UK comments on various LED-related documents
submitted by ELC/CELMA to the European Commission

Submitted by the UK Market Transformation Programme on behalf of
UK's Department for Environment, Food and Rural Affairs (Defra)

The following table lists the eight CELMA[1] and ELC[2] documents submitted to the European Commission, including the title of the documents, the filename and notes that describe the content and the date. The items that are not shaded (items number 1, 3, 5 and 8) are discussed in this memo. The shaded items number 2, 4, 6 and 7 were consider to be related to topics that are not the focus of this review – specifically, linear tubular fluorescent lamps and/or LED luminaires. (N.B., Although the file name always starts with CELMA, these documents are either exclusively ELC or CELMA documents, or joint efforts. The authors of each document are identified in the "Notes" section of the table below.)

#	Title	Filename	Notes
1	Directional LED Lamps Survey on relevant data for inclusion of Directional LED lamps in the EU Regulation on ecodesign requirements for Household lamps, Part II	CELMA LED(SM)049A_ELC summary of requirements directional LED lamps for EU Reg Part 2_09032010.pdf	An ELC document that contains a summary of essential definitions and requirements related to Directional LED lamps to become part of a new European Regulation. Version: March 9, 2010
2	LED lamps replacing linear fluorescent lamps Survey containing relevant data supporting the inclusion of LED lamps replacing linear fluorescent lamps in the EU Regulation on Ecodesign for Household lamps (Part 2).	CELMA LED(SM)049B_ELC summary of requirements LED lamps replacing fluo for EU Reg Part 2_09032010.pdf	An ELC document that contains a summary of essential definitions and requirements related to LED lamps replacing linear fluorescent lamps to become part of a new European Regulation.
3	LED modules for General Lighting Survey containing relevant (LED) data supporting the inclusion of LED Modules in the EU Regulation on Ecodesign requirements for household lamps, Part II	CELMA LED(SM)049C_ELC CELMA summary of requirements LED modules for EU Reg Part 2_09032010.pdf	A joint ELC and CELMA document, that contains a summary of essential definitions and requirements related to LED modules to become part of a new European Regulation. Version: March 9, 2010
4	CELMA request to exclude LED luminaires for the moment from the future EuP Regulation on domestic lighting part 2	CELMA LED(SM)049D_CELMA request to exclude LED luminaires from EU Reg domestic lighting part 2.pdf	A CELMA document that requests that LED luminaires will for the moment be excluded from the future EU Regulation on domestic lighting part 2. March 2010.

[1] CELMA is the federation of national manufacturers associations for luminaires and electrotechnical components for luminaires in the European Union.
[2] European Lamp Companies Federation represent lamp manufacturers in the European Union

#	Title	Filename	Notes
5	Directional (Retrofit) LED lamps ELC survey with relevant (LED) data supporting the inclusion of Directional (Retrofit) LED lamps in the EU Regulation on ecodesign requirements for household lamps, Part II	CELMA LED(SM)054A_ELC Background info_directional LED lamps_domestic part 2 Regulation.pdf	An ELC document that compiles various files and memos, brought together in order to give an overview of ELC input for the new European regulation, in particular related to Retrofit LED lamps of the Directional type therein. March 11, 2010.
6	LED lamps replacing linear fluorescent lamps Survey containing relevant (LED) data supporting the inclusion of LED lamps to replace linear fluorescent lamps in the EU Regulation on Ecodesign for Household lamps (Part 2)	CELMA LED(SM)054B_ELC Background info_LED lamps for tubular fluo_domestic part 2 Regulation.pdf	An ELC document that gives an overview of input relevant to the inclusion of LED lamps intended to replace linear tubular fluorescent lamps in a new European Regulation.
7	CELMA position paper T5 and T8 Fluorescent Lamp and LED Lamp/Module Adaptors "Retro-fit Conversion Units" for T8, T10 & T12 Luminaires	CELMA LED(SM)054C_CELMA position paper on ADAPTORS_FINAL.pdf	A CELMA document based on Lighting Industries Federation (LIF) Technical Statement No. 41: Issue 3A. Status as of February 22, 2010.
8	LED modules for General Lighting Survey containing relevant (LED) data supporting the inclusion of LED Modules in EU Regulation on ecodesign requirements for household lamps, Part II	CELMA LED(SM)054D_ELC CELMA Background info_LED Modules_domestic part 2 Regulation.pdf	A joint CELMA and ELC document that gives an overview of input relevant for the inclusion of LED modules in the new European Regulation. It covers minimum performance requirements for LED modules intended for General Lighting applications on basis of white light.

1.1 CELMA LED(SM)049A

This is an ELC-drafted document, focused on directional LED lamps, and presents a “Survey on relevant data for inclusion of Directional LED lamps in the EU Regulation on Ecodesign requirements for Household lamps, Part II.” The document summarises the main definitions and requirements related to modifications that ELC is proposing to the relevant sections of EU Regulation EU 244/2009 dated March 18, 2009. These recommendations include draft regulatory language with possible new text for the upcoming EU Regulation on Ecodesign requirements for household lamps Part II, directional LED lamps. ELC provides a caveat indicating that these language suggestions are in no way complete, but they contain “the most important aspects to become part of the new Part II and/or presently not covered in Regulation 244/2009 and the modifications thereof in Regulation 855/2009.”

On the first page of this document, the ELC makes it clear that it “strongly recommends”:

1. The inclusion of minimum performance requirements for Directional LED lamps in European legislation, and
2. To make relevant sections of Part 2 applicable for EU Regulation 244/2009 as far as LED lamps are concerned.

In the following sections, ELC text from the submission appears in italics, and MTP comments are interspersed in normal text.

