, in Brussels, with HID lamps, we do not reach a CL of 1.3 !!! We are at levels <1.1 because we renew the whole installation. In the case of a complete renewal of the installation, with repositioning of the pole, this value may be lower. The renewal strategy therefore has an impact. And finally, the functionality of Constant Light Output (CLO) also exists for discharge lamps and influences the CL. Conversely, adapting the LED current to obtain the correct light flux, has a serious impact on the management of the data basses of the grid operators and on the exploitation of road lighting.	In terms of impact on the grid – CLO or dimming will have a serious impact on the grid if taken at a large enough scale. But this should never be a sufficient argument to justify not saving energy or reducing light pollution.
Energy efficiency:	Supported by the Dialux freeware	Thank you for your input –

should a format be specified for the photometric file?	yes! *.cen (european standard) or *.ldt (industry standard in EU) are most common.	which has now been introduced into the supporting rationale in TR 2.0.
	File format should not be proprietary, but should be a common open format. However, specific design software should be able to use standard file formats, so the actual format is not relevant.	
	The photometric file has to be developed through an open source software and has to be modifiable. It is necessary to have specific certifications, according to the Directive 2014/24/EU, art. 44.	
	8) Yes. Italian GPP are requiring open certified XML format.	
	File format should not be proprietary but should be a common open format such as eulumdat or IES. However specific design software should be able to use standard file formats so the actual format should not be relevant.	
	Yes, It is necessary to define the format. At this moment the photometric file format EULUMDAT (.ldt extension) is currently use by the industry and software programs. This file was created by the lighting industry and is known and used word wide. There is an existing CEN file format descripted in standard CEN - EN 13032-1:2004+A1:2012, but it seems not to be used currently at this time. It should be interesting to standardize the creation of the matrix. à choose between; "relative efficient matrix", "relative matrix" "absolute matrix"	
Energy efficiency: is self-certified data acceptable?	Self-declaration is adequate if the internal laboratory is accredited to a recognised European accreditation body. Otherwise, verification or certification should be requested.	Accepted.
	Only if laboratory is accreditet to a recognized accreditation body.	
	Self-declaration is adequate if the internal laboratory is accredited to a recognised European accreditation body. Otherwise verification or certification should be requested.	
	It is necessary to have a matrix measured in an accredited laboratory. Certification is highly recommended. In addition, it is essential to request the photometric study, with the assumptions taken for the maintenance factor, depending on the installation and its maintenance. It is not sufficient to accept photometric file and the other parameters based on self-declaration. Verification or certification is a must. So luminaires performances can be proven by an ENEC+ certificate for the family of luminaires. As the ENEC+ is a commercial mark but based on EN standards for performances the equivalent conformity to these standards can be proven by measurement reports published by an institute- laboratory with EN ISO 17025 accreditation for the scope of the measurements.	Accepted in principle. However, other stakeholders believe that a self-declaration is acceptable so long as the laboratory is certified. EU GPP cannot make a direct mention of ENEC+ in the criteria but this could be researched further in the supporting rationale – especially the issue of poorly performing LED chip batches.
Energy efficiency: Should tiers be implemented to account for future	our answer for both PDI and AECI is a resounding "YES!"	Accepted
	The PDI limit may be concerned by some updating. As previously argued, the proposed constant PDI: PDI[W/(lx.m2)] < 0,035	Rejected. Too difficult to set a single value independent of road width due to changes in

LED developments?	may be lowered as the available technologies evolve.	utilance.
	No, this will introduce complexity for users that will be difficult to administer. Updating the GPP criteria to reflect technology developments is preferable.	Rejected. We believe tiers are highly relevant for this criterion.
	Yes. It would be useful to have a technical observatory with the aim to analyse the technical aspects and the performances of each product category available on the market (average products and best products).	Accepted – is there an EU equivalent of the US DOE Lighting Facts database?
	5) Italian GPP set progressive level of IPEA* and IPEI* during time. But with 161/RW it could be too complex to administer.	Accepted. No we promote a more transparent calculation where the future improvements in luminaire efficacy are almost entirely down to improved lamp efficacy.
	No, this will introduce complexity for users that will be difficult to administer. Updating the GPP criteria to reflect technology developments is preferable.	Rejected. We believe tiers are highly relevant for this criterion.
	LED's will become each year between 4 and 8% more efficient (industry tells us) and this for the next 3 to 5 years� So may be tiers can be usefull.	Accepted.
	No, this will introduce complexity for users that will be difficult to administer. Updating the GPP criteria to reflect technology developments is preferable.	Rejected. We believe tiers are highly relevant for this criterion.
Energy efficiency: Do you agree about the PDI (and thus AECI) dependence on road width?	It is justified to fit PDI limits with some relation. But the concept of PDI should lead to no dependency to RW, in order to design the installation for lighting the target only, and preventing any spill of light.The GPP should not endorse spilling of light and should be incentive on that issue. The GPP should promote the independency of PDI to RW. The GPP shouldn't caution that, the narrower the road, the higher the PDI in the proportions seen in Table 4-1. GPP must orient product and lighting policy offers, not the opposite, complying with unfriendly environmental products or lighting standards. Thus, the PDI limit should be fitted by a simple constant, based on the performance of medium wattage HPS clear, according to Table 4.1, or possibly on the performance of warm LEDs, for instance: PDI[W/(lx.m2)] < 0,035 The GPP criteria must promote and be compatible with low wattage lighting installations. Due to the many adverse environmental impacts of white LEDs (ref. [1-7] in § Guidance), the GPP criteria must not be compatible with white LED sources only.	Rejected. Although the principle of the comment is reasonable, the reality is that PDI is affected by the poorer utilance factors on narrower roads. The new proposals for PDI and AECI try to make this as clear as possible. Further inputs relating to the potential for improved utilance with LED luminaires would be welcomed.
	Dependency to RW is promoting spilling of light. The PDI criterion shouldn't depend on road width, neither with LED nor with HPS luminaires. The GPP should incite to a better efficacy and less spilling of light emanating from narrow roads; see comment on question#1 of §4.2.3.1.4 And moreover, no dependency with RW is all the more relevant with LEDs, for they are supposed to show improved emission orientation control.	
	Yes, we agree with the principle of the proposed table 4-1 for GPP scenario 'free design parameter.' However, the values have to be evaluated also on regular basis, because technology is evolving. It also depends on how the proposals are awarded.	No longer relevant because we have changed the proposal to a

	Anyhow, a double check of table 4-1 should be done because; e.g. table 4-1 road profile E: width of the carriageway is 7 m instead of 10 m and the value for M3 RW 10m (20.9 /17.7) is a lot below the recommendation of EN13201-5 (25-27)	PDI and AECI based method.
	1) This parameter is too simplistic and the scale too broad. Moreover, the Cx and Px classes cannot be assess with only street lighting luminaires. We would suggest to use IPEA* and IPEI* benchmark. IPEA* and IPEI* criteria are more equitable and straightforward.	Accepted. We have now moved to a PDI and AECI based approach (more similar to IPEA and IPEI but without labels and with a different ambition level).
	No. As the link between PDI and AECI was demonstrated the use of both values is questionable (see page 23). Unless a good reason is provided to consider both metrics PDI should be dropped and AECI solely used.	Rejected. The reason to include PDI is if you want to guarantee a minimum level of light on the road.
	Due to lack of time this value cannot be verified at this stage. More time for examination of the proposed numbers by the synergrid experts is needed. They need to compare them to their database	No longer relevant – a completely different proposal is now included, based on PDI and AECI.
	Yes. Based on technology and solutions that are available today, irrespective of the technology, light has to be spread over a larger area. Optics can direct the light efficiently, but cannot account for a too low lumen output from a light source. This either requires multiple smaller lumen output luminaires or fewer higher lumen output luminaires. Both solutions have an impact on energy usage.	Accepted. We have now inserted a reference table for how the utilance factor should vary as a function of road width when calculating the PDI
	Yes	
	Yes. Irrespective of the technology light has to be spread over a larger area. Optics can direct the light efficiently but cannot account for a too low lumen output from a light source. This either requires multiple smaller lumen output luminaires or fewer higher lumen output luminaires. Either solution impacts energy usage.	
	Yes	
Energy efficiency: Table 4-2	Which road surface is used for this calculations? We (EANDIS) did not have enough time for making our own calculations to investigate the proposed values.	No longer relevant since the 161 x RW calculation is no longer proposed.
Energy efficiency:Metering	Metering at the installation scale would already be a fair criterion. Metering at the luminaire scale is not a critical green criterion.	Accepted as suitable core AC for metering at installation level. Luminaire scale metering could bring environmental benefits by helping identify sub-optimal performance and individual faults.
Energy efficiency:Cost of metering	Cost of metering systems) can vary a lot	Over what sort of range?
	Difficult to say at this moment. Smart technologies are evolving every day and the cost had to involve the costs of : The used materials Implementation on site Implementation at company level + security of the used communication channels and technology Training of personal	Accepted. This is why metering is only suggested as an AC at this stage. If the procurer definitely wants or needs metering, it should be

	Data transfer + It is not only the smart meter ... it is necessary to modify the power supply cabinet (which will takes up more space in the public space) and add the communication costs	introduced as a TS in the invitation to tender.
Energy efficiency:ease of implementation?	Provision of metering is generally the concern of the owner of the installation. However, also the luminaire manufacturer can play a role here. Adding metering functionality to the electric control gear of LED based luminaires, or combining it with a remote system, is possible already today. This can also contribute to further energy reduction by operating intelligent dimming regimes over time. A bonus should be in place for those offers that provide a remote system, including metering, in order to create a system that rewards this aspect.	Accepted. This distinction has now been made in AC for metering
	The metering system should be implemented in any renovated system to capture the unexpected consumptions.	The decision on whether or not metering is to be requested is that of the procurer and will consider all of the points raised in these comments.
	Yes for power panel; no for point-to-point metering. Also energy consumptions of the lighting system could differ from the sum of energy consumption of each luminaire.	
	Provision of metering is generally the concern of the electrical installer and not the luminaire supplier. As such no comments are submitted.	
	For Synergrid experts based on pilot sites it is proven that it is not easy to implement systems on old installations. The existing architecture (ex. cabinets are too small) of the grid and the regulations of the municipalities are obstacles. Experiences prove at the moment that this can be a financial important supplementary cost for realisation.	
	Often a metering system is NOT easy to be implemted, because physical place is often a problem (cities do not want more cabinets in the street�).	
Energy efficiency: common practice?	We never heard of that.	These comments confirm that metering in road lighting installations is the exception rather than the rule. A push towards metering would be beneficial as it would help prove compliance (or demonstrate non-compliance) with energy efficiency claims. It may also help identify abrupt failures and provide real benefits caused by the implementation of curfew dimming instead of theoretical calculations.
	EANDIS has no meter on its public lighting installations, but we take dimming into account to make the bill. We have defined dimming programs (eg: between 22h and 6h 50% of light), so we can calculate the power used.	
	Not with Eandis. We do not have meters on our public lighting grid and are calculating the kWh's (taking into account switching on/off and dimming). If a system with IoT (internet of Thing) can 'measure' the power consumption of each lighting fixture with	
	1) In Italy is not mandatory	
	As only a minority of road lighting installation in Belgium are metered by energy meters. The actual system is based on burning time (controlled over all the country by centralised commands systems) and standard energy consumption of the used luminaire. For luminaires where dimming is applied the central control systems emit signals to start and stop dimming. So for example between 22:00h and 05:00h dimming is active. The energy consumption at 100% and at dimming level is taken in account for billing.	
	Only a minority of road lighting installation in Belgium are metered by energy meters. In the Belgian model, line losses by Joule effects have to be added to lighting consumption so a smart meter at the top of segment is irrelevant. The consumption shall be measured at the luminous point.	
Energy efficiency: Lowest Life Cycle Costing LLCC. Can the LLCC jeopardise fair competition.	The Life Cycle Cost is a fair criterion. It must be easy to read. It should be based on: the cost of the installation (including labour, not including cost of credit or financial charges), divided by the expected lifetime, leading to, the yearly installation cost, the yearly energy consumption (subscription cost included), the yearly maintenance cost.	It appears that LLCC is highly relevant but there are concerns about its use as a major criterion to decide the award of contracts. There is a need to very clearly define a number of assumptions so that LCC can be calculated in
	One LCC needed or no comparision is possible. If we (EANDIS) do a tender with LCC, we use our own LCC program and	

	ask to the manufacturers to deliver the data we need to run the LCC.	the same way. It may be that the procurer simply asks for certain cost data and then does the LCC calculation themselves. At the level of EU GPP criteria, it is felt that it would be more appropriate to use LCC in a more general way to support the design making process when considering if simple relamping or renovation of a lighting installation is most appropriate. Cost is always the dominant factor in awarding tenders and care should be taken that it is not counted twice (once when comparing bid costs and twice when awarding points for LLCC). Together with minimum requirements on product durability and maintenance factors, the criteria set already are set up to favour lower LCC solutions in a less direct way.
	There is a problem when there are different LCC calculations If everybody use the Swedish LCC-tool, it's in english but could be translated to different language (attached)	
	Whilst the use of LCC calculations as part of the decision making process would be beneficial, it would require very careful definition in the tender document to ensure that all solutions used the same financial information for installation, operation, and maintenance. A full LCC calculation is complex and it can be difficult to compare between different solutions with any surety of consistency. Unless a comprehensive set of default inputs could be defined, this should be avoided as a requirement although could still be mentioned to highlight the desirability of LCC analysis. In addition, check also the latest developments in CLC TC 111x on EU standardised LCC methodology.	
	It could be quite difficult to compare different LCC analysis. For this reason, it should be identified every single voice of cost that has to be included, so to avoid non-objective and non-comparable calculations.	
	Perhaps the experience from Sweden can give feedback for this question? LCC prescribed parameters should allow for as much (or better considering it is more comprehensive) comparability than on price alone. Is modularity considered? Keep LCC, but the mininum information that must be provided should be clear, perhaps as an LCC tool like in the Swedish example.	
	1) Yes	
	Whilst the use of LCC calculations as part of the decision making process would be beneficial it would require very careful definition in the tender document to ensure that all solutions used the same financial information for installation, operation and maintenance. A full LCC calculation is complex and it can be difficult to compare between different solutions with any surety of consistency. Unless a comprehensive set of default inputs could be defined this should be avoided as a requirement although could still be mentioned to highlight the desirability of LCC analysis	
	A LCC calculation is necessary as is use to compare different solutions. The experts of Synergrid request more time for answering this question as each grid operator had his own approach. The operator used their own calculation method and require the needed information from the manufacturers. Warning: The LCC as presented in the document does not seem to take into account the cost of production of products or end-of-life treatment. It's completely truncated. It is essential to correctly define the calculation period according to the lifetime of the equipment. A method including a complete method of calculation of the LCC must therefore be provided. In the balance sheet, it is also necessary to foresee the costs of controlling system of the existing installation (necessary in case of dynamic scenario and / or LED) (communication costs, software, staff, etc.) In addition, when the installation is completely renewed, it is not the energy costs that account for the largest share of the costs.	
Selection criteria: Design teams, minimum experience.	The complexity of this standard is not in line with current guidelines on procedures' simplification carried out in France by a dedicated State Secretariat for State Reform and Simplification (see attachment for link). If complex criteria as the PDI are promoted, three years of experience may be needed. But, three years of experience needed for handling the complexity of the GPP, disqualifies the GPP. Friendly handled standard may be more effective.	Rejected. After much discussion, we have opted for a PDI and AECI based approach – but trying to make those calculations as transparent as possible.
	How to validate years of experience? What with new young companies? We (EANDIS) is an grid operator for more than 200 cities, our people make there own lighting calculations for which they followed an internal course. How to deal with this? For our tender	These are all perfectly valid points.

