Research Report

Lot 19 Part 2: Analysis Relating to Working Documents on Directional Lamps and Household Luminaires and Ecodesign Requirements for Directional Lamps, LED Lamps and Halogen Lighting Converters

Analysis in support of the European Commission's regulatory process on Lot 19 Part 2 prepared by Michael Scholand, N14 Energy, and CLASP's technical advisor Marie Baton in cooperation with eceee's Executive Director, Nils Borg (positions expressed herein do not necessarily reflect the final views of eceee as an organisation).

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ABOUT CLASP

Established in 1999, CLASP is an independent non-profit organisation serving as a resource and voice for energy efficiency worldwide. CLASP has provided technical assistance on standards and labelling (S&L) in over 50 countries, supporting and promoting energy-efficiency in appliances, lighting and equipment. In 2009, CLASP became a ClimateWorks Foundation (CWF) global Best Practice Network on S&L. CWF funding has enabled CLASP to expand its activities globally to reduce the emission of greenhouse gases that cause climate change. Currently, CLASP has offices or programmes in China, the European Union, India, Latin-American and the United States.

CLASP's primary objective is to identify and respond to the analysis needs of S&L practitioners in targeted countries and regions while making the highest quality technical information on S&L best practice available globally. To this end, CLASP works on the ground providing technical analysis and expertise to national governments and local partners; aggregates resources; assembles project teams from diverse and highly-qualified organizations; oversees projects; partners and collaborates with policy makers and members of industry alike; and disseminates information for maximum impact. This report was prepared for and provided by CLASP's Europe office as part of its effort to strengthen the European Commission's regulatory analysis on directional lamps and household luminaires.

For more information about CLASP, please visit our website: http://www.clasponline.org/index.php

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Acronyms and Abbreviations

CCT	Correlated Colour Temperature
CELMA	Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components in the European Union
CFL	Compact Fluorescent Lamp
CIE	International Commission on Illumination
CLASP	Collaborative Labeling and Appliance Standards Program
CRI	Colour Rendering Index
DLS	Directional Lighting Source
DOE	Department of Energy (United States)
DSI	Deposition Sciences Inc.
EC	European Commission
eceee	European Council for an Energy Efficient Economy
EISA	Energy Independence and Security Act (US, 2007)
ELC	European Lamp Companies Federation
ELI	Efficient Lighting Initiative
EN	European Standard (Norme européenne)
EST	Energy Saving Trust
EU	European Union
GLS	General Lighting Service
HID	High Intensity Discharge
HV	High Voltage
IEC	International Electrotechnical Commission
IRC	Infrared Reflective Coating
JRC	Joint Research Centre
kWh	Kilowatt hour
LED	Light Emitting Diode
LLCC	Lowest Life-Cycle Cost
LM	Lumen
LV	Low Voltage
MEPS	Minimum Energy Performance Standards
MR	Multifaceted Reflector
NDLS	Non Directional Lighting Source
NEMA	National Electrical Manufacturers Association
NGLIA	Next Generation Lighting Industry Alliance
OEM	Original Equipment Manufacturer
R&D	Research & Development
UK	United Kingdom
US	United States
W	Watts

1 Summary of Findings

The purpose of this report is to provide input to the European Commission on a few specific issues that arose in discussions at the Ecodesign Consultation Forum meeting held on July 5, 2011. CLASP has addressed the following issues that we felt would benefit from more detailed study:

- Why the Commission may consider adopting a halogen infrared reflective coating (IRC) regulatory level for low-voltage directional lamps at Stage 1;
- Why the Commission may consider adopting a premium IRC/LED standard for directional lamps at Stage 3;
- Why CLASP supports the Commission's proposal of an efficiency requirement of 92.5% for halogen converters at Stage 1, and potentially a higher level at Stage 3;
- A global review of LED quality standards, to assist the Commission in its effort to define appropriate and proportionate requirements for Europe; and
- Why CLASP supports the Commission in maintaining Stage 3 of the regulation.

Brief explanations for each of these points are provided below, followed by more detailed discussion on these points in the subsequent chapters of this report.