On page 2, second paragraph titled “Article 2 Definitions” proposes the adoption of three definitions: LED Lamp, LED Cap and Lamp Holder or Socket:

> *(xx) “LED lamp” means a lamp, incorporating a LED light source and any additional elements necessary for stable operation of the light source, provided with a lamp cap conforming IEC 60061-1, which cannot be dismantled without permanent damages.*

Unless defined elsewhere, the ELC might find it advantageous to create two definitions, one for an “LED lamp, integrated” and one for an “LED lamp, non-integrated” as there are both types in the market. This approach would also be consistent with how these terms are treated in international standards. The above definition (presumably an LED lamp, integrated), should state that it is intended to operate directly on mains voltage (e.g. 220V AC) and the non-integrated lamp should state it is intended for ‘connection to an LED driver or an LED luminaire and cannot be operated directly on mains voltage.’

> *(xx) "lamp cap" means that part of a lamp which provides connection to the electrical supply by means of a socket or lamp connector and, in most cases, also serves to retain the lamp in the socket;*

No comment, this seems OK.

> *(xx) “lamp holder” or "socket" means a device which holds the lamp in position, usually by having the cap inserted in it, in which case it also provides the means of connecting the lamp to the electric supply.*

This definition is otherwise fine, but could be clearer if it read: (xx) “lamp holder” or "socket" means a device which holds the lamp in position, usually by having the lamp cap inserted in it, providing a means of connecting the lamp to the electrical supply.

On page 2, bottom half of the page, ELC makes a suggestion to insert text into Annex I for appending the definition of "Lamp lifetime" with the following statement:

> *For LED lamps, "Lamp lifetime" is the period of operation time during which a given fraction of the total number of lamps(F_x) provide more than a pre-defined percentage of the rated luminous flux (L_x), under standard test conditions.*

As long as the values of F_x and L_x are set by the Commission and are consistent for all manufacturers (which the statement "pre-defined" implies), then this definition seems reasonable. Useful life is the period of operation a light source delivers a minimum acceptable level of light in a given application, and that concept is captured by this definition.

On page 2, bottom of the page, ELC makes a suggestion for a new paragraph to be inserted into Annex II, under Section 1: Lamp efficacy requirements:

> *Directional LED lamps have to fulfil the following efficiency requirements. Reference is made to the related definitions of EU Regulation 244/2009 on ecodesign requirements for household lamps. The maximum allowed rated power (Pmax) of a LED lamp is provided in Table 1 of 244/2009. Tables 2 and 3 of EU Regulation 244/2009 shall apply for Directional (LED) lamps as well.*

This suggested language would make Directional LEDs subject to the requirements of all three tables in 244/2009. These efficacy requirements are plotted in the figure below, along with the reflector lamp regulations for Australia, Canada and the US. (note that the Canadian and US regulations have been adjusted to account for differences in line voltage)

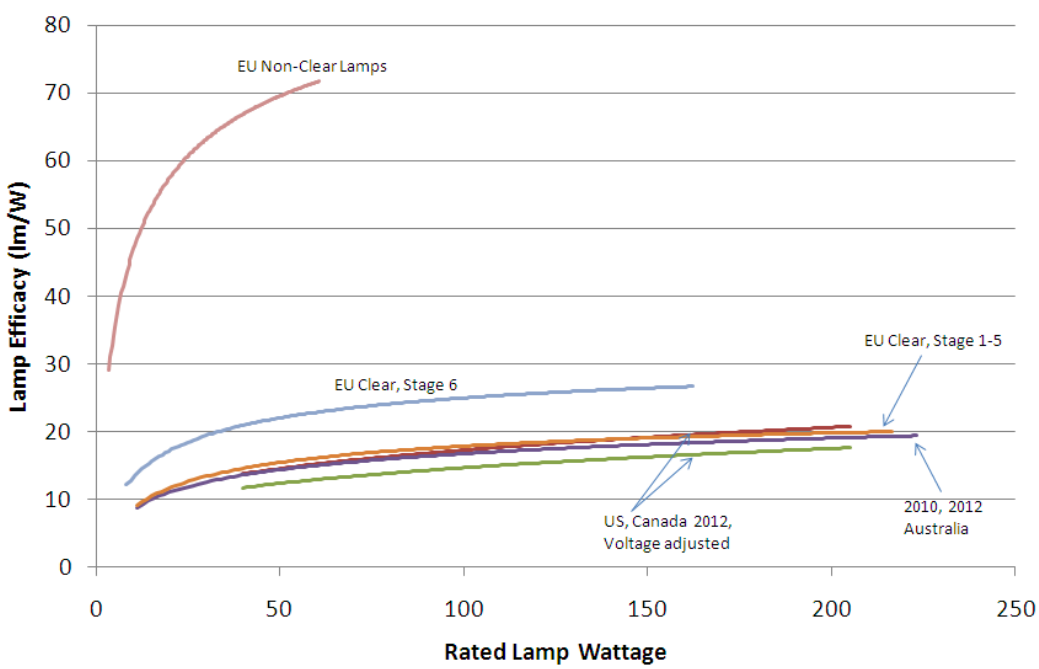

Figure 1. Plot of EU Regulation 244/2009 Compared with Directional Lamp Regulations

For clear directional lamps, ELC's proposal to adopt Table 1 efficacy requirements for directional lamps will place LEDs in the EU market the same regulatory level as Australia for clear incandescent and halogen lamps. These efficacy requirements are too low for directional LED lamps.

For non-clear directional lamps, the Table 1 efficacy requirements are significantly higher, as they are based on an integral CFL. The efficacy requirements, however - for example, a 15-watt lamp would be at about 54 lumens per watt – representing a lamp package output of approximately 800 lumens. That efficacy level is achievable by good quality LED lamps.