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<td>The problem with this metric is that it is a very rough broad-brush. A designer who has only one year of experience, but that year was totally concerned with the design of road lighting installations, will have a higher level of expertise than a designer with three years of experience, but who designs a broad range of lighting installations and only a small percentage of the three years was on road lighting. The list of relevant designed lighting schemes would be a more useful indicator. Also, ‘scale of projects’ handled is important. Consider to add expertise integrated in a kind of ‘company valuation’ as alternative to ‘individual experience’ to reduce administrative burden for SMEs and large companies that employ multiple lighting designers.
Certified Lighting Technician or 3 years of experience would be also possible.</td>
<td rowspan="7">Perhaps it is most relevant to simply refer to the minimum experience of the person who will sign of the project – effectively taking responsibility of the work of those beneath them.
This way, flexibility is allowed for the rest of the staff involved in the project but experience and quality control is assured.
In this case the minimum experience could even be increased, say to 5 years?
We would also welcome any input about appropriate certification schemes.</td>
</tr>
<tr>
<td>It would be better to consider at least three years of experience, then assessing potential specific experiences in designing installations similar to the object of the contract, according to type and dimension.</td>
</tr>
<tr>
<td>1) First of all, we need to distinguish between electrical designer and lighting designer. For both, Italian GPP ask for 5 years of experience and a registration to a relevant professional body. Moreover, lighting designers must have already done lighting projects with a total amount of luminaires equal to half the luminaires included in the tender</td>
</tr>
<tr>
<td>The problem with this metric is that it is a very rough broad-brush. A designer who has only one years’ experience but that year was totally concerned with the design of road lighting installations will have a higher level of expertise than a designer with three years’ experience but who designs a broad range of lighting installations and only a small percentage of the three years was on road lighting. The list of relevant designed lighting schemes would be a more useful indicator.</td>
</tr>
<tr>
<td>To speak of experience in terms of years is not logical and accurate.
Executing 10 studies in 3 years is less relevant than executing 60 in 2 years !!!!
On the other hand, there should be foresee a possibility of training (a junior can study under the supervision of a senior)
How to validate years of experience must be descripted. Requiring more than 3 years will close the marked as new players will never build-up 3 years of experiences with young people. They will need to attract people with experiences from other companies.</td>
</tr>
<tr>
<td>The EEB does not believe the current proposal for core and comprehensive criteria on the competency of the design team is sufficient with “at least three years of experience in lighting design and/or having a suitable professional qualification in lighting engineering or membership of a professional body in the field of lighting design.” This formulation weakens and compromises the criteria, and may result in un-qualified individuals carrying out the work.</td>
</tr>
<tr>
<td>Taking into account the complexity and importance of street lighting installations being planned and carried out in a professional and competent way, our suggestion would be as follows:
Core criteria: “Where a new lighting system is being designed or an existing system is being renovated, the tenderer shall demonstrate that the design will be undertaken by personnel with at least three years of experience in street lighting design and at least one year experience in LED street lighting design."
The EEB notes that the publication of these criteria may stimulate companies with an interest in the street lighting market to ensure their staff are qualified in time to meet the EU GPP criteria.</td>
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<td>Taking into account the complexity and importance of street lighting installations being planned and carried out in a professional and competent way, our suggestion would be as follows:
Comprehensive criteria: “Where a new lighting system is being designed or an existing system is being renovated, the tenderer shall demonstrate that the design be undertaken by personnel with at least three years of experience in LED street lighting design.”
The EEB notes that the publication of these criteria may stimulate companies with an interest in the street lighting market to ensure their staff are qualified in time to meet the EU GPP criteria.</td>
<td rowspan="2">Rejected. We do not want to put any technology specific experience requirements – especially since LED has only recently become widespread in road lighting applications.</td>
</tr>
<tr>
<td>We agree that three years should be sufficient time, but of course it would depend on how many projects the experts have overseen during that time. In a worst-case scenario, the lighting designer could have been working with one municipality for</td>
</tr>
</table>

	three years and still have not completed a single installation, yet could demonstrate compliance with three years. Thus, the EEB recommends that that JRC interviews a few street lighting design companies to find out what would be typical practice and consider adding a minimum number of projects in addition to the time period	
	In this document no requirements exist concerning calculation software. And yet this is a fundamental basic. Recent comparison of results delivered by different simulation programs prove some divergences in the results. If luminance and illuminance results were similar major differences were noted for the threshold increment (old TI now fTI requirement of standards EN 13 201 series. The draft of CIE "technical report CIE 140 proposed" a benchmark for evaluating "light calculation software". I proposed this will be investigated by the workgroup members.	We support the further investigation of the CIE 140 proposal – please let us know what may be concluded.
	It is a professional responsibility to perform CPD activities (Continual Professional Development) to ensure up-to-date knowledge on lighting topics. It would perhaps be as useful to ask what knowledge update activities have been performed in the last three years. A combination of training and experience is preferred. In addition, we have to be aware people working for multinationals can be very well in-company trained and/or educated without participation in formal external training.	Hopefully this issue has been resolved by applying the minimum requirements to the project manager who signs off the design.
	2) Both training and experience are required. But who wil verify and validate the training? Why not adding it as a comprehensive criteria?	We hope to have solved the issue by requiring that the minimum experience relates only to the senior personnel and not ALL personnel in the project.
	It is a professional responsibility to perform CPD activities (Continual Professional Development) to ensure up-to-date knowledge on lighting topics. It would perhaps be as useful to ask what knowledge update activities have been performed in the last three years.	
	No Attention: other skills than road lighting alone are necessary: design (urban vision), electrical knowledge of distribution networks, dimensioning of electrical circuits. Moreover, it is essential to ensure: That the designer arrives as first in the process and on the site study (this as recognition of the site, the obstacles,- balconies, trees, garages, urban cabinets, ...) and after having made his photometric study (Calculation of the inter distance of the lighting points) to ensure accurate and realistic positioning of the lighting points. For urban sites the process descripted above must be a requirement in any case! So different possibilities can be taken in account. Training by: External organisations (universities, lighting institutes, training centre software developers… Manufacturers training centre Internal company training (grid operator technical services municipalities …) + Other prposition: a system like a binomial junior-senior. is necessary	Accepted. Some of these aspects have now been mentioned in the SC. The minimum requirements now apply to the senior member of staff in the project.
	For verification of the proposed criterion on lighting design, the EEB believes that the JRC should add a requirement for the tenderer to provide assurance that the individuals named are actually going to do the work and aren't simply being named to secure approval. Some kind of formal, legal statement that the applicant must sign and date, affirming and committing their organisation to the information provided in the application.	Accepted. This is now addressed in a CPC.
Selection criteria: installation team competences	Five years of experience needed for handling the complexity of the GPP, may disqualify the GPP. Friendly handled standard may be more effective.	And if this only applied to the project manager?
	Similar to 4.2.2.4, the problem with this metric is that it is a very rough broad-brush. An installer who has only one year of experience, but that year was totally concerned with the road lighting installations, will have a higher level of expertise than an installer with three years of experience, but who installs a broad range of lighting installations and only a small	Accepted. Flexibility has been built into the SC to allow for this

	percentage of the three years was on road lighting. The list of relevant installed lighting schemes would be a more useful indicator. Additionally, it is a professional responsibility to perform CPD activities (Continual Professional Development) to ensure up-to-date knowledge on lighting topics. It would perhaps be as useful to ask what knowledge update activities have been performed in the last three years.	at the procurers discretion.
	It would be better to consider at least three years of experience, then assessing potential specific experiences in installing lighting systems similar to the object of the contract, according to type and dimension.	
	That make no sense. A contractor team that renews public lighting consists of: Machine operators Road workers Electricians Team Leaders It is not necessary for machine and road workers, in particular, to have experience in Road lighting ... Only persons who connect the installations at level of the pole, junction box or luminaire must have experience in lighting. On the other hand, it is important that they have skills in trench execution, cable placement, networking, signalling and tagging, site management, ... And again: Expressing experience in a year does not make sense. The number of achievements seems more important. Not allowing "juniors" to work under the supervision of "seniors" blocks the market ... In Belgium at grid operators level trainings are organised and must be followed by tenderers. It involve safety, technical knowledge, ….. The tenderer cannot work for the grid operator if the exams at the end of the training are not success full passed. If necessary the agreement to work for a grid operator can be suspend for a person if checks prove the non-respect of the requirements explained during the training. So a 5 year experience is not a necessity. This requirement risk to close the market for new companies hiring young personal starting the job with no experience.	Valid points. Now the SC has been target at the project staff who sign off the installation works instead of ALL personnel in the project.
	The EEB does not believe the current proposal for core and comprehensive criteria on the competences of the installation team is sufficient with “at least three years of experience in lighting design and/or having a suitable professional qualification in lighting engineering or membership of a professional body in the field of lighting design.” This formulation weakens and compromises the criteria, and may result in un-qualified individuals obtaining certification.	These are all perfectly valid points. Perhaps it is most relevant to simply refer to the minimum experience of the person who will sign of the project – effectively taking responsibility of the work of those beneath them. This way, flexibility is allowed for the rest of the staff involved in the project but experience and quality control is assured. In this case the minimum experience could even be increased, say to 5 years? We would also welcome any input about appropriate
	Taking into account the complexity and importance of street lighting installations being planned and carried out in a professional and competent way, our suggestion would be as follows: Core criteria: “Where a new lighting system is being designed or an existing system is being renovated, the tenderer shall demonstrate that the design will be undertaken by personnel with at least three years of experience in street lighting design and at least one year experience in LED street lighting design.” The EEB notes that the publication of these criteria may stimulate companies with an interest in the street lighting market to ensure their staff are qualified in time to meet the EU GPP criteria. We agree that three years should be sufficient time, but of course it would depend on how many projects the experts have overseen during that time. In a worst-case scenario, the lighting designer could have been working with one municipality for three years and still have not completed a single installation, yet could demonstrate compliance with three years. Thus, EEB recommends that that JRC interviews a few street lighting design companies to find out what would be typical practice and consider adding a minimum number of projects in addition to the time period.	
	Eandis itselfs organises lessons for tenderers installing lighting installations. At the end of these lessons, a test has to be done by each individual person. If he/she succeed the test, he/she gets the permission to do work for Eandis. This permission c	

		certification schemes.
	For verification of the proposed criterion on lighting design, the EEB believes that the JRC should add a requirement for the tenderer to provide assurance that the individuals named are actually going to do the work and aren't simply being named to secure approval. Some kind of formal, legal statement that the applicant must sign and date, affirming and committing their organisation to the information provided in the application.	Accepted. This is now addressed in a CPC.
Light pollution: How can RULO criteria affect the cost and efficacy of the luminaire?	Cost: The cost a light shield. Efficacy: A better efficacy is awaited as there will be less spill light. Less spill light means lower power to reach the same illuminance level.	Accepted in principle.
	Current good practice luminaire designs using LED technology already take this into account, and cost implications are negligible for performance road lighting luminaires. In addition, we have to be aware that an increased ULR will impact the efficacy of the luminaire negatively, but in most cases to serve a purpose (e.g.) urban luminaires.	Accepted.
	LEDs ULR is already almost zero	Accepted.
	Current good practice luminaire design will using LED technology already take account of this for cost implications are negligible for performance road lighting luminaires.	Accepted.
	It is not at the level of the luminaire that one must see the impact of the RULO, but at the level of the complete installation. And roughly, in motorized roads, at most the RULO is low, how higher is: The power to install; The number of luminaires to install; The nuisance light. To fulfil the RULO criteria the photometric characteristics of the luminaires had to be adapted to these requirements. This photometric impact will probably impact the PDI. So an impact on the cast can be expected. Further investigation is needed.	Accepted in principle and further input about the potential cost implications of 0% RULO versus say 1% RULO would be welcomed.
	because of de smaller angels to fullfil the ULOR criteria, probably the PDI and AECI will be higher. Price???	
Light pollution: CRI	I would not use CRI for this criteria. White LED has less blue emission with higher CRI than with lower CRI (you can see it in any technical sheet (for example, a 2700ºK LED with CRI = 90% has less blue emission than 2700ºK LED with CRI = 70%). By other hand, AMBER LED or PC-AMBER type LED has less blue emission with lower CRI (CRI=40%) than higher (CRI=50%), but the difference in blue emission is short in this case.	It would be interested to know more about the relationship between CRI, CCT and blue light.
Light pollution: factors that only white LED can meet	For functional road lighting this is reasonable. For any luminaires with an amenity requirement, requiring significant levels of vertical illumination or low-mount road lighting for specific applications is too stringent. For urban lighting when using more decorative products that can include vertical illuminances, 15% ULR is a good reference. A separate light outlet for guidance/direction indication should be exempted from the 1% RULO. NOTE: concerning RULO the CIE knows 2 abbreviations: ULOR inst (Upward Light Output Ratio installed): reference CIE126:1997 and ULR (Upward Light Ratio): reference CIE150:2003. We suggest to use ULR, as it is the latest CIE definition.	Thank you for the comment. The question is if the latest definition (ULOR) is to be changed to RULO in the near future or not? Any clarity on this matter? We will make it clear that the criteria for RULO are to be applied when there is no other need for vertical or amenity lighting.
	1% RULO is a realistic value for road lighting as a general reference but it could be useful to have higher values for historic centers.	
Light pollution: glare and obtrusive light: should glare classes	Glaring and obtrusive light prevention would be advantageously addressed by ULORa and "CIE flux code" N3 requirements.	There are some conflicting comments here: One side in favour of the RULO
	Eandis works with the G-classes instead of ULOR. G2 is common use, G3 or G4 for areas where upward light is an issue.	