- *Why the Commission may consider adopting a halogen infrared reflective coating (IRC) regulatory level for low-voltage directional lamps at Stage 1:*

As discussed in our July 5 Consultation Forum comments, CLASP is concerned about the lack of ambition for low-voltage halogen lamps shown in Table 2 of the draft Ecodesign Working Document (Ecodesign requirements for directional lamps, light emitting diode lamps and halogen lighting converters). This proposal runs counter to our expectations, particularly in the light of recent research published by eceee, including B-Class Halogens and Beyond[1] and Evaluating the Potential of Halogen Technologies.[2] We have analysed this issue and believe the Commission would be wise to consider adopting a level equivalent to halogen IRC at Stage 1 rather than Stage 3. We hold this view because of our assessment of (1) end-user payback periods, (2) maturity of the technology, (3) capacity of industry to meet demand, (4) mitigation of patent risk through existing cross-licensing agreements, and (5) other methods to improve efficacy of low-voltage halogen lamps besides IRC. In Chapter 2, we discuss each of these points and provide the evidence and rationale underpinning the recommendation. In section 2.6 we discuss the regulatory measure itself highlighting the importance of adopting a wattage cap for certain lamp types to ensure energy savings are realised.

- *Why the Commission may consider adopting a premium IRC/LED standard for directional lamps at Stage 3:*

CLASP believes it would be reasonable for the Commission to consider adopting an ambitious regulatory measure for all directional lamps in Stage 3. The level could be set such that only the best performing IRC halogen lamps can reach it, and reasonably good quality LED directional lamps. We believe this level is necessary and appropriate because: (1) LED technology is rapidly evolving and surpassing all competing lighting technologies; (2) IRC halogen has proven its capability in the market and still has more improvement potential demonstrated in the laboratory; (3) higher

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[1] http://www.eceee.org/press/B_Class_lamps/BClassHalogens_and_beyond-eceeeReportDecember12.pdf

[2] http://www.eceee.org/Eco_design/products/directional_lighting/halogen_technologies_report/eceee_report_halogen_technologies

regulatory requirements at Stage 3 appear to be economically justified; and (4) an ambitious regulatory level at Stage 3 will result in significant energy savings in Europe.

- *Why CLASP supports the Commission's proposal for an efficiency requirement of 92.5% for halogen converters at Stage 1, and potentially a higher level at Stage 3:*

CLASP strongly endorses the Commission's proposal to adopt a 92.5% efficiency requirement for halogen converters at Stage 1, and potentially an even higher level at Stage 3. We support the Commission's proposal because: (1) energy-efficient halogen converters are widely available in the market; (2) the energy savings potential of a regulation on these products is significant; and (3) this regulation is cost-effectiveness for consumers. CLASP also fully supports the Commission's proposal in the Working Documents to require that halogen converters: (1) be able to operate at all power loads, ranging from 15% to 100% of their nominal output power; and (2) for certain models, have a no-load power consumption of 0.5W when the lights are switched off. Both of these requirements are reasonable and appropriate. See Chapter 4 for a more detailed discussion on this topic.

- *A global review of LED quality standards, to assist the Commission in its effort to define appropriate and proportionate requirements for Europe:*

In Chapter 5 of the report, CLASP conducts a brief review of global LED quality standards, to assist the Commission in its effort to define appropriate and proportionate requirements for LED lamps in Europe. There are many quality metrics to consider for LEDs, and although we reviewed 7 different publications, not every quality standard include every quality metric. One of the most critical quality measures is efficacy, which quantifies the amount of light an end-user will enjoy for each watt of electricity they must pay for. In addition to this, the quality of the light emitted is also very important, and so colour rendering, correlated colour temperature, colour consistency and colour maintenance are all reviewed. Reliability is another critical factor, and some of the global LED quality programmes incorporate tests to measure lamp lifetime, premature failure rates and frequent switching durability tests. These and other quality standard levels are discussed in this Chapter 5 of the report, with a final suggestion as to what a minimum quality standard level could be for Europe.

- *Why CLASP supports the Commission in maintaining Stage 3 of the regulation:*

CLASP noted that during the July 5 Consultation Forum meeting some participants called for the elimination of Stage 3, and others called for a review cycle in 2014/2015 whereby any provisions adopted for Stage 3 might be revised or overturned based on any economic or technological changes. CLASP does not support either of these recommendations. Instead, our strongly held view is that long-term regulatory planning is an excellent catalyst for stimulation of innovation in product design and developments to acknowledge this trend and to establish energy savings. CLASP supports the Commission including a mandatory Stage 3 level, not subject to review/amendment at Stage 2, for the following reasons: (1) Stage 3 is a critical part of enabling Europe to achieve its energy savings objective; (2) Stage 3 provides considerable lead-time for companies to plan financial and human resources to prepare for the regulation; (3) Stage 3 would be consistent with other major economies such as the United States and China; and (4) Stage 3 recognises and builds upon a wealth of knowledge around technology trends and forecasts for improvement, ensuring the regulation will still be relevant in the future. See Chapter 6 for more details.