The graph below plots the lumen output against rated lamp wattage. The slope of the lines is the efficacy (lm/W). Looking laterally across the graph at a lumen output level – such as 1000 lumens, is indicative of the maximum power consumption under the regulations of Table 1 for each of the stages and lamp types. The EU Non-Clear lamps seems like a more reasonable efficacy requirement of directional LED lamps than the EU Clear requirements. The EU Clear lamp requirements are below commercially available LED products already available on the market today. However, if the objective of the Commission is to simply protect consumers from very poor quality LED products, then a lower minimum specification such as the EU Clear lamp may be a good point to start from. (note: to determine a reasonable minimum quality performance threshold to adopt would be an output of Task 5.)

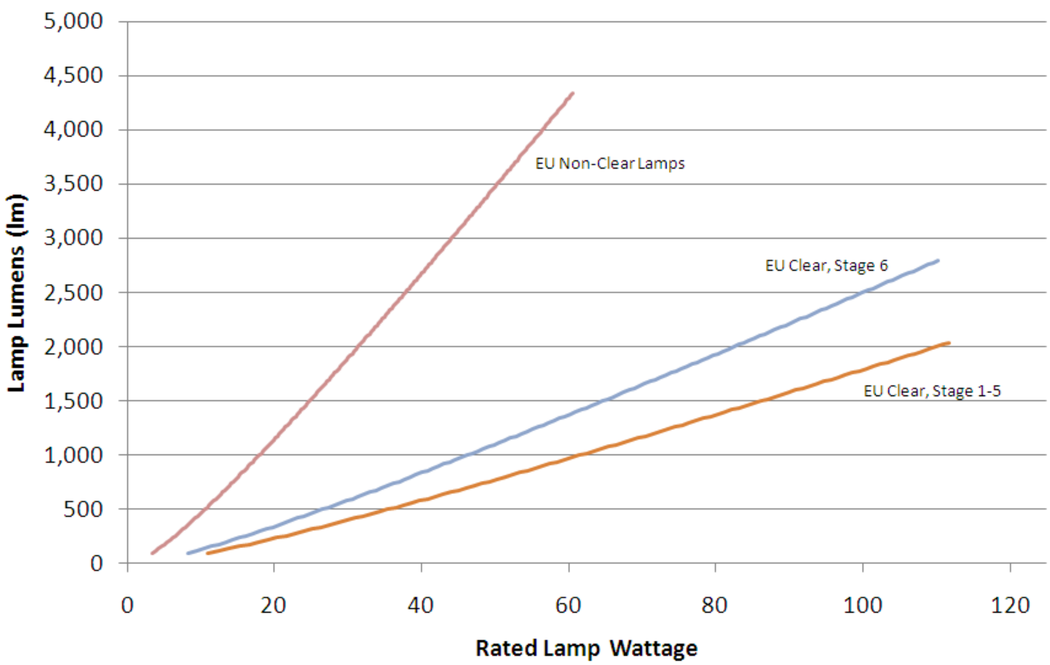

Figure 2. Lumen vs. Wattage Plot of EU Regulation 244/2009

ELC proposes to insert a new table, in addition to the existing Tables 4 and 5, which provides requirements for LED Retrofit Lamps – both directional and non-directional.

Table xx:
Functionality requirements for LED Retrofit lamps (Directional and Non-directional)

Functionality parameter	**All stages**	
Minimum lamp lifetime (for L_{70},F_{50})	≥ 10000 h	
Switching cycle test (acc IEC/PAS 62612 Ed 1)	> 5000 cycles (30 sec on/off) without failure	
Lamp power factor (Note 1)	*P ≤ 2 W*	No PF requirements
	2W< PF ≤ 25W	PF > 0.5
	P > 25W	PF > 0,9
Starting time	< 0,5 sec	
Run-up time to 95% rated lumen output	< 30 sec	
Max. early failure rate (at 10% of rated life in hrs)	≤ 2%	
CRI (acc CIE 13.3:1995)	≥ 80 (>65 for outdoor and industrial applications)	
CCT (acc IEC/PAS 62612 Ed 1, IEC 60081, Annex D)	2700K, 3000K, 3500K, 4000K, 5000K or 6500K	

Note1: Power Factor requirements only apply to self-ballasted LED-lamps connected to mains voltage
Note 2: The switching cycle according EU Regulation244/2009 has been defined as a cycle of 1 min on and 3 min off. The Performance Standard IEC/PAS 62612 Ed. 1 has defined a switching test based on a 30 sec on/off cycle. Further study is required.

Figure 3. Screen Capture of ELC Proposed Requirements for LED Retrofit Lamps

This table has some lower than expected quality parameters. A few particular issues warrant discussion:

- Lifetime for L_{70}, F_{50} – this is the design life of an LED lamp, with 70% maintenance of initial lumens and 50% failures at a certain point in time. Setting this requirement at 10,000 seems low for a technology that is capable of 25,000 and more hours of service life. Further information on the rationale behind this abbreviated lifetime should be sought.
- LED power supplies are non-linear loads, and have a power factor associated with them. Power factors closer to 1.00 are better and many utilities require aggregate end-user loads to have a power factor of 0.9 or better. With the expertise and recent advances made in electronics, it seems unusual for LED lamps rated 2W through 25W would have a power factor as low as 0.5. This wattage range includes the most popular general service lighting lumen output ranges (i.e., a 20W LED lamp operating at 50 lumens per watt would emit 1000 lumens of light, roughly equivalent to a 75 watt incandescent lamp). For commercial and industrial end-users (where LED lamps will first penetrate the market), low power factors may require costly correction equipment or incur penalty charges from electric utilities due to poor power factor.[3] The US LED L-Prize specification require LED power supplies to have a power factor of 0.9 for commercial entries and 0.7 for residential.
- The run-up time to full brightness allows for an unusually long time period (as many as 30 seconds) – it is unclear why this is the case, as LEDs do not require such long warm-up periods to attain full brightness.