be used instead of RULO?	Eandis works with the G-classes (old standard) instead of ULOR. G2 is common use, G3 or G4 for areas where upward light is an issue.	criterion and the other side in favour of glare class specification. It is proposed to continue with the RULO criterion if indeed it is a simpler concept to understand and specify because these simpler approaches are to be preferred in GPP.
	G classes indicate maximum luminous intensity limits above defined angles, but do not provide an overall quantity criteria of light for these angles in the same way as RULO does. G classes are more useful for glare control and less applicable to generalised obtrusive light concerns. In addition, the use of classes G1 – G6 would require additional guidance on how they are to be applied within the context of GPP. So, the use of RULO is a simpler and more transparent metric and it should be kept next to the G classes.	
	Yes. Also Italian GPP use G* classes	
	G classes indicate maximum luminous intensity limits above defined angles but do not provide an overall quantity criteria of light for these angles in the same way RULO does. G classes are more useful for glare control and less applicable to generalised obtrusive light concerns. In addition the use of classes G1 – G6 would require additional guidance on how they are to be applied within the context of GPP. The use of RULO is a simpler more transparent metric and should be kept.	
	As Standard EN 13201 series introduces criteria for disability glare and control of obtrusive light, it seems more logical to follow the standard than introduce a RULO limitation.	
Light pollution: Can further information about the effect of light on species be requested/expected?	No. Tenderers may produce either the CCT or the spectrum, not both. And the influence on species should not be explained. It is devoted to scientists to answer the environmental impact of a CCT value or a spectrum content.	Accepted about the effect of light on the species. If there is a particular local effect of concern, the procurer should define what it is. The specification on CRI has been removed in the proposed criterion in TR 2.0.
	Each animal has different sensitivity to different wave lengths. So the limits of 3000K and CRI 70 are good for one kind of animal, but not good for others. Better to give suggestions than give an fixed value?	
	left open for the tenderer to provide specific information	
	This should be specified by the tender and not by GPP in giving details on species covered by the comprehensive criteria.	
	The tenderer must provide complementary information, so this must left open.	
	This should be specified by the tender	
	This should be reworded as otherwise any reply will have to be generic covering any expected specifies of animals and plants and this generic approach will make the statement fairly useless. Any specific concerns for wildlife that exists within the vicinity of the road should be specifically stated and a more comprehensive reply to these specific concerns should be expected. NOTE that the specification of a maximum CRI is fairly meaningless. To achieve white light a number of spectral peaks will be required that cover most of the visual range. Low CRI will be defined by the gaps between the peaks and not particularly by the overall width of the spectral band. In addition as different species react to different wavelengths a meaningful outcome is not guaranteed.	
	Based on information's and comments of experts of animal behaviour, it seems that depending the concerned species the impact of CCT value is different. So it seems illogical to impose CCT lower than 3000 K. Some advice from experts is needed for this requirement. Imposing CCT 300 K will impact on the energy consumption as for example 4000 K LED are more efficient. In Belgium 3000 K and 4000 K are normally used, but in exceptional case other can be used if the impact on nature can be reduced.	Rejected. Other stakeholders have shown that there is only a modest (3%) decrease in energy efficiency when going from 4000 to 3000K.
Light pollution:	ANPCEN in its "Lighting installation environmental requirements" (http://wikinight.free.fr/?p=588) ask for: ULRa = 0	Is this to apply to ALL road lighting or only in certain

standard methods for measuring RULO, CRI and CCT?	CCT < 2100K or, "Amber LEDs" CIE flux code N3 > 98 recommendation from ANPCEN, is to be released in 2017.	circumstances? Are these recommendations applied throughout France?
	verification needed, standard available for measurement, no self declaration!	
	CIE 13.3-1995 defines the calculation methodology for CRI. CIE 15:2004 defines the calculation of chromaticity coordinates and CCT. ULR is calculated from the photometric intensity table measured according to EN 13032-1:2004 + A1:2012 or EN 13032-4:2015. Self-declaration in a certified internal lab is sufficient.	So the CIE standards should be referenced and self declarations should not be used unless the declaring party also have an appropriately certified laboratory.
	It would be better to have a certification about RULO, CCT and CRI values, according to the Directive 2014/24/EU, art. 44.	
	7) CIE 13.3-1995 defines the calculation methodology for CRI. CIE 15:2004 defines the calculation of chromaticity coordinates and CCT. ULR is calculated from the photometric intensity table measured according to EN 13032-1:2004 + A1:2012 or EN 13032-4:2015. CRI and CCT shouldn't be used to assess light pollution (see attachment)	
	Yes, there are existing standards. On the other hand, this is not yet the case for the glare associated with LED luminaires. This is an important topic to be developed. The needed standards are at disposal concerning the required measurements. These standard are at IEC (world level and are all be transposed at EN level at the moment. Not limitative list: IEC 62717 LED modules for general lighting – Performance requirements IEC 62722-1 Luminaire performance – Part 1: General requirements IEC 62722-2-1 Luminaire performance – Part 2-1: Particular requirements for LED luminaires	Accepted: For LED there are different standards to be referenced.
Light pollution; worth looking at flux above 70 or 80 degrees for prevention of obtrusive light?	Upward Light Output Ratio is abbreviated ULOR. ULR should be preferred to ULOR, for all non technicians confuse ULOR with ULR. ULR is a straightforward intuitive concept. ULR has been preferred by the lighting industry since the availability of the LED technology. ULOR or ULR is a too limitative description of the spatial distribution of light: the percentage of flux above 90° (horizontal plane). A more relevant GPP requirement would be the percentage of flux above 80° or 70°, accounting for spill light, intrusive light, and glaring. This is the purpose of the "CIE flux codes".	What is the exact difference between ULR and ULOR? Some additional comments about the flux codes have been added to the technical report. This should be discussed further in the 2nd AHWG meeting.
Light pollution: photobiological safety – should it be included as GPP criteria?	It should be hoped that photo biological safety of light sources is handled in some other regulation than the GPP.	A split opinion was expressed here. On the one hand, it was felt that GPP should make some requirement based on photobiological safety and on the other hand, it was felt that this should be addressed by other standards and controls. One option would be to limit light sources to risk groups 0 and 1 only. The EN 60598 standards have been mentioned in the stakeholder discussion section of
	Is photobiological safety also needed as a criteria?	
	YES	
	Photo-biological safety is included within the LVD via EN 60598 - low voltage safety directive 2014/35/EU. Additional criteria are not necessary.	
	Yes, they should include at least the CCT.	
	No	
	Photo-biological safety is included within the LVD via EN 60598. Additional criteria are not necessary.	
	Yes is an obligation and limit them to RG 0 and RG1. For photobiological safety the risk group had to be defined for the luminaire. This in in conformity with the existing	

	standards. Not limitative list: IEC/TR 62471-2 Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety IEC/TR 62778:2012Assessment of blue light hazard EN 60 598-1 Luminaires . General requirements and tests	the light pollution criteria
Light pollution: Is it necessary to define a tolerance for RULO measurement?	No. The satisfaction of requirements on emission angle is an easy task (a matter of shield fixtures). GPP requirements must incite the use of efficient luminaires and orient the industrial production towards efficient designs.	Rejected if there is a commonly accepted tolerance for these measures.
	same tolerance as for normal photometrice measurements?	Which would be?
	Measurement tolerances on photometry and methods to confirm photometry are given in annex D of EN 62722-1:2016 and these should be used. Field measurements of RULO (ULR) are generally impractical.	Accepted about the impracticality of field measurements.
	It would be better to include the measurement tolerance for RULO in the criteria setting, with higher values for historic centers.	How much higher for historic centres?
	Yes, but EN 62722-1:2016 already gives measurement tolerances	So what tolerance is mentioned in Annex D of EN 62722-1.2016?
	Measurement tolerances on photometry and methods to confirm photometry are given in annex D of BS EN 62722-1:2016 and these should be used. Field measurements of RULO are generally impractical.	
	It seems logical that the tolerance criteria required for photometrical measurements had te be used.	
Light pollution: ULOR or RULO?	Why not using ULOR (upward Light output Ratio)? Same definition, well know because mentioned in standards. RULO = ULOR.	It is expected that this will change to RULO in future versions of relevant standards.
	In actual standrds the used name is ULOR = Upward Light Output Ratio. The definiation is identical. But as the actual standards had to be updated to the new required names agreed at international level and this will take some time. it would be practocal for readers to mention that RULO is the old ULOR.	
Light pollution: ambition level for RULO	The JRC proposes core and comprehensive criteria (TS2) that allow for a maximum light proportion going above the horizontal of 1%. We do not (!) agree with this recommendation. The EBB feels strongly that all luminaires should be zero cut-off – in other words, no upward light emission. This is easily achievable with LED luminaires, and it is actually difficult to find LED luminaires with upward light output if they are designed and installed correctly. The EEB calls on the JRC to further research and discuss issues around CCT and the impact on people and the environment in more detail as they are of concern to our members and there is a lack of clarity in the documentation. We recognise that impact is a function of two factors - intensity of and duration of the exposure. Thus, JRC should broaden the evidence base for this criteria proposal, including scenarios. More research is emerging related to impacts on e.g. aquatic ecosystems, bats and birds or insects which react to different parts of the light emission spectrum. Therefore, we call on the JRC to study this topic in more depth and provide a sound justification for its recommendations together with the updated version of the criteria proposal. Nonetheless, the EEB appreciates the JRC's recognition that there can be a negative impact on biodiversity that results from street lights with higher CCT values. Therefore, we insist that the lighting design must take into account the relative sensitivity of the installation due to its location in the first place. Our recommendation based on the current explanations in the draft preliminary and technical report is to limit CCT at least in the comprehensive criteria (TS2) as an expression of the precautionary principle. We support the proposed limitation to ≤ 3000 K at this stage but invite the JRC to investigate the implications of setting a stricter value such as 2700 K. In the final set of criteria, it should be made very clear that the CCT	Accepted. We have now proposed 0% RULO as the default criteria (core and comprehensive) Some additional text has been added about the effect of light on species. Stakeholders are welcome to contribute on this. Limits for CCT have been included in the TR 2.0 criteria and we have removed any requirements related to CRI. If a minimum CRI is to be reintroduced, it should be discussed at the 2nd AHWG

	criterion alone is not be sufficient to prevent adverse effects of outdoor lighting and that additional requirements in particular with regard to adequate lighting levels should be taken into account for the layout of the street lighting system. The EEB does not support the JRC's proposal to limit colour rendering index (CRI) in the comprehensive criteria (TS2), indeed quite the opposite should be implemented here. With improved colour rendering, human eye performance also improves and lower levels of illuminance can result which will have less impact on biodiversity.	meeting. The point raised is a valid one and may be especially justifiable for installations where curfew dimming will be applied in urban areas.
	ULR should be preferred to ULOR. ULOR<1%, for all road types, would be a great improvement considering the current situation in lighting installations. Beware that ULOR<1% be the final results of the luminaire on the inclined pole in the street (angle a), not horizontally in the lab. It is called ULORa.Better than ULOR<1%, ULORa<1% should be required. ULRa should be preferred to ULORa. There is no reason to recommend any >0 ULOR values. First because this emitted light is lost, second, because even below 90° (the horizontal plane), we deal with useless light emission; say between 70° and 90°. For these light emission between 70° and 90° is, either lost in far field, or intrusive, or glaring. ULOR 0 should be mandatory, whatever the lighting class of the road. Better than ULOR 0, ULORa 0 should be mandatory, whatever the lighting class of the road. The GPP should go further than prescribing the luminaire ULOR (or ULR), it should set requirements on the luminaire distribution of emission below the horizon, aiming at the prevention of spill light and glaring. The GPP should set requirements on the two "CIE flux codes" N3 and N4, for instance: CIE flux code N4 = 100 (i.e. 100% of the total flux of the luminaire is emitted downwards) CIE flux code N3 > 99 (i.e. 99% of the downward flux is emitted below 75.5° - solid angle Ω=2π/3) The CIE flux codes are directly derived from the luminaire photometric diagram, and are a standard output from the DIALux luminaire database for instance. To be noticed: Because CIE flux codes are laboratory measurements with no inclination of support, CIE flux code N4 = 100, may replace ULOR / ULR = 0 CIE flux code N4 = 100, can not replace ULORa / ULRa = 0	What exactly is the difference between ULR and ULOR? What wording is most appropriate to ensure that tilted luminaires also meet 0% ULOR should be discussed further. We have proposed a ULOR of 0% by default unless the local situation justifies otherwise. The flux codes would need to be discussed further – perhaps it is an option in areas where obtrusive light is an issue.
	1) ULOR (or ULR) is impractical and is more permissive with high polluting lights than low-emission fixtures (because it's a ratio and not an absolute value). I would like to suggest Italian GPP approach (see attachment).	Not relevant if ULOR is set to zero.
	1% RULO should be for installed attitude of it is meaningless. For functional road lighting this is reasonable. For any luminaires with an amenity requirement, requiring significant levels of vertical illumination or low-mount road lighting for specific applications it will be too stringent.	We are proposing a 0% RULO by default unless the situation requires otherwise – i.e. amenity lighting as you mention
	The RULO is especially very false at the level of the limitation of the luminous sky glow! (American method). The greater part of the luminous sky glow is due the reflection on the road, not the direct upper emission of the luminaire. However, when a luminaire, with a too sharp photometry, is used, it is considerably less efficient in terms of luminance (situation with road calculation). So, more power will be needed to achieve the expected results required by the standards ... and the light nuisance is greater. For information Company Schreder realised a study on this subject years ago. These documents can be consulted by the workgroup. It is more realistic to work with the G-classes as defined by Standard EN 13201 series	Could a certain glare class be assumed to deliver a RULO of 0% (thinking of laboratory measurements, not field ones)? Is specifying G classes simpler to assess and verify than RULO?
Light pollution: requirements on CCT	There is no reason to rely on "For areas where light pollution is of concern..." to call for requirements on CCT. The section "Comprehensive criteria" itself, should call for requirements on CCT. Within areas where light pollution is of concern, procurers should be invited to follow the "Comprehensive criteria". Considering, the adverse effects of light pollution (references [1-7] in question #6 on Guidance),	Agreed that there could be a different split in environmental zones. The GPP criteria for CCT is