2 An IRC Regulatory Level for Low Voltage Halogen Lamps at Stage 1

As discussed in our July 5 Consultation Forum comments, CLASP is concerned about the lack of ambition for low-voltage halogen lamps shown in Table 2 of the draft Ecodesign Working Document (Ecodesign requirements for directional lamps, light emitting diode lamps and halogen lighting converters). This proposal runs counter to our expectations, particularly in the light of recent research published by eceee, including B-Class Halogens and Beyond[3] and Evaluating the Potential of Halogen Technologies.[4] We have analysed this issue and believe the Commission would be wise to consider adopting a level equivalent to halogen IRC at Stage 1 rather than Stage 3. We hold this view because of our assessment of (1) end-user payback periods, (2) maturity of the technology, (3) capacity of industry to meet demand, (4) mitigation of patent risk through existing cross-licensing agreements, and (5) other methods to improve efficacy of low-voltage halogen lamps besides IRC. In this chapter, we discuss each of these points and provide the evidence and rationale underpinning the recommendation. In section 2.6, we discuss the regulatory measure itself, highlighting the importance of adopting a wattage cap for certain lamp types to ensure energy savings are realised.

2.1 Payback Periods for Low-Voltage Halogen Lamps

The latest generation of high quality 35 Watt IRC low-voltage halogen lamps are able to produce the luminous flux equivalent of conventional halogen 50 Watt models[5], and can be readily installed into the same sockets at the time of failure or earlier. In its review of the economics of this option, CLASP found that even with the relatively conservative assumptions from the Preparatory Study, the low-voltage 35 W IRC MR16 lamps are already a more attractive option than the 50 W standard halogen lamps for all types of consumers. Using more realistic assumptions, the advantages of shifting to an IRC requirement are even more clear.

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[3] http://www.eceee.org/press/B_Class_lamps/BClassHalogens_and_beyond-eceeeReportDecember12.pdf

[4] http://www.eceee.org/Eco_design/products/directional_lighting/halogen_technologies_report/eceee_report_halogen_technologies

[5] See for example, Philips's 2011 MR-16 catalogues: http://download.p4c.philips.com/l4bt/3/332430/energy_advantage_ir_mr16_332430_ffs_aen.pdf and http://download.p4c.philips.com/l4bt/3/332431/mr16_332431_ffs_aen.pdf

Table 2-1. Cost-Effectiveness of IRC for Low-Voltage Directional Halogen Lamps

Variables	Household LV MR-16		Professional LV MR-16	
	Standard Halogen	IRC Halogen	Standard Halogen	IRC Halogen
Lamp Wattage[1]	50 W	35 W	50 W	35 W
Lamp Lifetime[2]	3000 hours	5000 hours	3000 hours	5000 hours
Hours Use/year[3]	500 to 820 hours		1800 hours	
Cost of Electricity[4]	€0.1676/kWh		€0.1037-0.1676/kWh	
Incremental IRC Price[5]	€1.8-5.5			
Annual Savings with IRC		7.5 -12.3 kWh €1.3 - 2.1		27 kWh €2.8 - 4.5
Simple Payback in Operating Hours		727-2188 hours (15-44% of lamp life)		727-3536 hours (15-71% of lamp life)
Simple Payback		0.9-4.4 years		0.4-2.0 years

[1] Manufacturer Catalogues

[2] Manufacturer Catalogues; comments from Ray Burgin on eceee study http://www.eceee.org/Eco_design/products/directional_lighting/Comments_Burgin_eceee_report

[3] EuP Preparatory Study, Lot 19, part 2, Table 2-15; Australian average household operates 2.25 hours/day.