[3] In a utility's distribution network, low power factor loads draw more current than high power factor loads for the same amount of useful work. Higher currents increase the losses in the distribution network, which is lost sales to the utility and in certain circumstances may require upgrading the wires or adding power factor correction equipment. Due to the additional equipment and wasted energy, utilities usually charge penalty to commercial customers who have a low power factor.

- One issue that could be problematic is having different CRI requirements by end-use sector – i.e., ≥ 80 CRI for commercial and residential applications and >65 for outdoor and industrial applications. This may require definitions, application descriptions or some other clarifying language.

Page 3, second paragraph from the bottom, ELC states "existing Tables 4 (CFL-I based Directional lamps) and 5 (Incandescent and Halogen Directional lamps, describing the minimum lumen output required per directional lamp (type)" – would it be possible to see those tables?

Page 3, bottom paragraph and all of Page 4. ELC proposes a large table of "Performance Equivalence table for reflector lamps." This is a good concept, as it will facilitate communication with consumers across the market on equivalent LED performance claims. However, there are a few issues that require further study:

(1) whether it makes sense to quantify only the lumens contained in a 90 degree cone, or if all forward light emitted by the lamp should be used. This is a larger test procedure issue that needs to be taken into account by the Commission. Is all forward-projected light from a directional lamp useful, or is it only that which is focused in a 90 degree cone? LEDs are naturally more directional and emit in tighter degree cones, so an LED-based MR-16 replacement would have close to all of its light emission within the 90 degree cone while a line-voltage halogen MR-16 would not. This could result in claims of equivalence where the LED matches the lumen output within a cone, but it is not perceived by the consumer as equivalent because they are accustomed to viewing and using all forward light emission into their living space as useful light.

(2) the quantities presented should be verified against a small sample of commercial product to ensure the values are artificially low (which would enable claims of equivalence that are note realised once the lamp is installed). Some of these values appear to be low.

Page 5, at the top, ELC proposes to establish seven categories of directional lamp, based on beam angles. Figure 4 presents these categories and ELC's recommended correction factors that apply primarily to the narrower beam directional lamps.

Depending on the beam characteristics of a Directional lamp, a correction factor shall be applied to the above lumen values, according the table below:

Table xx:
Lumen correction factor according beam-width category

Group NSP	Group SP	Group NFL	Group FL	Group WFL	Group VWFL	Group XWFL
3 – 9°	9 – 15°	15 – 20°	20 – 30°	30 – 40°	40 – 60°	> 60°
Min Flux (lm) % of reference	Min Flux (lm) % of reference	Min Flux (lm) % of reference	Min Flux (lm) % of reference	Min Flux (lm) % of reference	Min Flux (lm) % of reference	Min Flux (lm) % of reference
80%	85%	90%	100%	100%	100%	100%

Figure 4. Screen Capture of ELC Proposed Groups of Beam-Width Categories

For completeness of coverage, the smallest beam-width category ("Group NSP") should better be set to cover from zero (nadir) to 9 degrees. Otherwise, these appear to be reasonable categories. The lumen correction factors will be discussed in Task 2.

Finally, on page 5, ELC proposes some additional citations be added to Annex III:

- IEC 62560: Safety Requirements for Self-ballasted LED lamps > 50V
- IEC/PAS 60612 Edition 1: Performance Requirements for Self-ballasted LED lamps.
- IEC TS 62504: Terms and Definitions for LEDs and LED modules in general lighting.

These IEC standards are identified and briefly discussed in a separate document to the European Commission. We have no further comment on these.

1.2 CELMA LED(SM)049C

This document is a joint comment prepared and submitted by ELC and CELMA to the Commission proposing some textual amendments to the EU Regulation 244/2009 dated March 18th 2009. This comment pertains to "LED Modules" as opposed to the comment discussed in the previous section which focuses on "LED Directional Lamps". The comment opens with a strong, underlined statement: "The European Lighting Industry strongly recommends the inclusion of minimum performance requirements for LED modules in European legislation…"

The document summarises the main definitions and requirements related to modifications that ELC and CELMA are proposing to the relevant sections of EU Regulation EU 244/2009 dated March 18, 2009 for LED Modules. These recommendations include draft regulatory language with possible new text for the upcoming EU Regulation on Ecodesign requirements for household lamps Part II, directional LED lamps. The joint comment provides a caveat indicating that these language suggestions are in no way complete, but they contain "the most important aspects to become part of the new Part 2 and/or presently not covered in Regulation 244/2009 and the modifications thereof in Regulation 859/2009."

On page 2, the joint comment recommends that the following two items be added to the existing list of light sources excluded from the scope of the regulation:

(h) packaged (single or multiple) LED's not mounted on a printed circuit board;
(i) LED modules fully integrated in a luminaire construction, i.e. "sealed for life", the module cannot be removed/exchanged without permanently damaging the luminaire. (Possible minimum performance requirements for these LED products are determined by or derived from those applicable for the complete luminaire, if any).

Below are a few concerns that are raised for consideration about these exclusions:

- On the packaged LEDs, while it seems reasonable on its face that LEDs not mounted on a printed circuit board (PCB) should be exempt – however, might there be other mounting substrates that industry would consider 'non-PCB' and thus exempt from the regulation? For example, would mounting LEDs directly on a ceramic-insulated aluminium substrate (as is the practice with many LED products today) be considered exempt? Technically, that substrate is not a PCB, although it can function as one. More detail should be sought on this exemption, and the onus should be placed on the industry to prove that it will not be exploited as a loop-hole before it is granted (N.B., gathering and filing such evidence would prove valuable should the EC find itself in an enforcement lawsuit).