	the French laws (see comment on the whole document) that the GPP should be aimed at restoring a sound nocturnal environment, CCT requirements should be already set in Core criteria, for instance, CCT <3000K for Core criteria CCT <2500K for Comprehensive criteria to be reminded, January 2017, Montreal (1,650,000 p.) decides on warm LED lighting showing CCT <3000K, without stating being an area where light pollution if of concern. The guideline CIE 126 (1997) defines zoning (Rural, Suburban...) with no equivalence in some countries laws. In France for instance, there is only one administrative division: inside and outside built-up areas, materialized by the city entrance signs in the sense of the Highway Code.	ultimately the procurers choice. We suggest a core and comprehensive level of 3000 and 2700K respectively. However, the whole criterion should only be considered if cold lighting is an issue (i.e. in historic city centre areas, residential areas or areas of high potential ecological impact).
	This should be left to the procurer to define.	Accepted. In principle, it is up to the procurer to choose or modify any of the EU GPP criteria. The 3000K and 2700K levels are considered to be of a suitable ambition level for the EU level. Any more stringent local requirements can be used instead of course
	The procurer should define and document this in the tender. Whilst the definition should be based upon a standard methodology used within an individual Member State these can vary across the EU. Note: Any restrictions on colour temperature and CRI in the comprehensive criteria are not supported by LightingEurope.	
	Yes	
	The procurer should define and document this in the tender. Whilst the definition should be based upon a standard methodology used within an individual MS these can vary across the EU.	
	Logically the procurer had to define these criteria	
	The proposed criteria on light sources are missing the strong environmental adverse impact of CCT i.e. the intrinsic light pollution of light sources is missing (references [1-7] in guidance comments - question#6 §3.2.2). Without criteria on the light source CCT, the aims of the French "Grenelle Law" at ruling the spectral distribution of light sources (Décret 2011-831 Art. R 583-4) won't be addressed.	
Correct installation: what do you think about in-situ testing of road areas for compliance with PDI and AECI design claims?	It is costly. The GPP should focus on the most significant holistic environmental criteria: AECI, ULORa, CIE flux codes N3 and N4, CCT. Case of the classical technologies: field measurement not mandatory.With few exceptions, the rated data in manufacturers catalogues are reliable. With the photometric diagram of the luminaires, these data give access to the criteria values. The criteria values are, or can be derived from, standard outputs of calculation softwares (DIALux), sparing the costly measurement in the field. Case of the LED technology: field measurement mandatoryThe rated data in manufacturers catalogues may be reliable. But considering the many versions of a LED luminaire sample (many available wattages and optics), it is difficult to check which item was effectively settled in the street. That is, a field measurement is the only way to assess the compliance with the GPP criteria.	The points raised are valid. For this reason, all the requirements relating to post completion checks and assurances have been inserted as CPCs. In particular regarding the monitoring of energy efficiency and in-situ illuminance, this is only inserted as a comprehensive CPC (CPC5) that the procurer should decide if it is to be applied.
	Too costly and time-keeping to measure each installation. Eandis places +/- 20 000 new lighting fixture each year. Often installations of 10 to 20 lighting fixtures. This is meaning 1000 measures each year� labour at night-time, risks at nighttime, costs.	
	Measurements would have an associated cost. The road surface can vary significantly from the standard, and in this case illuminance is measured and compared to illuminance results calculated by the design software (on demand only and in case of doubt). If the illuminance is comparable, and if the reflectance factors are equal, then the luminance would be in compliance with the design as well. Producing these measurements for a small installation would be cost prohibitive, but for	Accepted. The in-situ measures have been kept as a comprehensive CPC only and

	large installations it could be a reasonable requirement. To reduce the impact of costs, it should be required for a randomly selected number of systems, instead of having this procedure to every single project (Note: This maybe further implemented by considering the verification steps as described in the "lighting system design process" project in CEN TC 169). The option of core criteria versus comprehensive criteria does allow flexibility of approach and core criteria should be kept to consist of documented proof of equipment installed. In addition, make sure that there is a proper consideration of tolerances to avoid discussion when comparing 'calculated' versus 'measured' values (e.g. Annex E and F of EN 13201-4).	allow illuminance to be measured instead of luminance. Do you have any further information about CEN TC 169?
	We consider it as a good opportunity, in the Comprehensive criteria.	
	Measurements would have an associated cost. In addition it is difficult to really measure road luminance as the road surface can vary significantly from the standard, and in this case illuminance is measured and compared to illuminance results calculated by the design software. If the illuminance is comparable then the luminance would be if all other factors were equal. Producing these measurements for a small installation would be cost prohibitive but for large installations it could be a reasonable requirement. The option of core criteria versus comprehensive criteria does allow flexibility of approach and core criteria should be kept to consist of documented proof of equipment installed	
	First of all, the exact positions of the lighting points must be chosen before starting the construction site. As the subsequent displacement of the installation is not to be taken in account (this requires in particular a cable junction - which will be weakened - and the move of a pole after the check). The control must therefore be done BEFORE and the supervision of the site make it possible to verify that the planned sites are well respected during the construction site. Second, we must distinguish two situations in road lighting: Non-Urban road lighting, where the luminaires are placed at a fixed interdistance, according to the photometric study. There, we can be constant in implantations of the lighting points. Lighting urban areas, where the positioning of the photometric study is modified according garages, trees, balconies, ... as regards the poles / according to the widths of the facade, the windows, the adjoining positions for placement on facade. Numerous elements (facades, trees, cars, inclination of the road network, etc.) also interfere in an on-site measurement. These will results in differences if compared to a photometric study that does not take it into account. Finally, if the location / result does not correspond to what was foreseen, what measures will be taken in account in the proposed specifications? Move everything? Replacing by new luminaires? The "comprehensive criteria" is potentially expensive, does not solve anything in case of problems and does not correspond to good practices of execution of a site. Only measurements on the field can deliver real values obtained by the installation on site. So random measurements is advised. The random check of limited numbers of installation can give an image of the obtained results and so validate the chosen policy of the municipalities. Also random check can reassure the municipalities that their responsibility is engaged on real obtained numbers and not on theoretical calculations.	How would this first comment potentially influence any of the proposed CPC wordings? The distinction between urban and non-urban roads is a valid one although perhaps the selection of random areas means you end up in an area that is not suitable for measuring (e.g. obstructions or background light interference). So we propose that the procurer chooses – but that the contractor has the right to complain if the area is not considered suitable.
Correct installation: how to potentially switch of presence detectors or alter dimming controls?	Users and procurers could see it with their own eyes... or very basic measurements (illuminance or luminance variation). Notice that extinction scenario, instead of dimming, is easy to check, minimise consumption, and is of maximum environmental efficiency.	It is accepted that this is an issue that has wider (i.e. network) consequences than a single project for one lighting installation. A central management system is preferable, but usually is beyond the scope of a single ITT. Controls installed in the luminaire are considered to be freer from potential unwanted
	Central management system?	
	This is very difficult as controls are generally relatively low mounted and accessible. Integrated controls within the luminaire are more secure due to greater mounting height.	
	This can be avoid as only authorised personal has access to the control system or if control is based on a central management system. External interference had to be avoid. It is essential to foresee for regular monitoring of lighting installations, but not at the level of the specific project but at an overall level of management of the lighting park. Two possibilities exist: either a recurrent monitoring or a permanent	

	detailed monitoring thanks to an Intelligent Street Lighting system. However, this should not be included in this chapter.	interference or vandalism.
Correct installation: any alternative methods to demonstrating compliance of actual installation with PDI and AECI?	no alternative needed. Use the standards and do not introduce new methods or values. Measuring electrial parameters (amps, power, voltage, power factor, �) can give you already a good estimation of PDI and AECI. These measurements can take place during da	In-situ measurement is considered important but should be used sparingly due to associated costs. Where relevant and possible, remote monitoring of luminaire performance provides the best level of monitoring and control. In any case, no alternative to PDI and AECI was considered necessary.
	Knowing it is not 100 % perfect, a comprehensive control system that communicates to a central controller allows in-depth analysis of luminaire and installation performance. However, for many installations this could be cost prohibitive.	
	The assessment of the operative performance is the best choice to check if the provided performance is coherent with the requested one.	
	A comprehensive control system that communicates to a central controller allows in-depth analysis of luminaire and installation performance. However for many installations this could be cost prohibitive	
	Why is an alternative necessary? Measurements on the grid of the electrical parameters can give a reliable estimation of the values for PDI and AECI.	
	The EEB supports the JRC's proposal for contract performance clauses (CP1+2) surrounding the commissioning and demonstration of successful operation of the system. This is critical to the 'turn-key' concept and optimisation of energy savings potential of GPP endorsed projects.	
Correct installation: provision of instructions	.For the last 3 proposals (instructions for maintaining the light flux, the control of natural lighting and the time management), it is not wise to subject them to the specific lighting installation. Network operators will not install different and specific equipment for each road, depending on the supplier. This type of management / operation must be done in a uniform manner on all the managed roads. Therefore, this should not be included in this proposal for specifications but in a more general specification relating to the management and piloting of a complete road lighting park of a city.	So how does a road lighting network evolve? Is it not worth trying out new control arrangements in individual lighting installations first before deciding if this would be advantageous for the wider network?
	Maintenance and disassembly instructions are already required according to the eco-design requirements. Therefore, there will be no additional benefit in including these here.	The overlap with Ecodesign is accepted in principle - but there is no harm in detailed what type of information is to be included in those instructions to be absolutely clear on what is required and explain how this can contribute to better maintenance and recycling at End of Life.
	The EEB supports the JRC's proposal to use the provision of instructions with the installation of new or renovated systems including: Disassembly instructions for luminaires; Instructions on how to replace light sources (where applicable), and which lamps can be used in the luminaires without decreasing the energy efficiency; Instructions on how to operate and maintain lighting controls; For daylight linked controls, instructions on how to recalibrate and adjust them. For time switches, instructions on how to adjust the switch off times, and advice on how best to do this to meet visual needs without excessive increase in energy consumption.	
Correct installation: any experience of problems with false signals from traffic sensors?	We do not (yet) use traffic sensors because false triggers are too common. The cost of sensors and a software system behind it, is too big and will not be paid back by the saved energy consumption. The more and more LED's are energy efficient, the less th	Accepted. Due to these possible problems and uncertainties, we will not specifically suggest that traffic sensors be procured as part of any dimming control system.
	Attention The configuration and monitoring of the control bodies is indeed an important challenge. For information, in Brussels, the optimal installation of presence detectors required 3 settings of each sensor.	

	And only a one year later monitoring indicated that one in five sensors was deregulated and consumption increased. It is therefore necessary to provide several adjustments and regular monitoring (by recording and analysis of consumptions / comparison with expected load curves). That said, this should not be foreseen in this specification, at the level of each specific installation, but rather in a more general specification of management and control of a complete public lighting park.	
	None known. Further to the question raised above, LightingEurope suggests to further explore the introduction of comprehensive criteria for automatic or self-commissioning systems; generally, they are available in checking if the luminaires are operating properly, according to the intended set of parameters. This can save costs.	We would welcome any specific input on this topic ahead of the 2nd AHWG meeting where it could be discussed further.
	None known	OK.
Waste recovery: Is it useful to request a bill of materials?	Some bill of materials would be valuable for both toxicity or recycling issues.	It is accepted that the list of critical raw materials is an unnecessary additional burden that the industry may not be willing to accept or one that will be fully taken advantage of by procuring authorities in the future. This is an even bigger doubt as the lifetime of LED light sources is much longer than traditional HID lamps. The main concern from a disposal perspective is Mercury. It is still to be decided if Mercury should be permitted in EU GPP road lighting (even if at low levels).
	Bill of material is usefull but not necessary.	
	The complete bill of material should not be part of GPP. The specified list of critical raw materials would be provided but it is not 100% helpful, because these materials are bound within specific electronic components in extreme low amounts. A list of critical materials is not practical. It has to be clearly defined which materials have to be listed. It must be clear: what is the purpose of the list, who uses the information? It can create very much workload (=costs) to obtain the information. If the list is for end-of-life treatment: after years or decades of operation the information will no longer be available. In 99.9 % the information is not required for recyclers as no special critical materials are in use, e.g. radioactive substances.	
	It is useful for material flow analysis to have this information, which in turn, can support better recycling and policies towards recovery of these materials. It is important to remember that criticality changes with circumstances so materials currently on the EU list may not be on the updated list. It may be better to refer to the EU list directly as well as other key materials of interest for recycling regardless of criticality.	
	A list of critical raw materials could be provided. However this would have to be preserved for 20+ years as it only has relevance at end of life	
	How will this information be used to award the contract? If one installation includes more mercury but the other more indium ... how to determine which one is best? Especially if we consider that for a technology, for one we can recover the dangerous components but that it is not possible for the other, this depending to the level of integration of the components... This criterion seems inappropriate	
	We don't know	
	A bill of materials will not show this information and a specific list will have to be produced for each product. This will be a costly burden. In particular, a bill of materials is a list of material numbers (manufacturer part numbers) of components, parts, and subassemblies used in a product. It is not a bill of chemical substances and material compositions used in the product. It must be clear: what is the purpose of the list, who uses the information and for which purpose?	
	The complete Bill of material should not be part of GPP. The specified list of critical raw materials would be provided but it is not 100% helpful, because these materials are bound within specific electronic components in extreme low amount . A bill of materials would not show this information and a specific list would have to be produced for each product. This would be an huge costly burden.	
	It could be interesting for the final dismantling.	