[4] Eurostat:http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-10-046/EN/KS-QA-10-046-EN.PDF

[5] The incremental IRC price is the difference between the retail price of a standard lamp and the retail price of an IRC lamp. The price differential of €1.8 came from the Australian analysis. The price differential of €5.5€ came from the EuP study Lot 19, part 2, Table 2-18. According to our research, the 2011 price differential in Europe would be between the two, around €2.40 (see Table 2-2).

Using electricity prices from the latest available report of Eurostat, the average purchase prices and the operation hours reported in the Ecodesign study[6], we calculated payback periods around 4 years for households and 1 to 2 years for professional consumers. Using more reasonable assumptions for operating hours, the payback periods are shortened to 0.9 years for households and 0.4 years for professional consumers. For both scenarios, these payback periods are well within the service life of the IRC directional lamp, meaning the additional cost of an IRC lamp is recovered within the lamp lifetime.

Moreover, CLASP considers some of the input assumptions to be conservative, for example in the household sector the Preparatory Study estimates that these lamps are used for 500 hours per year, which is about one hour and twenty minutes per day. This estimate is based on the REMODECE study[7], which had a broad remit across multiple appliances and technologies and was not a robust end-use lighting study. Criticisms of the study that have been raised in the past which will tend to reduce the operating hour estimates include:

1. Subjects knew they were being studied, thus metered households may adjust their behaviour and surveyed households may not respond truthfully to questionnaire;
2. The study did not identify directional vs. non-directional lamps, nor did it consider low-voltage halogen. Instead, it classified five lamp types: incandescent GLS, halogen 230 volt low wattage; halogen 230 volt high wattage; compact fluorescent and linear fluorescent.

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[6] The Ecodesign study reports average purchase prices of €1.5 for non-IRC and €7 for IRC low voltage halogen, and operation hours of 500 hours/year for the residential sector and 1800 hours/year for non-residential.

[7] http://remodece.isr.uc.pt/downloads/REMODECE_PublishableReport_Nov2008_FINAL.pdf

3. The study only considered two room types - "living room" and "other rooms", thus high usage rooms where low-voltage MR-16 lamps are commonly found such as kitchens were not explicitly studied.

Furthermore, the Preparatory Study's incremental price increase of €5.50 was not supported by our research on European lamp suppliers. We found the difference in retail price to be much lower than was estimated in the Preparatory Study and we therefore presented ranges for several parameters in Table 2-1 above, in order to also account for values we consider more realistic, both for incremental prices and for operating hours.

We identified lamps with and without IRC that could be considered equivalent (i.e., same manufacturer, same luminous flux and rated average lifetime), and compared the prices from online suppliers who offered a price for the two equivalent products. The table below shows the products considered, their performance characteristics, and their prices. The value used by VITO in the Preparatory Study is approximately double the price differential of 2011.

Table 2-2. Price comparison IRC/non-IRC MR-16 Lamps in France, 2011

Model	Power	Light (24D)	Lifetime	Price
MASTERLINE ES MR-16	35 W	800 lm	5000	€5.39
Accentline MR-16	50 W	800 lm	3000	€1.69
2011 price difference				€3.70
DECOSTAR 51 ECO MR-16	35 W	4100 cd	4000	€3.39
DECOSTAR 51S Standard MR-16	50 W	2600 cd	3000	€1.01
2011 price difference				€2.38
Preparatory Study price difference				€5.50

Sources: Manufacturer Catalogues; http://www.getalamp.com/, http://www.lampesdirect.fr/

In Australia's analysis of IRC directional lamps, the Beletich Associates market survey found an incremental lamp cost of AUD2.50 (€1.80) and household operating hours of 2.25 hours per day (820 hours/year) were reported. If we calculate the payback period using the Australian incremental cost[8] and operating hours, we find that for a household, the payback period is 728 hours, *i.e.* less than a year, and for a professional sector end-user, the payback period is 1156 hours, *i.e.* less than 8 months. Using either the Preparatory Study estimates or our own more up-to-date inputs, the payback periods for both scenarios are compelling and well within the service life of the IRC directional lamps, meaning the additional cost of an IRC lamp is recovered within the lamp lifetime.

2.2 Maturity and Potential of IRC Technology

IRC is a mature, well understood, and reliable technology for improving the performance of halogen lamps. It is already widely available in the market, and is incorporated into products retailed by all major lamp manufacturers. Expanding its market penetration through regulatory measures incurs no uncertainty or risk from a technological point of view. Furthermore, laboratory prototypes have already demonstrated that there is existing potential for increasing the performance of IRC coatings beyond what is commercially available today.