- LED modules fully integrated into a luminaire that are non-removable can be (and are) the light source of luminaires that were analysed in the luminaire part of the Preparatory Study, Part 2. Would granting this exclusion limit the scope of a future regulation aimed at establishing MEPS on luminaire efficiency only, ignoring the LED module part of the system? Again, further detail and evidence demonstrating that this exclusion will not be exploited should be sought.

Page 2, middle of the page. Under “Article 2 Definitions”, the joint comment suggests that the following definition is added to the existing list:

> *(xx) “LED module” means a unit, supplied as a light source, containing one or more LEDs, possibly combined with further components e.g. optical, electrical, mechanical and electronic, requiring connection to a control gear (driver) for operation.*

This definition is largely consistent with the draft proposed ANSI/IES definition for an “LED array or module”, which reads:

> An assembly of LED packages (components), or dies on a printed circuit board or substrate, possibly with optical elements and additional thermal, mechanical, and electrical interfaces that are intended to connect to the load side of a LED driver. Power source and ANSI standard base are not incorporated into the device. The device cannot be connected directly to the branch circuit.

The ELC and CELMA definition could be strengthened by revising the list of components to remove duplication of ‘electrical’ and to add ‘thermal’, reading: “e.g. optical, electrical, mechanical and thermal.” The definition could also enhance clarity by stating that the LED module does not necessarily have a standard lamp base. Incorporating these suggested revisions, the definition would read:

> (xx) “LED module” means a unit, supplied as a light source, containing one or more LEDs, possibly combined with further components e.g. optical, electrical, mechanical and thermal, without a standard lamp base and requiring connection to a control gear (LED driver) for operation.

Page 2, in the bottom half, the joint comment suggests that the following definition is added to Section 1 (Technical parameters for ecodesign requirements) in ANNEX I:

> *(d) “Lamp lifetime”, which is the period of operation time after which the fraction of the total number of lamps which continue to operate corresponds to the lamp survival factor of the lamp, under defined conditions and switching frequency. For LED lamps, “Lamp lifetime (L_x, F_x)” is the period of operation time during which a given fraction of the total number of lamps (F_x) provide more than a pre-defined percentage of the rated luminous flux (L_x), under standard test conditions.*

This definition is largely consistent with the proposed definition of Lamp Lifetime for LED lamps:

> *For LED lamps, "Lamp lifetime" is the period of operation time during which a given fraction of the total number of lamps(F_x) provide more than a pre-defined percentage of the rated luminous flux (L_x), under standard test conditions.*

And the comment provided in the first section also applies here: as long as the values of F_x and L_x are set by the Commission and are consistent for all manufacturers (which the statement "pre-defined" implies), then this definition seems reasonable. Useful life is the period of operation a light source delivers a minimum acceptable level of light in a given application, and that concept is captured by this definition.

At the bottom of page 2, the joint comment suggests the inclusion of new language into Annex II, Section 1 (Lamp efficacy requirements):

> *LED modules have to fulfil the following efficiency requirements. Reference is made to the related definitions of EU Regulation 244/2009 on ecodesign requirements for household lamps. LED modules (as defined in IEC 62504 TS Ed.1) normally operate on a supply voltage < 250V and require a control gear (driver) to provide the correct supply voltage. LED modules can be of the Selfballasted type, meaning the module operates on mains voltage.*

On the following page (page 3), the joint comment presents a table of proposed maximum power limits on LED modules:

The maximum allowed rated power (P_{max}) of a LED module (Self-ballasted, without secondary optics) is provided in Table 1.

Table 1

Application date	Maximum rated power for a given rated luminous flux (Φ)	
Stage 1 (ca. 2012)	$P_{max} \leq 0{,}24\sqrt{\Phi}+0{,}0103\Phi$	for $\Phi \leq 600$ lm
	$P_{max} \leq 0{,}0200\Phi$	for $\Phi > 600$ lm
Stage x (ca. 2015)	$P_{max} \leq (0{,}24\sqrt{\Phi}+0{,}0103\Phi)/\mathbf{1{,}20}$	for $\Phi \leq 600$ lm
	$P_{max} \leq 0{,}0167\Phi$	for $\Phi > 600$ lm

Note 1: In Stage 1 the minimum efficiency is identical to those of CFL-i, with a maximum of 50 lm/W (for modules delivering > 600 lm). For Stage x the minimum efficiency shall be > 20% higher for all versions.
Note 2: The linear relation above 600 lm takes into consideration that it is possible to create LED modules with very high total luminous flux by mounting many LEDs on a single PCB where the module efficacy is basically determined by the efficacy of the individual LEDs.

Figure 5. Screen Capture of CELMA/ELC Recommended LED Module Efficacy

These equations for Stage 1 (ca. 2012) and Stage x (ca. 2015) maximum rated power for a given rated luminous flux requirements are plotted in the figure below. For comparison, this plot also includes the ELC Proposed LED Lamp regulations from Table 1 of 244/2009.