	A bill of materials would not show this information and a specific list would have to be produced for each product As this information is not requested by Synergrid specifications no data concerning this matter are at disposal. + At this moment no info is at diposal.	
	The major problem with recycling of luminaires is there scrap metal value. This means that luminaires may be sold outside the recycling chain to scrap metal dealers, preventing correct recycling. Whist this is not part of the tender/purchase process for new installations, for refurbishments it would be better to have a requirement on the contractor to provide documentation as to the correct disposal of old product. In conclusion, further criteria for recovery of waste going beyond WEEE are not necessary. Italian legislation Reduction and Recovery of waste 4.3.4.3. Legislative Decree 151/2005 – WEEE Adoption of Directive 2002/95/EU The Legislative Decree 151/2005 provides the transfer of competence on the management of WEEE from Municipalities, or delegates, to the producers of EEE, which take the responsibility through "Collective Systems", Sistemi Collettivi. Municipalities retain responsibility for effectively organizing the collection of WEEE at the ecological platform. For municipalities, or entities responsible for collection, pick-up and treatment is free. Legislative Decree 49/2014 – WEEE Adoption of Directive 2012/19/UE WEEE recast (art 16)– in force from 12th April 2014. Art 29 confirms the rule of the Electronic National register https://www.registroaee.it/en for Parties responsible for the financing of WEEE management systems, set up according to the provisions of Regulation 25 September 2007, n. 185, in order to ensure the collection and maintenance of information necessary to verify compliance with the requirements of the legislative decree and the proper treatment of WEEE and to allow the definition of market share. Producers are required to register by means of distance communication in the National Registry, before starting to operate in the Italian territory, as specified in Article 1 of Regulation 25 September 2007, n. 185. Ministerial Decree 121/2016, - pick-up "one against zero", uno contro zero – in force from 22nd July 2016 This regulation adopt the provisions for the simplified management of the free pick-up by distributors of very small WEEE. Ministerial Decree 140/2016 – Eco-design and production of EEE – in force from 7th August 2016 The Ministerial Decree of June 10, 2016 - n. 140, contains the regulation laying down the criteria and procedures to facilitate the eco-design and production of EEE, in accordance with the provisions of art. 5 of Legislative Decree 49/2014. The purpose of the regulation is divided into three basic actions: Encourage eco-design and production of EEE, for easy reuse and simplified process of recovery of WEEE: relating to the eco-design of EEE, manufacturers must provide a series of measures and strategies to optimize and facilitate the reuse and recycling operations through use of recyclable and biodegradable materials, reduction of the quantity and diversity of the materials, increasing the recyclability of the product and its components, Restriction of hazardous substances optimization of disassembly of the product. Producers can apply for a reduction of the eco -contribution. This reduction is calculated on the basis of the actual savings generated by the end-of- life management. They must present appropriate documentation demonstrating to have lowered the cost of management of the EEE at the end-of- life. The documentation is subject to the verification by the Supervisory Committee together with ISPRA (The Italian National Institute for Environmental Protection and Research). Promote cooperation between producers and operators of treatment, recovery and recycling plants. Art. 4 provides actions for the promotion of cooperation between producers of EEE and operators of treatment , recovery and recycling plants. This activity will be facilitated by the Coordinating Centre. Manufacturers provide free information useful for re-use and adequate treatment and conclude an agreement for the definition of guidelines for the design, production, dismantling, recovery and recycling. activities. Support the market of recycled materials also for the production of new EEE. Art. 5 reports the requirements to encourage the prevention of waste production and preparation for the reuse of EEE. They include an increase in the durability and reliability of the product, a facility in the maintenance and repair, technical development and mass product	Accepted that requirements in line with WEEE are sufficient for waste recovery. Thank you for the reference to the Italian legislation with regards to aspects such as recyclability and design for disassembly.

	design. Manufacturers aim at recommending the developing of advertising campaigns to end users.	
Waste recovery: Is it useful to specifically mention WEEE?	While these criteria are covered by the WEEE Directive, it might still be helpful to specify here as often responsibilities for collection are unclear or overlooked. Collection rates continue to be a challenge in the WEEE Directive for many member states and product categories, including lighting. Study on challenges for WEEE collection rates http://ec.europa.eu/environment/waste/weee/pdf/Final_Report_Art7_publication.pdf	Accepted. This is a very valid point and a CPC has been inserted to cover compliance with this criterion.
	The criterion is not clear in terms of waste treatment. We must distinguish 2 things: The old installation removed from the network: for this one, it is necessary to follow all the rules of waste management (and not only electrical waste, but also polluted soil!) And to produce the Ad hoc certificates. The new installation we are considering. For this one, it is more difficult to know what to do. Since it is particularly difficult to understand the possibilities of recycling / sorting, 15 years in advance. For the new installation, it seems more appropriate to make a complete Life Cycle Analysis and if possible, to list the dangerous components. Clarification is needed: does this concern only luminaires / sources / auxiliaries? Or the whole installation (with remote control panels in power supply cabinet, control units, ...)? This subject is covered by WEEE. In belgium the "RECUPEL" organisation is in charge of the problematic.	Accepted. This is a clear distinction. It is true that the contract can only realistically cover waste generated during the implementation of the works. However, collection of failed lamps can also be relevant during the warranty period.
	We also support the JRC's proposal around the reduction and recovery of waste – both in the core and comprehensive criteria (CP3).	Thank you, although it appears that a bill of materials is of limited value only.
Luminaire criteria: compatability with dimming, analogue or digital?,	The EEB supports the proposed criteria from the JRC on compatibility with dimming and other controls (section 4.4.2.1.2.2).	Accepted.
	What are the definitions of digital and analogue dimming (PWM, current dimming, voltage dimming, Hybrid systems, �)?	Accepted. The specific reference to digital and analogue has been removed.
	In this context there is no clear understanding on the meaning of "Digital" and "Analogue" dimming. Further clarification would be necessary. In general, controls and luminaires should be compatible and therefore there should be no differentiation. Again, this may have implications for compatibility with additional controls in the future. In any case, the digital controls/dimming would be preferred.	
	Controls and luminaires should be compatible and therefore there should be no differentiation. Again this may have implications for compatibility with additional controls in the future	True – so this would favour digital over analogue then?
Luminaire criteria: necessary to discriminate between lamps > and <20W?	NO. See comment #54.	Agreed that it is the procurer who should decide. Therefore dimming controls are specified by default and only in cases of e.g. low rated power, could the absence of dimming controls be potentially justified. An LCC and power curve should always be the basis for this decision
	A significant part of the market is low wattage/low flux. From energy saving point of view, also for this part of the market maximum benefits from controls should be stimulated. On the other hand, we have to be aware that dimming at lower wattages brings in absolute values lower savings and is usually less effective due to relatively higher losses in the gear. Also, the costs compared to the expected savings are higher for lower wattages. Therefore, it makes sense to discriminate for wattages <20 W. Let the market decide if the product is dimmable or non-dimmable. This is a pricing issue and should allow a customer to specify enhanced requirements for all luminaires.	
	Yes.	
	This is a pricing issue and should allow a customer to specify enhanced requirements for all luminaires. Base requirements should allow the 20W break-point	
	Attention: the 30% energy saving figure is not realistic. If it is related to the CLO, the reason will be that the dimensioning was not done correctly (30% reduction on average throughout the lifetime / exploitation time of the installation?)	The equation was a simple example that did not account for CLO dimming, just curfew

	Question: Was the installation oversized by 60% If it is linked to the dimming in off-peak hours, it is excessive: one can reduce by 30 to 50% during the HALF of the hours of operation time: this is between 15 and 25% of energy saving. As a result, the value of 20W is too dependent on the considered hypotheses. So no, we must not make a difference ... The interest of dimming will depend on the assumptions taken by the Adjudicator.	dimming. If due to dimming, 30% sound s reasonable, considering 50% dimming during 6 of the 11 hours of operation.
	Our lowest power for LED lighting fixtures is 19W (bicycle path applications). Dimming is in our system with Line Switch (or also called 'Pilot line'). 50 euro extra for dimming controls is not true for this system. It has to be still possible to provide	So what is the cost for the dimming control if it is not 50 EUR?
Luminaire criteria: is it necessary to specifically request compatibility with dimming controls?	Compatibility with installed or specified controls is easy to verify and prove and should be part of the criteria. However, forward compatibility with controls added at a future point cannot be guaranteed and in this case the controls should be compatible with the installed lighting equipment. Furthermore, it is not desirable to require a compatibility list because it never can be complete enough. Anyhow, please consider that there are still a lot of ON/OFF installations and there is still demand for those. It would make sense in general to push for light management functions fitting to the application and customer for new installations. For a municipality, a centrally controlled light management system or luminaires can be prepared for a later "upgrade."	Now that the default approach is not only to be compatible with dimming controls (TS2) but to have them installed too (TS3), compatibility becomes almost a moot point (i.e. if procurers apply TS3, they do not need to apply TS2). In the "opt-out" case, i.e. when dimming controls are not considered cost effective (i.e. low power rating) or practical (i.e. already very low lighting levels required) then TS2 should apply instead of TS3.
	It is necessary to consider independently the dimming and the control system from the other sensors because the first ones are always necessary and usually put in as a standard instead the use of the last one has to be specifically considered for each situation.	
	Compatibility with installed or specified controls is easy to verify and prove and should be part of the criteria. However forward compatibility with controls added at a future point cannot be guaranteed and in this case the controls should be compatible with the installed lighting equipment	
	These requirements – and efficiency and service life - must be incorporated into the overall design criteria of an installation.	
Luminaire efficacy and lifetime	Luminaire efficacy is not a guarantee of correct PDI and AECI values. You still can realise bad installations with high efficacy numbers for the luminaire. So luminaire efficacy is not a good solution for verification to the requirements, as it only covers performances of the luminaire, not these of the installations on the grid.	True, but you cannot achieve a good PDI with a bad luminaire efficacy.
	The meaning of By and Cz is unclear! How Does By and Cz are taken into account in Lx? For instance, how differ the total flux of a lighting installation at 60,000h labelled L70B50 @ 60,000h or labelled L70B30 @ 60,000h ? And the same with L70C80 @ 60,000h or L70C60 @ 60,000h. A classical FLLM should be derived from LxBy and LxCz and proposed by manufacturers. For instance: FLLM 0.70 @ 60,000h.	Are L70 and FLLM 0.70 not equivalent if both specified for the same time period?
	We have a few installations that we measure each year (we take 1 lighting fixture in that installation and measure it in a labo). Synergrid has also a testing area with already lighting fixtures installed in 2009.	Any relevant findings that are worth sharing?
Luminaire lifetime: how to verify 60000h claims?	It can never be assured, it have never been and if we compare to e.g. car tire, how many kilometer is OK? or the studded tire in the nordic countries, how many kilometer is OK?	It has to be based on extrapolated shorter term data.
	It is very difficult and manufacturer's reputation along with the use of quality assured components is required. An example would be because all data is given for 25 °C ambient temperature and constant current. In real life, if the ambient temperature is lower and the luminaires are dimmed, the lumen depreciation will be less. It can only be checked by measuring at the same temperature and dimming level (attention a lot of the luminaires have an automatic CLO function)	Another argument in favour of dimming then. Lab data should be based on a

	right after the installation and again after some 10,000 hours.	no dimming scenario if actual dimming to be used in practice is not known.
	It is very difficult and manufacturers reputation along with the use of quality assured components is required	
	The only way to do this is to make a complete photometric measurement of the luminaire (a measurement of illumination on site is not sufficient, the aging / the level of dirt is not of the same level in each direction). But this is unpayable. And in addition it requires removing the luminaire for several days of the network. It is better to use representative sampling across a network? Synergrid has measurements results of following up of photometrical and electrical characteristics of luminaires placed on the grid. Abnormal behaviour can be detected and further investigation can be ordered.	Interesting. And have you found that the manufacturers claims are normally valid? Even when accounting for LLMF and LMF?
Luminaire efficacy: should different requirements be set for different types of luminaires?	Not appropriate. Let us make the GPP as simple as possible.	There is a clear split in opinion here. Some stakeholders asking for no differentiation and others yes. The main need for differentiation appears to be based on the function of the lighting. Specifically this means that a lower efficacy should apply for amenity lighting and, with Synergrid, this can be considered as: "built in ground lamps and spotlights, illuminated markers (bollards) or lighting columns less than 3m high or appliances used exclusively for artistic or architectural purposes.
	No. All luminaires for road lighting should fullfill the asked criteria.	
	No	
	Yes, we need to distinguish between road lighting and public lighting (decorative designed lighting in some sensitive areas) .	
	Yes. Luminaires have many function from pure performance for road lighting through amenity to way guidance or solutions for specialist situations. There is no one-size-fits-all efficacy, as the specific requirements will define the limitations of the solution.	
	Yes. Luminaires have many function from pure performance for road lighting through amenity to way guidance or solutions for specialist situations. There is no one-size-fits-all efficacy as the specific requirements will define the limitations of the solution.	
	Yes ... Between a functional luminaire, an urban luminaire or a stylist luminaire, as these have not the same level of efficiency. For Synergrid all luminaires as defined in the scope of Synergrid technical specification C4/11-3 must be in conformity with the requirements.	
Luminaire efficacy: is a criterion needed when there are already criteria for PDI and AECI?	These criteria should not be considered specifically. It is only necessary to use the criteria relating to the complete installation, even it is suggested to be a little less constraining considering the imposition to use the existing positioning of the existing pole. Working on the basis of efficiency and lifetime of fixture is a truncated way of thinking! It is necessary to take into account the suitability of the lumen package and the distribution of the light flux with respect to the space to be illuminated. Failing this, it will sometimes be necessary to install more luminaries and electrical power for a luminaire "more efficient" in absolute but less suitable for the considered space to light.	A clearly negative response to the need to include luminaire efficacy as a standalone criterion. It is proposed to be kept in TR 2.0 simply because it is the key metric to knowing how appropriate is the ambition level set in EU GPP criteria relating to energy efficiency. The PDI and AECI calculations have now been broken down into different parts to make the calculations for transparent. It is clear that the main source
	It is not straightforward that the GPP should prescribe the lighting installation efficacy at the luminaire scale: that way, environment friendly HPS low wattage installation or warm LEDs, won't comply with the GPP.The holistic AECI, that characterizes the installation, is a better criterion of the global impact of the whole lighting installation. The GPP should let the tenderer design the highest possible flux, or illuminance level, complying with a given AECI criterion. On the other hand, ULOR, "CIE flux code" N3 and CCT, are relevant criteria at the luminaire scale. They could be alternative or complementary criteria to the lumen efficacy, in an environmental oriented GPP.	
	The efficacy requirement is not needed at the luminaire scale for it is already included at the installation scale (AECI).	
	lm/W -> which lumen (LEDlumen, luminaire lumen, light source lumen, �), which W (light source, luminaire, installation/number of lighting fixtures). Why defining luminaire efficiency? With PDI and AECI we cover the efficiency of the	