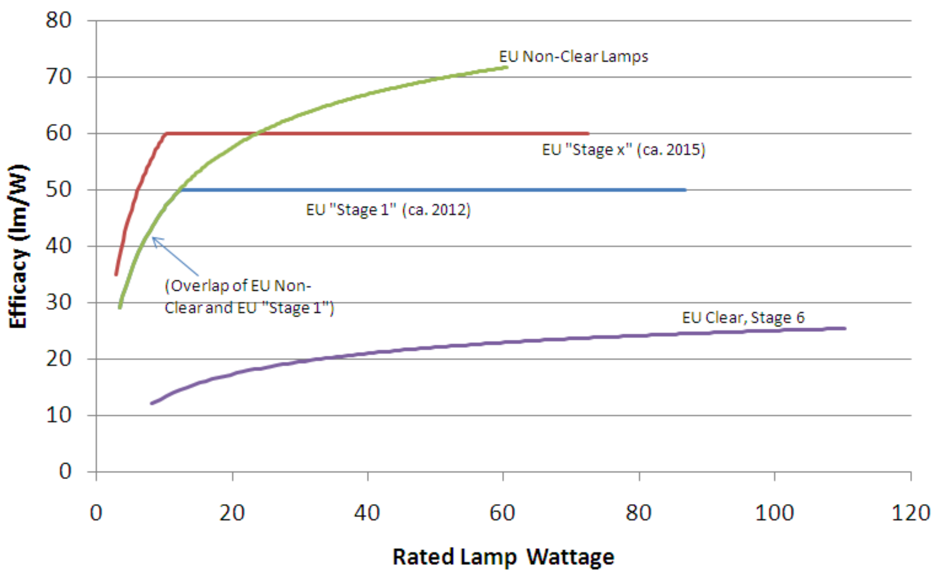

Figure 6. Plot of the CELMA/ELC Recommendation on LED Module Efficacy

The recommended efficacy requirements ramp up to a relatively low level of lumen output (600 lumens is approximately equal to the light output from a 50 watt GLS incandescent lamp) and then hold efficacy constant at all wattages and lumen packages above that point. This approach seems unusual, as efficacy will tend to scale with higher wattages, as product size and improved drivers are used. Furthermore, this proposal is not consistent with the recommendation from ELC for LED lamps (which arguably have optical losses that are not accounted for with LED modules), having lower efficacy requirements for LED modules that produce 600 lumens or more. The Stage x level is more ambitious, but similarly flat-lines at lumen flux levels of 600 or more. The Commission may choose to solicit further clarification for the rationale behind this flat-line approach, particularly as it is not consistent with the ELC proposal for non-clear LED lamps.

It is also worth mentioning that the projected efficacy levels set as minimum in this table are lower than the projected performance of LEDs by industry-supported forecasts such as those published by the US Department of Energy. In its US Department of Energy, Solid-State Lighting Research and Development: Multi-Year Program Plan, March 2010, integrally ballasted LED lamps (which will incorporate more factors contributing to losses than LED modules) are projected to be:

2009	69 lumens per watt
2010	86 lumens per watt
2012	121 lumens per watt
2015	172 lumens per watt
2020	219 lumens per watt

Given this forecast, it is unclear why LED modules should have only a 50 lumen per watt requirement in 2012 and 60 lumen per watt in 2015. The DOE projections are for commercially available products to be more than double those amounts. This issue would benefit from further investigation by the Commission as to the rationale behind this joint proposal from ELC/CELMA.

In the middle of page 3, the joint comment makes the recommendation that a new table be added which contains "correction factors" that are applied depending on the type of LED modules. These correction factors are used to determine the correct maximum allowed power for tested modules.

Table 3

Corrected maximum rated power	**P_{max} / BCF**	
	Self-ballasted LED modules	BCF = 1,00
	LED modules requiring external control gear	BCF = 1,10
Corrected lumen output	**$\Phi = \Phi_{integrated}$ x Optics Correction Factor x Lumen Maintenance Factor**	
	LED modules without "secondary optics"	OCF = 1,00
	LED Modules with "secondary optics"	OCF = 1,25
	Lumen Maintenance Factor for all LED Modules	LMF = 0,85

Figure 7. Screen Capture of Proposed Correction Factors

This section is presented without support in this comment, simply as the regulatory text that would be inserted into the document. These proposed correction factors are discussed later in this memo, in the supporting documentation provided by CELMA. In general terms however, these correction factors require much more justification than is provided in either of the comments submitted to date. On their face, they appear to be ways to further weaken proposed regulations that themselves are already weak by international standards.

At the bottom of page 3, the joint comment recommends inserting a new table to the regulation, similar to the one proposed in the first section for LED lamps:

Table 4
Functionality requirements for LED modules

Functionality parameter	**Stage 1**		**Stages 2 and 3**	
Minimum lamp lifetime (for L_{70},F_{50})	≥ 15000 h			
Minimum number of switching cycles before failure (See Note 2)	≥ 7500 cycles (30 sec on/off) without failure			
Power Factor (See Note 1)	P ≤ 2 W	None	P ≤ 2 W	None
	2W< P ≤ 25W	PF > 0,50	2W< P ≤ 25W	PF > 0,55
	P > 25W	PF > 0,90	P > 25W	PF > 0,90
Starting time	< 0,5 sec			
Run-up time to 95% rated lumen output	< 30 sec			
Max. early failure rate (at 10% of rated life in hrs)	≤ 2%			
CRI (acc CIE 13.3:1995)	≥ 80 (≥ 65 for Outdoor and Industrial applications)			

Figure 8. Screen Capture of Proposed Functionality Requirements for LED Modules

This table has some lower than expected quality parameters. Three particular issues warrant discussion:

- Lifetime for L_{70}, F_{50} – this is the design life of an LED lamp, with 70% maintenance of initial lumens and 50% failures at a certain point in time. Setting this requirement at

15,000 seems low for a technology that is capable of 25,000 and more hours of service life. Further information on the rationale behind this abbreviated lifetime should be sought.

- LED power supplies are non-linear loads, and have a power factor associated with them. Power factors closer to 1.00 are better and many utilities require aggregate end-user loads to have a power factor of 0.9 or better. The LED module power factor for 2W through 25W lamps is only 0.5 (and later 0.55). With the expertise and recent advances made in electronics, it seems unusual for LED modules to have such a low power factor. This wattage range includes the most popular general service lighting lumen output ranges (i.e., a 20W LED module operating at 50 lumens per watt would emit 1000 lumens of light, roughly equivalent to a 75 watt incandescent lamp). For commercial and industrial end-users (where LED lamps will first penetrate the market), low power factors may require costly correction equipment or incur penalty charges from electric utilities due to poor power factor.[4] The US LED L-Prize specification require LED power supplies to have a power factor of 0.9 for commercial entries and 0.7 for residential.
- .
- The run-up time to full brightness allows for an unusually long time period (as many as 30 seconds) – it is unclear why this is the case, as LEDs do not require such long warm-up periods to attain full brightness.
- One issue that could be problematic is having different CRI requirements by end-use sector – i.e., ≥ 80 CRI for commercial and residential applications and >65 for outdoor and industrial applications. This may require definitions, application descriptions or some other clarifying language.

Finally, page 4 of the joint comment proposes the addition of certain industry standards documents to Annex III. These IEC standards are identified and briefly discussed in a separate document submitted to the European Commission. We have no further comment on these.

1.3 CELMA LED(SM)054A

This document is an ELC submission that was prepared by the ELC working group on LED light sources, and is based on a variety of files and memos that are summarised to provide an overview of the ELC's position with respect to the new European regulation on retrofit Directional LED lamps. This document provides context and background for some of ELC's positions taken in their recommendations to the Commission. Rather than review each of the 19 pages in detail, we will pick a few key points from the document to discuss.

On page 7 of 19, ELC provides a graphic (see Figure 9) which projects the system efficacy of 3000K (CCT) retrofit LED lamps. Although some of the graphic is obscured, it approximates that in 2010, lamps are at approximately 40 lumens per Watt, and reach 75 lumens per Watt by 2015. ELC states that this forecast is based on "based on (and derived from) various publications from international independent sources (like NGLIA, OIDA, etc)." NGLIA stands for the "Next Generation Lighting Industry Alliance", which is a partnership

[4] In a utility's distribution network, low power factor loads draw more current than high power factor loads for the same amount of useful work. Higher currents increase the losses in the distribution network, which is lost sales to the utility and in certain circumstances may require upgrading the wires or adding power factor correction equipment. Due to the additional equipment and wasted energy, utilities usually charge penalty to commercial customers who have a low power factor.

between the US Department of Energy and the National Electrical Manufacturers Association (NEMA). OIDA is the Optoelectronics Industry Development Association.

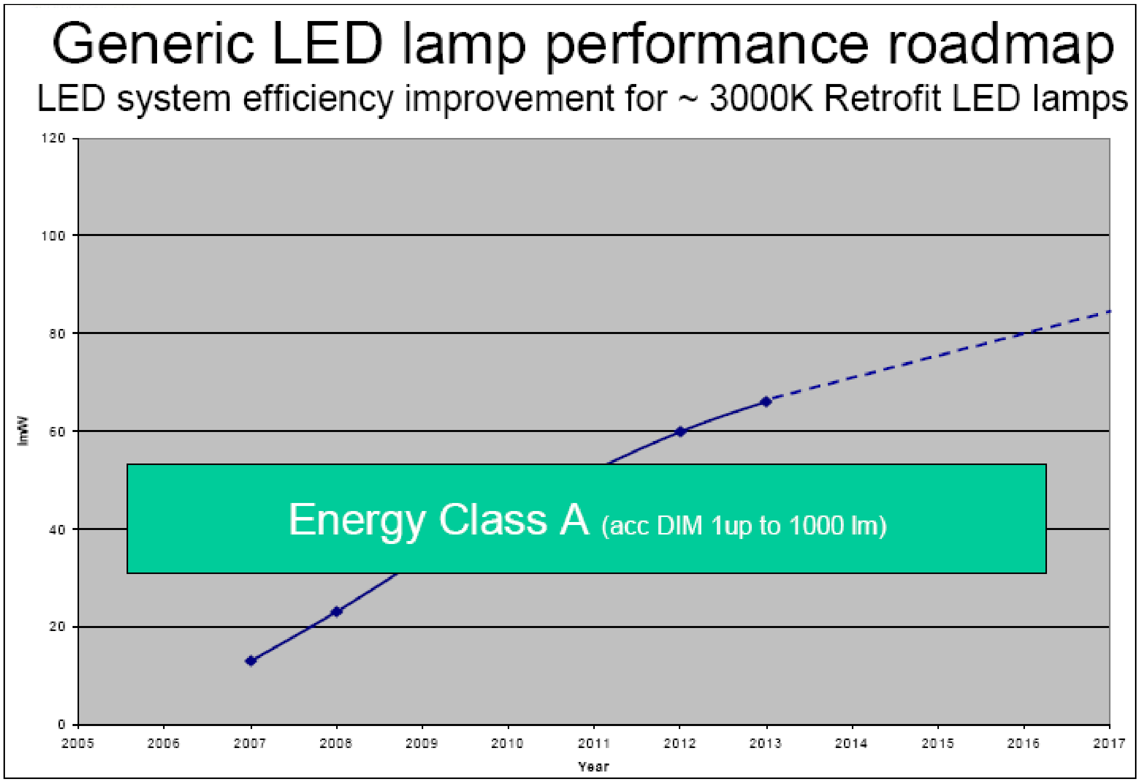

Figure 9. Screen Capture of ELC Forecast of LED Lamp Performance

The US Department of Energy recently published their updated Multi-Year Programme Plan, containing LED system performance forecasts that were developed in conjunction with members of the NGLIA. The table below provides the forecasts for LED system performance (taking into account package efficiency, thermal efficiency, driver efficiency and fixture efficiency). A row has been added to the bottom of the table providing estimates of the LED lamp efficacy projected by ELC, which were read off the graph presented in the figure above.