	whole installation. Ev	of variation in terms of future improvement will be the luminaire efficacy. The reference luminaire efficacy is needed to calculate the reference PDI and AECI. While it is emphasised that luminaire efficacy should not substitute PDI or AECI (except perhaps in like for like relamping scenarios), there is no doubt this matter will need to be discussed in more detail in the 2nd AHWG meeting.
	No. No need to have luminaire efficiency. Use PDI and AECI for installation efficiency!	
	indeed, use PDI and AECI and NOT luminaire efficiency. Otherwise we have to define how to calculate luminaire efficiency and a good luminaire efficiency is not a garantuee for a good installation energy efficiency.	
	Everything which has to do with lifetime including LED useful lifetime is a matter from those who are designing the maintenance. So the question the is very relanvant. The problem has been, in the past, that those who was responsible for the lighting didn't have knowledge enough, so the suppliers had to made the rules e.g. set MF to 0.8, without knowledge how often the luminare is cleaned. It is both a design criteria and a lighting equipment.	
	They are intrinsically required, although they will be used in the design to define maintained lighting levels.	
	They are intrinsically required although they will be used in the design to define maintained lighting levels	
	GPP criteria shall not be based on luminaire efficiency (lm/W) as this is a poor metric. GPP criteria shall be based on PDI and AECI (kWh/km/year) requirements for a LED based product in its application considering lighting design, installation, commissioning, and maintenance of the lighting system. Consider to specify PDI and AECI requirements for both 'core' and 'comprehensive' criteria.	
	Yes depending upon luminaire type, although efficacy is a poor metric and should only be used as a quick check before more in-depth analysis using AECI	
	No ... Efficiency is really not enough. The lumen package and the type of photometry have to be adapted to the place - space to light... otherwise we risk installing "the most efficient luminaire" but "the most energy-consuming global installation". Luminaire efficacy is not a guarantee of correct PDI and AECI values. You still can realise bad installations with high efficacy numbers for the luminaire. So luminaire efficacy is not a good solution for verification to the requirements, as it only covers performances of the luminaire, not these of the installations on the grid.	
Luminaire lifetime: what standards to use?	we use IEC 62722-1	We have now made specific reference to both IEC 62722 and IEC 63013 in the product lifetime standard. It is understood that now IEC 63013 is available, it is not necessary to refer specifically to LM-80. Is that correct?
	It is according to IEC 62722-2-1 because it will be according to the long test in IEC 63013 which is according to ANSI/IEC.	
	LM-80 is a regional standard under the control of the IES. IEC 62722-1 should be used as this standard is international and more likely to receive a wide consensus, and via CENELEC is adopted as a European standard.	
	Logical would be to use IEC standards as these documents are transposed by CEN to EN standards	
	IEC 63013 will be a standard for LED packages – Long-Term Luminous Flux Maintenance Projection. Meeting PRESCO in November to make a FDIS (Final draft).	
	None known. Most LED manufacturers use internal modelling based upon historical data as verification of the model. Note: Verification of lifetime claims is still under discussion in IEC. Current view is to see if the reliability data of critical components used in the LED based luminaire in combination with the statistics used for the internal modelling can be independently verified.	
	None known. Most LED manufacturers use internal modelling based upon historical data as verification of the model.	
	Standards (of industry rules) are available.	
Luminaire testing: are there sufficient certified laboratories available and are self-declarations appropriate in	In Belgium we got enough possiblity's for independed or accredited labs.	It is agreed then that the specification of ISO 17025 laboratories would not be a problem but that it is important to not require that the laboratory be "independent", because there are many
	Such laboratories are available, but there is a cost implication. In addition, extended testing of lifetime is not feasible within product component timescales. A product that has been tested for an extended time period will have to change due to improvements in components, such as LED modules. Until the speed of development of LED technology slows, this will be a continual problem. As a consequence, if measured by an internal certified lab, it would be the best compromise.	
	There are enough EN ISO 17025 measurements institutes in EU. Even Asian labs had this accreditation level.	

certain cases?	if requirements for lighting fixtures, checked by independed or accredited labs	manufacturers that have their own certified laboratories and it would place additional cost and time constraints on product development and time to market for the rapidly evolving LED lighting products. It can also be supposed that there may be some confidentiality issues with early stage testing as well.
	Self-declaration is adequate if the internal laboratory is accredited to a recognised European accreditation body. Otherwise, verification or certification should be requested.	
	It is necessary to have a certification, according to the Directive 2014/24/EU, art. 44.	
	Self-declaration is adequate if the internal laboratory is accredited to a recognised European accreditation body. Otherwise verification or certification should be requested	
	It is essential to have the photometry's checked by independent or accredited laboratories ... But this cannot be done systematically (costs). In any case, experience shows that what is measured in an accredited laboratory is sometimes very different from what the equipment supplier announces. Synergrid specification handle the conformity by introducing the concept "family of luminaires". So the applicant had to deliver test reports for luminaires random chosen in the family of proposed luminaires. If the reports confirms the conformity to the announced values all the family of luminaires is declared in conformity. The test reports must be published by measurements institutes: With an official recognition or agreement (ex. CB scheme reports, ENEC certificate ….) Recognised by Synergrid With a EN ISO 17025 accreditation for the scope of the measurements Performance characteristics must be covered by a report published under a EN ISO 17025 accreditation.	
	I would like possibility to have a list over proved luminaires tested in accredited labs but is it legel? EU gave Finland a warning when the did that, they mean that the market i responsible for the guarantee of the performance.	This seems unusual. Do you mean something similar to what is done in US with the DOW lighting facts database? Only in Europe? Please provide more details so the issue can be looked into in more detail.
Luminaire lifetime: LxCz values – is lack of an industry standard a barrier to setting EU GPP criteria on this?	yes	For TR 2.0, no proposal is made for LxCz for the reasons stated. A warranty coupled with requirements for control gear failure rates is considered as more appropriate. Perhaps this will change with the publication of IEC 62681?
	IEC/TS 62861 Ed. 1: Guide to principal component reliability testing for LED light sources and LED luminaires, Draft approved for publication and will be published as a technical specification by 2017-03-31.	
	Yes, it is true. As the C value is difficult to measure and is predicted with an amount of statistical uncertainty, it is not always quoted.	
	Yes. As the C value is difficult to measure and is predicted with an amount of statistical uncertainty it is not always quoted. A main driver for luminaire operation is the failure rate of the control gear which is generally given by control gear manufacturers and could be a more relevant measure	
	Yes this could pose restrictions	
LED lifetime: are ambition levels suitable?	We use L80B10 on 60 000 hours. Industry tells us that this is common use to ask these values.	L80B10 at 60000 hours has now been inserted for the core level.
	They are too lenient, every percent under L100B10 is oversize the design and is waste of energy, there are BAT with L100B10@100 000h.	The energy is only wasted if no CLO dimming is included but point accepted. What is the market availability for L100B10

		LED luminaires?
	To design the road lighting you need "useful lifetime" (LxBy@zh) to know how much you must oversize the luminous flux output and we can see how fast the LED performance are increasing. To have luminaire physically checked on useful lifetime is not relevant when the development goes so fast.	The key here is how much is z?
	Probably too low, we may put in these numbers just before release of the new GPP	Agreed that the numbers should be rechecked prior to final publication.
	LxBy and Cz values are relevant for the application. In harsh environments or environments with large temperature variations reduced lifetime may be expected. These values (L92B50 @ 16,000 hours) would tend to remove products with L70B50 @ 50,000 hours and force L80B50 @ 50,000 hours as default. Therefore, the difference between core and comprehensive criteria may not exist in practice. Please note that L92C08 and L80C10 as reported in table TS1 are not possible because in case of catastrophic failure the L value would be 0. Note: there is a running discussion in LightingEurope to introduce lumen depreciation (LxBy) at e.g. 100K h, in this case it could be specified with a different L value to meet for the 'core' and 'comprehensive' criteria.	No LxCz values are proposed (warranty and control gear failure rate specified instead) but the point is accepted. The 50000 hour values have been extended to 60000 hours to increase the ambition level. We welcome any feedback about plans to introduce a 100000h value.
	Avoid lifetime related requirements because a) there is currently no practical test method available laid down in an international standard to determine over time performance; and b) there is no relation between performance at 3K/6K/16K hours and performance towards end-of-life so performance at 3K/6K/16K hours will not give any confidence in the product over time.	The IEC 63013 standard has just been published in early 2017. This should consider how to extrapolate short term data.
	An expected end of life value will be required but test data to 6,000 hours should be available	
	The metrics LxBy and LxCz are suitable to verify the performances but the proposed values are too lenient. We propose L80B10 and L80C08 at 50.000 h.	L80B10 at 60000 hours has now been introduced at core level and L90B10 for comprehensive.
	We consider a good option checking the lighting efficacy at longer period (i.e.: 50.000 h or 60.000 h).	
	Yes.	OK, but we have not gone with LxCz in the TR 2.0 proposal.
	Absolute values should not be defined. The road lighting installation is composed of: An electrical network (cable) Fixing supports (typically poles) Luminaires Each network operator must determine the lifetime of each of these elements (depending on its environment) optimally so that the renewal periods for each of these elements is compatible. Example: In cities, cables are regularly submitted to degradation. We can chose for a lifetime of the cables of 30 years and to choose the same lifetime for the dimensioning of the poles. In this case, we will chose for example for a lifetime of the luminaire of 15 years. This means that 15 years after the initial installation, we will only replace the luminaires and 30 years later, the entire installation. Outside an urban area, it can be considered that the cables are placed for 40 or 50 years. Depending on this, the manager will determine the sizing of the poles for a specific lifetime, for example 40 years (such as for the cables). And he can decide whether he chooses for luminaires of 12 years of lifetime (in which case he will make 2 intermediate replacements)	Interesting and practical points. However, one of the aims of EU GPP criteria is to encourage the use of long life and durable lighting products – this is also crucial for any LCC based decisions. Procurers across Europe must be made aware of what is a good level and what is not. At the level of the individual lighting installation, or even an

	or 20 years ... The price of the luminaire will depend of the lifetime expectancy wished by the manager. It should not be considered that the road lighting installation is limited to luminaires and control units! It is therefore better to define equivalent levels of light fluw maintenance for several lifetimes. Actually Synergrid specifications required L80B10 at 60000 h.	individual network, any requirements for shorter life anc cheaper products must be explained to the relevant procuring authority prior to the ITT being published.
Luminaire lifetime: Is it more suitable to ask for a warranty instead of LxBy and LxCz requirments?	Yes, for lifetime is the argument (with efficacy) which is put forward to justify the interest and the price of the LED sources. The lifetime must be guaranteed to ensure the economic calculations of the Life Cycle Costing. The warranty should be expressed as a FLLM value after some operating hours; as it is the case with classical technology.	Accepted in principle.
	We ask a combination. We ask 32 000 hours of warranty, which means 8 years (each year, a lighting fixture is 4000 hours swithed on.	Accepted, we have LxBy and a warranty rather than LxCz.
	I understand the insecurity from both sides but we have to be realistic and write requirements which is acceptable. I mean that we can't demand the manufacturer to guarantee e.g. L90B10@100 000h, BUT we can set requirements that the LED Luminaire passed the test according to the standard IEC or EN etc.	Accepted. Although this may be subject to further discussion.
	No, GPP should not include a warranty requirement. Additional warranty time and conditions depends on the risk the tender wants to take and therefore may change case by case. Note: Reputable manufacturers will not walk away in case of quality issues.	A minimum requirement and terms of warranty are suggested in the EU GPP criteria. The option for an extended warranty is also included, but, because this may entail an additional cost, it is included as an award criterion. Ultimately it will be up to the procurer to decide what terms they want and for what minimum time. Then it will be up to the market to respond.
	Yes.	
	A warranty is generally supplied as standard. However the period and terms of warranty may vary considerably and the manufacturer reputation with regard to honouring warranties can be as important. The problem with overly extended warranties is that the operating conditions are very unpredictable which could make an extended period warranty commercially unviable for a manufacturer without an increase in purchase price	
	The Adjudicator must in fact define a guarantee. But it is up to him to choose it according to his way of managing his lighting park (to see if he is able to follow the number of operating hours before default, to see whether it includes the costs of workhours for the intervention ...). Overall, the cost of the luminaire depends on the duration time of the warranty. The adjudicator must be given the opportunity to determine its strategy.	
Luminaire lifetime: are Ingress Protection ratings proposed adequate? Should EN 60529 be mentioned explicitly?	We need MF to know the maintained value. So we need IP to get LMF (Luminaire Maintenance Factor). So we definitely need some criterion here.	Mixed opinions were expressed about the IP rating. Even if it is slightly over-specified, it seems practical to set a minimum ambition level for IP ratings of IP 65 as this will also influence the maintenance factor, which in turn will influence the need to overdesign to account for dirt accumulation. The alternative is referring to a standard which the procurer may not be aware of or understand correctly.
	The EEB supports the JRC's proposal to have an ingress protection (IP) rating of 65 for all road classes (section 4.4.2.1.4.1). This will help to ensure the lifetime of the luminaire.	
	no, IP65 as a minimum, some other applications (e.g.in-ground luminaires) can have stronger requirements	
	No, the required IP rating is not optional and having a higher than required IP rating does not add value or increase sustainability.	
	No, the minimum level IP65 is standard in Belgium. For none road lighting applications hiher levels can be imposed.	
	IP65 is a minimum for all road classes	
	Yes. The use of minimum IP65 will help to improve the MF for the design, so contributes to energy saving. There is no reason to make an IP distinction between different applications.	
	It would be better to have IP66 for road classes ME1 to ME6 and MEW1 to MEW6 and IP55 for road classes CE0 to CE5,	