Table 1. US DOE LED Luminaire Performance Projections with ELC Addendum

Metric	2009	2010	2012	2015	2020
Package Efficacy-Commercial Cool White (lm/W, 25 C)	113	134	173	215	243
Thermal Efficiency	87%	89%	92%	95%	98%
Efficiency of Driver	86%	87%	89%	92%	96%
Efficiency of Fixture	81%	83%	87%	91%	96%
Resultant luminaire efficiency	61%	64%	71%	80%	90%
Luminaire Efficacy- Commercial Cool White (lm/W)	69	86	121	172	219
ELC Forecast of LED Lamp Performance (lm/W, estimated)	~35	~45	~60	~75	n/a

Notes for DOE values presented in this table:

1. Efficacy projections for cool-white luminaires assume CRI=70-80 and a CCT = 4746-7040°K.
2. All projections assume a drive current density of 35 A/cm2, reasonable package life and operating temperature.
3. Luminaire efficacies are obtained by multiplying the resultant luminaire efficiency by the package efficacy values.

Source: US Department of Energy, Solid-State Lighting Research and Development: Multi-Year Program Plan, March 2010.

The DOE projects the LED system efficacy for 2010 to be at 86 lumens per watt, rising to 172 lumens per watt by 2015. These values are more than double the estimated projections by the ELC in their comment (Figure 9 above). The ELC comment identifies four reasons why the efficacy is lower than might be expected relative to other forecasts:

- the use of Warm White light (3000 K) instead of Cool White
- lower lumen output because of higher operating (LED-junction) temperatures
- watt losses from a built-in driver
- optical system losses

However, as shown in Table 1, DOE already accounts for thermal efficiency, driver efficiency and optical (fixture) efficiency, therefore the only factor differentiating the DOE forecast from that of the ELC projection is a cooler colour temperature. This will make the ELC estimate less efficacious than DOE's projection, but not by such a significant margin. Due to this discrepancy between the published DOE forecast and the ELC comment, it is recommended that further data be request from ELC on the methodology applied to arrive at their projection.

1.4 CELMA LED(SM)054D

This comment, jointly authored by ELC and CELMA, addresses "LED Modules" which are seen as one of three different types of LED products available in the general illumination market: (1) Retrofit LED lamps, (2) LED Luminaires (integrated, non-replaceable LEDs) and (3) LED Modules (replaceable LEDs). ELC and CELMA strongly recommend the inclusion of minimum performance requirements for LED modules in European legislation, more in particular in the Regulation on Ecodesign for Household lamps (Part 2).

This document largely provides the back-up information pertaining to the joint comment discussed earlier on LED modules. It does not, however provide sufficient information on some of the issues raised and recommended for follow-up with industry in the second part of this comment.

On page 10 of 17, the comment recommends to perform all photometric measurements of LED modules with a goniophotometer. The reason given is because the Ulbricht sphere cannot measure the lumen output into a specific spatial area. The goniophotometer is able to measure all the necessary optical performance factors (candela, beam angle, cone/face lumens, LOR) with a single measurement. The comment notes that the luminous flux in a LED module with rotational symmetrical light output can normally be determined with only 2 perpendicular C-plane pairs (C0/180° and C90/270°), but for non-symmetrical outputs, it may be necessary to measure six full C planes at 30° intervals (C0/180°, C30/210°, C60/240°, C90/270°, C120/300°, C150/330°) to obtain an accurate result. Referencing CIE 127:2007 and IESNA LM79-2008, ELC/CELMA estimate that such measurements take only “a couple of minutes per module.”

The facility that is being alluded to in this comment is a projection-style photometer, where the light source is shone toward a “calibrated wall” which takes luminance measurements and generates all the calculations and illuminance images. These are expensive pieces of equipment, and require a lot of calibration/maintenance of the projection wall. A standard swing arm goniophotometer will take between a half and a full day to accurately measure the photometrics of one lamp. Thus, the Commission should investigate this recommendation further before making the goniophotometer system the required approach for measuring performance.

Starting on page 11 of 17, ELC/CELMA propose a methodology for determining the efficacy of LED modules that consists of the following steps:

b. Split the modules into two different optical groups – those having secondary optics and those without secondary optics.
c. Correction factors applicable per LED Module type – those without secondary optics have a correction for lumen maintenance and ballasts and those with secondary optics have these two corrections plus losses for built-in optics.
d. Optics correction factor (OCF) – only for modules having secondary optics, the Optics correction factor assumes an 80% efficient system: 1 /0,80 = 1,25.
e. Lumen Maintenance factor (LMF) – an adjustment to account for the fact that LED modules decrease over time, the measured lumens after ageing need to be corrected with the following maintenance factor - LMF for all LED modules: 0,85. This correction is proposed to be adjustable (e.g., L80 would have an LMF of 0.90 and L50 would have 0.75).
f. Ballast Correction Factor (BCF) – an adjustment is made for external control gear (driver) losses into the Energy Efficiency calculation. “Self-ballasted” LED modules have a correction factor of 1.0 (ballast losses already included in power measurements). BCF for “non-self-ballasted” LED Modules: 1,10.

Taking these adjustments into account ELC/CELMA presents the aggregated result, however this section is not particularly clear and it is concerning that some of these correction factors may be applied to actual measured results (thus double-counting for losses). Furthermore, the US DOE SSL Multiyear Programme Plan (which has input from the SSL industry) projects improvement in many of these values over time – which compounded, take an LED luminaire from 64% efficiency in 2010 to 80% in 2015 and 90% in 2020.

Finally, the efficacy values presented for LED modules in 2010 and 2015 in Table 3 (page 13 of 17) require further review, as they are lower than the efficacies of commercially available CFLs today. LED efficacy forecasts, including modules, will have exceeded the performance of CFLs by 2015, and setting such low requirements for a future target will not encourage technological innovation nor push the market to head in an energy saving direction.

Should you have any further queries or comments on the points made above please contact:
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