	S1 to S6, ES, EV and A. For road classes ME1 to ME6 and MEW1 to MEW6 IP66 is the best performance level, so a Comprehensive criteria is not so useful. For road classes CE0 to CE5, S1 to S6, ES, EV and A could be useful to define also a Comprehensive criteria for values > IP55.	Nonetheless, some distinction based on road class has been made. IP 66, IP 65 or IP 55 are specified depending on the road class in question.
	No, this is not logical. The IP class is related to the conditions in application and for some applications IP65 is an over-specification adding unnecessary cost and complexity. The range of IP numbers exist to reflect this variety in application requirements and should be applied correctly	
	For Belgium the national standard NBN _18-004 imposes min IP65 for all the road classes	
	Yes.	
	All requirements should have a basis in standards; test according to IEC 60598-1 clause 9 (Note: The tests for the ingress of dust, solid objects and moisture specified in this standard are not all identical to the tests in IEC 60529 because of the technical characteristics of luminaires. An explanation of the IP numbering system is given in Annex J.)	
	Yes, all requirements should have a basis in standards	
	Refrence to the standards is an obligation. EN 60529 EN 60 598-1 EN 60 598-2-3	
Luminaire lifetime: Warranty – is a 4-8 year period appropriate to ask?	Eandis asks 8 years warranty for electronic parts and 12 years for mechanical parts (e.g. corrosion) and we succeed to have is. So 4 years is really low�	The minimum warranty has been increased to 8 years.
	GPP should not include a warranty requirement. Additional warranty time and conditions depends on the risk the tender wants to take and therefore may change case by case. A 3- 5 years warranty is common and in principle it could be extended to 10 years, although currently this is a commercial decision. The main consideration is the value of the warranty: will it be honoured? Extending the time-span to 10 years may not add any benefit if the manufacturer is less reputable, but could add to the costs of a reputable manufacturer who will honour the warranty. A longer warranty period than 5 years could 'cosmetically' favour less reputable suppliers. Reputable suppliers will be around anyhow to take care of serious complaints (even outside warranty period) in good partnership with the customer. An additional difficulty would be replacement parts, as those components likely to fail are also those who may no longer be produced (LED module plus driver). Newer versions may not have the same footprint or be optically or electrically comparable. This would necessitate replacement with an equivalent product or similar look. TS3 a) and c) need consideration and better wording to define the initially specified light output. Is this the lumen output at start of life or end of life, and if at start of life is it only valid at switch-on?	These are all valid points. The warranty text has been significantly reworded. It is made clear that any extended warranty will only be paid for at the beginning of the extended period – not at the initial award of the contract. This should
	According to some producers, the warranty period can be extended to 10 years or more. It would be fine to have a warranty period of 10 years in the Core criteria and a warranty period of 15 years in the Comprehensive criteria.	We have proposed 8 and 10 years with the option of extended periods.
	5 years is used for medical imaging equipment and warranty award points and specifications have been used for electric vehicles and furniture.	True, warranties can be used in GPP – but cannot compare periods for different products.
	A 4 – 8 year warranty is common and in principle it could be extended to 10 years although currently this is a commercial decision. The main consideration is the value of the warranty, will it be honoured. Extending the time-span to 10 years may not add any benefit if the manufacturer is less reputable but could add to the costs of a reputable manufacturer who will	We have proposed 8 and 10 years with the option of extended periods in award

	honour the warranty. An additional difficulty would be replacement parts as those components likely to fail are also those who may no longer be produced (LED module plus driver). Newer versions may not have the same footprint or be optically or electrically comparable. This would necessitate replacement with an equivalent product or similar look.TS3 a) and C) need consideration and better wording to define the initially specified light output. Is this the lumen output at start of life or end of life and if at start of life it is only valid at switch-on	criteria. The future availability of replacement parts is a serious issue and even if identical parts are not available, some compatible equivalent must be provided by the contractor.
	A warranty period must be defined. But it must be determined by the manager according to its strategy and correspond to the lifespan of the installation. This said, the manager is not going to have specific contracts for the light sources sources for each renewal project. This must be globalized in a contract for the complete management of the park / purchase of light sources. In addition, the document concerns only light sources. But the drivers, Surge Protection Device and other electrical components are also important.	This is an important consideration – so how do warranties work when a new or renovated lighting installation is brought online within a wider network?
Luminaire lifetime: General remarks about product lifetime extension.	The EEB supports the proposed criteria from the JRC on warranty, service agreements and spare parts (section 4.4.2.1.3.2).The EEB firmly agrees that it is important that luminaires are easy to maintain and repair, and not necessarily only with proprietary equipment which can be expensive, but normal tools including those listed in the criteria.	Accepted.
	It is necessary to define the term 'control system' as used in the TS3 – product lifetime extensions core and comprehensive criteria. Do you mean a control of luminaire output by a built-in sensor or by a city control centre, or maybe it also covers a data connection?	Fair point. In the criteria proposed in TR 2.0, the term "control system" seems not to be used. In cases where controls are specifically mentioned (e.g. TS3 dimming and AC3 metering) it should be clear what controls are referring to.
Luminaire lifetime: reparability and availability of spare parts	Yes. Design for reparability is increasingly common in mid to high tier products. However this tends to add a small amount of cost and products aimed at the value end of the market will tend to be sealed for life to reduce costs. In addition, the term 'easily accessible and replaceable' must be defined in the GPP guidelines possibly by making reference to standards. The possibility to use a screwdriver does not guarantee that a luminaire can be serviced in a cost effective manner. Several levels of reparability/serviceability could be defined and linked to GPP. Next to warranty, spare parts and reparability, also the possibility to upgrade a luminaire (e.g. either through better performing components or with the addition of new functionalities) should be considered. Upgrades can improve energy efficiency (e.g. new more efficient LED module) or ensure that luminaires have a longer useful lifetime hence reducing waste (e.g. customers can upgrade to connected lighting and do not need to replace luminaires). The mechanical prerequisites for upgrading are very similar to those to repair a luminaire in many instances (possibility to access and replace components). In general, LightingEurope supports the upgradability of street lighting for future-proof operation. This would allow for an elegant and cost effective way to upgrade the Light Management System or the luminaire with a new functionality.	Accepted. Are there any specific ways to address "upgradability " in GPP criteria?
	Yes. The manufacturer could guarantee that the LED module and the ballast are designed to be independently substituted.	Accepted in principle.
	Design for reparability is increasingly common in mid to high tier products. However this tends to add a small amount of cost and products aimed at the value end of the market will tend to be sealed for life to reduce costs. In addition some specific product types may be sealed for life to help prolong their function in harsh environments.	Reparability is an extremely important concept in the Commission efforts to encourage the shift towards a circular economy. Even if there is a cost premium,
	It is up to the Adjudicator to define the technical criteria ensuring the possible replacement of the defective light sources or electrical auxiliaries. (And to determine if this replacement must be able to be done on site, on the ground, at the store, at the manufacturer ...) +	

	Yes design for reparability is possible. It's important for reducing the maintenance costs. Synergrid in his specification C4/11-3, for LED luminaires, catalogues the luminaires in 4 types. These types are defined in function of the possibilities to effectuate maintenance. Luminaire type 1 Luminaire for which the replacement of the LED module and auxiliaries can be performed on site (= at luminaire mounting height). Luminaire type 2 Luminaires for which the replacement of the auxiliary can be performed on site (=at luminaire mounting height). Luminaire type 3 Luminaire for which the replacement of the LED module and the auxiliary requires to remove the luminaire from his support. The repair of it may be performed by a technician or in a truck, or in the workshop without any specific equipment, under normal working conditions. (such as anti-electrostatic equipment) Luminaire type 4 (fit and forget) Luminaire that cannot be repaired and that will be permanently replaced in case of failure. A translated version of the specification is joined in annex.	it is recommended that a minimum degree of reparability is guaranteed. Therefore it is proposed to align with the "Luminaire type 1" defined in this comment.
	Some luminaires are 'sealed for life', so no repair is possible. Synergrid has a definition of 4 types of luminaires depending on where and how repairing is possible.	Such luminaires should not be promoted in EU GPP criteria.
	We think that for some spare parts this is not possible due to the still fast changing technology.	True. We now make it clear that we do not require identical spare parts but simply repairs and/or spare parts that result in an equivalent or better functional performance.
	Yes. In addition, spare parts should be accessible and replaceable by a skilled person. Moreover, spare parts should be identifiable and available. It is also necessary to define which spare parts should be considered (e.g. LED module, driver or more?). It is also not always necessary to bring back the same component, there can be a better one over time, or if it does not fit in the old version of the luminaire it can be a full luminaire.	
	As mentioned in reply 1 above it is not feasible to hold 10 years or spare parts of an obsolete component such as a LED module. This would entail writing off quantities of stock after 10 years which is neither financially nor environmentally supportable. spare parts will be held for as long as is feasible but until the development cycles of LED technology begin to plateau there can be no guarantee of availability of spares 10 years after final production of a product	
	Delivering of spare parts is crucial for road lighting. Traffic accidents can happen during the life time of an installation. So spare parts had to be at disposal of the grid operators. Manufacturers can promise it (and availability must be equal to the lifetime of the facility). But in fact, even if they commit themselves, it is often not respected (stop of production of certain ranges of luminaires, bankruptcy) Above all, Foresee of heavy penalties in case of unavailability of spare parts Foresee specific clauses in the event of replacement of a defective part by a "similar" but not identical part (correct thermal operation of the luminaire, lumen package and comparable photometric distribution, new warranty on the entire luminaire or only on the replaced component?) On the other hand, it is illusory to believe that a manager will have all the spare parts for all the LED models installed in stock. The defects will appear on site and will take longer resolution time with the LEDs than with HID, where the components were limited in number and interchangeable / compatible from one brand to another.	
	Yes. It is very important to consider the possibility to substitute the ballast independently from the LED module and to have a compatible device.	Accepted in principle.
	This is common for other product groups, e.g. healthcare EEE.	OK

Light sources: factors that only white LED can comply with? i.e. efficacy	Only white LEDs comply with these levels. These GPP criteria are promoting the most environmental adverse light source (references [1-7] in guidance comments - question#6 §3.2.2). To be reminded, January 2017, Montreal decides on warm LED lighting: http://www.rcinet.ca/en/2017/01/19/montreal-decides-on-warmer-led-lighting/ As previously argued, there should not be criteria on the light source efficacy.	Accepted. Only criteria relating to luminaire efficacy has been maintained in TR 2.0. But is this acceptable? Will relamping scenarios become the norm again?
	Low Pressure Sodium light sources meet high efficacy levels, and should not be omitted from recommendations.	
	No. The core criteria discuss light source efficacy measurements whilst the comprehensive criteria discuss luminaire efficacy measurements in the verification section. The verification should be for the luminaire, as replacing an efficient non-LED light source with a LED light source that does not function correctly (optically or electrically) within the specific luminaire is not logical.	
	These criteria should be explicitly stated for LED light sources. There is a large stock of non-LED luminaires in use throughout Europe and it should still be possible for these to be relamped using lamp technologies that comply with eco-design requirements	Agreed in principle. I presume that a market will be found for unwanted HID bulbs but it does not make sense to use them when superior products are available.
	Same remarks as previously, use of PDI and AECI are the best criteria for evaluation of an installation. A good result in lm/W for the light source will not guarantee a performant installation. + It is important to define if the W are those of the LED source or the LED module (driver consumption included or not?). In addition, one must be careful to consider the lm/W of the LED module integrated in the luminaire (and so taking into account the thermal behaviour). The purchase of sources will not be done specifically for a project. So the criterion seems irrelevant. In the context of more comprehensive procurement of light sources, TCO is generally taken into account, which includes - beyond minimal efficiency - lifetime, mortality curve, curative and preventive replacement costs of contractors and cost of the lamp. Moreover, it is necessary to define mechanical characteristics (dimensions, resistance to torsion) and electrical characteristics (lamp holder, ...)	Accepted, only efficacy data at the level of the luminaire is now included.
	The mentionned lm/W packages are on LED level, not on luminiare level!	Accepted – although this will also have an impact on LED luminaire costs no doubt.
	It must be mentioned in the report that the figure 4-1 concerns led packages and not values for luminaires efficacy.	
	HID: lower power, less efficacy. With LED's we see the inverse: More power in a luminaire, less efficacy, due to the needed heat dissipation.	Accepted – but LEDs still seem considerably better at higher power ratings.
	We still have tenders for HID lamps, to replace these in HID installations. HID lamps never get these light source efficacy. This efficacy is for new installations.	And has an LCC ever been done to consider the cost of relamping against renovation with LEDs?
	These criteria should be explicitly stated for LED light sources. There is a large stock of non-LED luminaires in use throughout Europe and it should still be possible for these to be relamped using lamp technologies that comply with eco-	Rejected. LED efficacies are rapidly improving every year

	design requirements. Traditional light sources are covered by European regulations and will be phased out naturally. Note: The proposed efficacy in TS1 of 140 lm/W (core) or 160 lm/W (comprehensive) is hard to meet with any of today's technologies.	now. The GPP criteria will not apply to all contracts in all places in reality, so the market will find a way to sell the existing stock one way or another – possibly even beyond the EU.
	The criteria can only be applied for LED technology. It is impossible to replace the existing HID luminaires which life time is normally foreseen at 25 years. So installation for example put in to service 5 years ago will need replacement of the HID lamps during their life time. As is expected that no further development will be realised by the manufacturers for HID technology the performance of HID lamps will not be ameliorated.	It is not only lifetime but energy efficiency that is important. A neutral opinion can be found by solely considering LCC when deciding if renovation is worthwhile or not.
Light source lifetime: LxBy and LxCz appropriate?	Before answering to this question, it should be clarified what "light source" means in this context. There is no clear distinction between a source alone, the source as build-in luminaire, the source are a retrofit to HID, the source as an upgrade module of already module installed, etc...	The intention is to refer to the lamp and specifically to the light source(s) in the lamp.
	We ask L80B10 on 100 000 hours. Industry declares that this is no problem.	It is agreed to definitely propose LxBy criteria although there is some hesitation about proposing LxCz requirements – with which there is a greater deal of statistical uncertainty and which is perhaps better covered directly by a warranty. The proposed LxBy values have been modified in TR 2.0, now being more ambitious than those in TR 1.0. However, it is possible that the comprehensive requirement could be more ambitious still (e.g. L80B10 at 100000 hours). Now that the European approach to extrapolating test data seems to have been published (IEC 63013), it makes sense to be discussed further in the 2nd AHWG meeting.
	A light source maintenance factor derived from LxBy and/or LxCz should be preferred. See preliminary remarks on §4.4.2.1.1 "Efficacy and lifetime"	
	We propose L80B10 and L80C08 at 50.000 h.	
	LxBy and Cz values are relevant for the application. In harsh environments or environments with large temperature variations reduced lifetime may be expected. These values (L92B50 @ 16,000 hours) would tend to remove products with L70B50 @ 50,000 hours and force L80B50 @ 50,000 hours as default. Therefore the difference between core and comprehensive criteria may not exist in practice	
	An expected end of life value will be required but test data to 6,000 hours should be available	
	Ideally yes although 16,000 hours is not a short time in testing terms and will have implications on cost and time to market. 6,000 hours is the standard test time, 10,000 hours is increasingly common	
	whilst LxBy and Cz are not perfect it would be unwise to further confuse the market with alternative metrics.	
	None known. Most LED manufacturers use internal modelling based upon historical data as verification of the model. Note: Verification of lifetime claims is still under discussion in IEC. Current view is to see if the reliability data of critical components used in the LED light sources in combination with the statistics used for the internal modelling can be independently verified.	
	Avoid lifetime related requirements because a) there is currently no practical test method available laid down in an international standard to determine over time performance; and b) there is no relation between performance at 3K/6K/16K hours and performance towards end-of-life, so performance at 3K/6K/16K hours will not give any confidence in the product over time.	
	There is currently no practical test method available laid down in an international standard to determine over time performance. Measurement and calculation methods from reputable companies are fairly robust. The difficulty comes in the declaration of the life time claims where it is hard to compare claims for different L and B values at different life times. A standard declaration time is required.	

	We consider a good option checking the lighting efficacy at longer period (i.e.: 50.000 h or 60.000 h).	
Light source: efficacy requirements needed when PDI and AECI also to be calculated in design?	Why asking light source efficacy. Use PDI and AECI for good final installations	Light source efficacy is no longer proposed as a criterion. Now the main criteria are: Luminaire efficacy PDI and AECI. These three measures should be able to capture the most important aspects of energy efficiency. The luminaire efficacy is important not only as a standalone criterion but also for calculating the reference PDI and the reference AECI.
	first a good definition of 'light source' and the needed power en flux of this light source. More easy to use PDI and AECI for the installation. Bad lm/W luminaires will fall out when restrictions to PDI and AECI are severe enough.	
	Tiers should be in PDI and AECI	
	part of the design criteria	
	They are intrinsically required, although they will be used in the design to define maintained lighting levels.	
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	Absolutely, these requirements are not specifically needed. The light source criteria will be advantageously covered by holistic installation design criteria. As previously argued, there should not be criteria on the light source efficacy.	
	As previously argued, there should not be criteria on the light source efficacy.	
	Same remarks as previously, use of PDI and AECI are the best criteria for evaluation of an installation. A good result in lm/W for the light source will not guarantee a performant installation.	
Light source lifetime: availability of suitable standard methods?	None known. Most LED manufacturers use internal modelling based upon historical data as verification of the model	The availability of suitable standard methods should not be a major concern now that the criterion has been removed. However, given than the IEC 63013 standard for extrapolating LxBy data has been published, this discussion should be brought up again at the 2nd AHWG meeting.
	Measurement methods from reputable companies are fairly robust. The difficulty comes in the declaration of the life time claims where it is hard to compare claims for different L and B values at different life times. A standard declaration time, for example L80B50 at xx hours, is required	
	No and whilst LxBy and Cz are not perfect it would be unwise to further confuse the market with alternative metrics	
	IES document ANSI/IES LM-80-15 IES aproved Method : measering luminous flux and color maintenance of LED packages, Arrys and modules. IES document IES LM-28-114 Projectiing Long-Term Luminous flux maintenance of LED lamps and luminaires IES Document IES LM-84-14 Measuring luminous flux and color maintenace of LED lamps, light engines and luminaires	
	Not at this moment	
Light source lifetime: availability of suitable independent and accredited laboratories?	Such laboratories are available, but there is a cost implication. In addition, extended testing of lifetime is not feasible within product component timescales. A product that has been tested for an extended time period will have to change due to improvements in components such as LED modules. Until the speed of development of LED technology slows, this will be a continual problem.	Valid point, but due to the long life claims for LED, there needs to be some testing to back this up.
	Experience prove to Synergrid that self-declaration is not acceptable. There are enough EN ISO 17025 measurements institutes in EU. Even Asian labs had this accreditation level. It impossible to accept the terminology “tests are carried out by an independent laboratory complying with the general principles of ISO 17025”. How the “general principals” can be defined and proven? Your scope is under EN ISO 17025 accreditation or not.	The idea is that any laboratory complying with the general principles of ISO 17025 would be ISO 17025 certified…
	Tests in an independent laboratory.	The main requirement is that the laboratory is certified and
	It would be better to have a certification, according to the Directive 2014/24/EU, art. 44.	

	Self-declaration is adequate if the internal laboratory is accredited to a recognised European accreditation body. Otherwise verification or certification should be requested	accredited for doing the test. It is of less importance if that laboratory is independent or owned by the supplier.
Light source lifetime: are warranties suitable?	We ask waranty of 8 years for electronic components.	A warranty has been proposed as a minimum technical specification for a period of at least 8 years. The option to extend the warranty is also covered in an award criterion.
	No, GPP should not include a warranty requirement. Additional warranty time and conditions depends on the risk the tender wants to take and therefore may change case by case. Note: Reputable manufacturers will not walk away in case of quality issues.	
	It could be a good option.	
	A warranty is generally supplied as standard. However the period and terms of warranty may vary considerably and the manufacturer reputation with regard to honouring warranties can be as important. The problem with overly extended warranties is that the operating conditions are very unpredictable which could make an extended period warranty commercially unviable for a manufacturer without an increase in purchase price	
Control gear lifetime: gear failure rate	The EEB supports the proposed criteria (TS2) – both the derivation from the preliminary report which identified the higher quality units and then establishing the criteria at a failure rate of <0.2 per 1000 hours for core criteria and <0.1 per 1000 hours for comprehensive criteria. This will ensure a long service life and the achievement of anticipated payback periods and resource efficiency gains. Furthermore, the LCA studies reviewed had found that manufacturing was the second most important product performance criteria after energy-in-use, thus having these criteria is both necessary and appropriate .	Accepted.
	This would be difficult to administer. The visible effect would be a lower failure rate and therefore a longer gear life. The mechanism that achieves this, is internal to the product and difficult to verify. Therefore, specifying criteria at control gear component level should be avoided. Please note that this issue is under development in IEC and GPP should not overrule the issue for the time being.	What sort of timescale is there for IEC to address this issue? The EU GPP criteria should be published around mid-2018 if all goes well.
	This would be difficult to administer. The visible effect would be a lower failure rate and therefore a longer gear life. The mechanism that achieves this is internal to the product and difficult to verify. Therefore specifying criteria at control gear component level should be avoided	
	In principle the limits are well chosen. In practice this has a cost implication that must be accepted in that higher quality and longer life control gear are more expensive. In cost sensitive low-tier products this could be a factor. Note: Life time testing could also be done by an internal certified lab (see answer 13 above).	Accepted. We want EU GPP criteria to promote longer lasting lighting products. If cost is such a significant factor, maybe this should be an award criterion instead?
	In principle the limits are well chosen. In practice this has a cost implication that must be accepted in that higher quality, longer life control gear is more expensive. In cost sensitive low-tier products this could be a factor.	
	Rate unit must be specified in criteria: % per 1000 h.	Accepted
	Without any standard to refer to, it is not possible to verify the declaration; because no EN standard are available on this respect, only reputable control gear manufacturers are capable to make such predictions. This means that self-declaration should be adequate if the internal laboratory is accredited by a recognised European accreditation body.	Accepted – although it is understood than an IEC standard is forthcoming.
	Reputable control gear manufacturers test to standards by default. This means that self-declaration should be adequate if the internal laboratory is accredited to a recognised European accreditation body. Otherwise verification or certification should be requested	
Traffic signals:	Siemens indeed has a 1W signal head, but this requires also a new traffic signals and a new traffic controller. This may be an option for new installations but even then this will never be a cost effective investment.	Only one criterion is proposed

ambition levels for light source efficacy	However I agree that we have to promote to use traffic signals with a power consumption that is as low as possible.	for traffic signals and there is some uncertainty about the market availability of different traffic lights that meet different efficacy requirements. In the absence of more concrete input from stakeholders, and considering that, from a GPP perspective traffic signals are not typically the same subject matter as road lighting, it is proposed to remove the criterion.
	It would be a good option but only if there are enough products on the market to guarantee the free concurrency.	
Traffic signals: criterion on operating wattage	At this moment this is not very realistic taking into account that voltage/current measurements are used in the traffic controller to determine if something is wrong with the signal heads. All commonly used traffic signals (in Europe at least) have higher power consumption than stated (f.e. Swarco, Peek, Siemens,..).	
Same lifetime criteria as for road lighting light sources?	No: this doesn't take into account that there are minimum requirements for the luminous intensity of signal heads as defined by EN 12368:2015	
Traffic signals: relevant standards?	EN12368:2015	
Is warranty a good idea instead of testing for lifetime in the laboratory?	Yes	
	It would be fine to have an extended warranty period of 10 years in the Core criteria, as for the lighting installations. In the Comprehensive criteria, the warranty period could be 15 years.	
	The EEB is agrees that the operating wattage requirements – inclusive of the power demand from the signal head power circuit (i.e., the 'driver') – for traffic signals are adequate. We also agree that the lumen maintenance and failure rate of minimum 16000 hours is adequate for this application. The EEB does not believe there is a need to have different Core and Comprehensive criteria, as these requirements are already focusing (correctly) on ensuring energy-efficient traffic signal modules are installed. Duty cycle and dimming should not apply because that could impinge on safety.	
Discarded criteria: efficiency of ballast and control gear	yes, removing this requirement	Accepted. Confirmed that the criterion will be removed permanently. A PDI criterion is included.
	Yes. Ecodesign requirements will prevent low efficacy control gear being on the market and it is unlikely that a lower efficacy control gear will have the correct footprint and fixings or electrical characteristics to allow substitution.	
	Yes. Ecodesign requirements will prevent low efficacy control gear being on the market and it is unlikely that a lower efficacy control gear will have the correct footprint and fixings or electrical characteristics to allow substitution	
	The EBB can support the HID ballast and/or LED control gear requirements being removed from the technical specification and award criteria only if system efficacy is adopted. In other words, yes – if the PDI equation is included and EN 13201-5:2015 is followed, taking into account the losses of the ballast/driver. In case the revised GPP criteria end up being based on light source efficacy only, then we would seek to have driver efficiency included. That is because we insist it's the system performance which matters overall, and ideally, the street light luminaire including driver, light source and optics could all be included the criteria.	
	Yes. It would be useful to have specific criteria on service life of ballast and control gear.	
Discarded criteria: mercury content	yes, removing this requirement	What are the potential consequences of a complete ban on Mercury in light sources? How many light sources would be removed by this?
	Yes. Mercury content is controlled via RoHS and additional criteria in a market becoming dominated by LED is not logical.	
	Yes.	
	Yes. Mercury content is controlled via RoSHS and additional criteria in a market becoming dominated by LED is not logical	

	OK ... Only a full LCA criterion is relevant..	Are there special collection and disposal arrangements in place in all EU Member States for dealing with the Mercury from road lighting?
	The EEB feels strongly that mercury content should continue to be included as a criterion and applicants must report on mercury content when demonstrating compliance with GPP criteria. Although mercury is not used in LED light sources, we think it should form part of the EU GPP criteria because HID sources using mercury are still commercially available on the market – and they will be during the duration of this GPP criteria set. A GPP criterion on zero mercury content would clearly differentiate GPP products from the rest of the market, and remove any risk of municipalities or manufacturers including mercury-containing products such as metal halide or high pressure sodium lamps. High pressure sodium lamps generally contain 10 to 50 mg of mercury. Souce: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/Sa%FAde/imerc_fact_sheet_mercury_use_in_lighting.pdf	
Discarded criteria: packaging of lighting equipment – do you agree to remove this?	yes, removing this requirement	Accepted. The packaging criterion has been removed from TR 2.0.
	Yes	
	yes	
	Yes. This requirement has little through-life environmental impact on the solution.	
	Yes.	
	Yes. This requirement has little through-life environmental impact on the solution	
	OK ... and yet, using recyclable packaging can be a plus in terms of the environment (ex: reusable boxes for luminaires), taking in account they ensure a greater protection of the luminaires during the work on site for example... However, the Contracting Authority will have to define the maximum sizes of packaging and delivery methods if the equipment is delivered to him.	
	The EEB accepts that it would be reasonable to remove the packaging requirement for lighting equipment. This is obviously not a 'hot spot' for environmental impact of this product category from a life cycle perspective. Most municipalities / installers will already have recycling schemes in place for separating waste anyway into paper, plastic, etc.	
Discarded criterion: points for the percentage of dimming. Do we need a criterion for standby loss for LED dimming?	yes, removing this requirement	It has been decided to remove this criterion. A mandatory requirement is now made that all new luminaires should be capable of curfew dimming to at least 50%. Whether the procurer actually does this or not is up to them.
	No. Maximum requirements for standby losses are already part of the Ecodesign and shall not be repeated in GPP.	
	The main loss in efficacy and performance is at lower dimming levels. Mainstream applications generally do not need dimming to these levels as even dropping one or two lighting classes is not such a significant change. Therefore this would be of limited use and applicability	
	It is important to have the data curve light flux / power. This from 100% to 0% flux when the luminaire is fully in function (including all the auxiliaries)	
	There are two pathways to save energy in street lighting – the first is to have a more efficacious source and the second is to control it. With existing market trends, we can expect the efficacy of LED lighting to increase and the penetration in the market to continue, however if dimming is not valued by the GPP, then it may become more difficult to capture the additional (second pathway) to saving energy – namely controls. While the points system may not be ideal, the EEB does insist that for the Comprehensive Criteria lighting controls should constitute part of the solution. Dimming to levels as low as 0% may not be necessary, but offering recognition for dimming to reasonable levels that are commonly used in the market would continue to enable this criterion to be used.	