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[8] Average currency exchange rate from August 2010 to August 2011: 1 EUR = 1.3670 AUD: http://www.ecb.int/stats/exchange/eurofxref/html/eurofxref-graph-aud.en.html

IRC coatings are thin-film coatings that are applied to the exterior of a halogen capsule. The coating generally consists of two alternating materials, one with a high refractive index and one with low refractive index. By adjusting the number of layers and the thickness of each layer, a manufacturer can adapt the reflective (to infrared light) and transmissive (to visible light) properties of the coating.

In addition to having a good coating, it is also important that the halogen capsule be optically designed so that the wavelengths of reflected infrared light are adsorbed by the filament and converted back into heat. This heating of the filament through the 'recycling' of otherwise wasted energy, enables manufacturers to reduce the wattage consumption of the filament while maintaining the optimum operating temperature. Thus, the filament can continue to operate at 3000 Kelvin with the same visible light output, but only consume 35 W instead of 50.

The diagram below depicts a halogen capsule with an IRC, which is labelled and depicted as a green curved line on the outer shell of the capsule. The orange arrows represent the light emitted by the filament. The red arrows represent the infrared light that is reflected back onto the filament by the coating, while the visible light (yellow arrows) pass through the coating and are emitted into the living space.

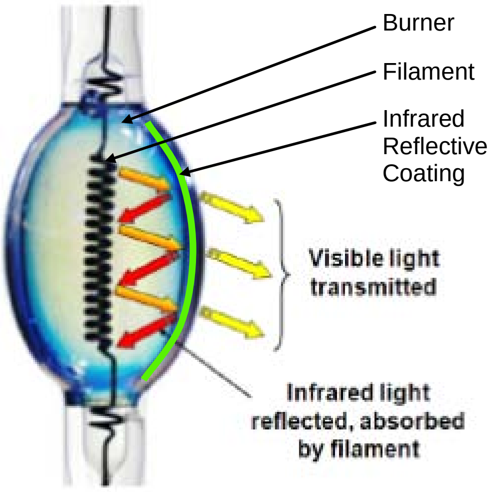

Figure 2-1. Diagram of Infrared Reflective Coating
Source: Ecos Consulting, 2011

The IRCs commonly used in commercially available low-voltage reflector lamps today are not the best coatings available in the market. When assessing the performance of a coating, manufacturers typically refer to the 'gain' of a coating, which represents the performance of a coated capsule relative to a non-coated capsule, at the same hot filament resistance. To better understand the meaning of 'gain', consider the following example for a single-ended halogen capsule shown in the table below. The first row of the table gives the performance characteristics for the non-coated halogen capsule. The second row shows that same capsule with an IRC applied to the capsule, but no other adjustments made to the lamp. The resistance is higher, the wattage is slightly lower, but most important is the lumen (lm) output, which has jumped nearly 45%. In the third row of the table, the resistance is adjusted until it matches the original non-coated capsule. For the coating on this capsule, the 'gain' is 1.26, calculated by taking the ratio of the two efficacies of the lamps.

Table 2-3. Single-Ended Halogen Lamp Before and After Coating

Type	Voltage	Current	Wattage	Resistance	Lumens	Efficacy
Non-Coated	12.01 V	3.16 A	37.9 W	3.80 Ohm	549.0 lm	14.5 lm/W
IRC capsule	12.01 V	3.01 A	36.2 W	3.99 Ohm	787.8 lm	21.8 lm/W
IRC capsule, adjusted resistance	10.78 V	2.84 A	30.6 W	3.80 Ohm	558.2 lm	18.2 lm/W

Source: Auer Lighting, Personal Communication, 6 September 2011.

As explained above, besides the quality of the coating itself, the geometry of the burner has an important impact on the halogen capsule “gain”. The typical gain of commercially available IRC used by major lamp manufacturers today is approximately a 1.35 to 1.40. The best commercially available coatings today for these low-voltage directional lamps have a gain of 1.40 to 1.45. The best coatings demonstrated in the laboratory, but not yet commercialised have a gain of 1.50 to 1.55. At these higher gains, fewer watts are needed to produce the same quantity of visible light.

Thus, as new and better coatings and burners are developed and commercialised, it would be reasonable to expect to see further improvements in efficacy for these directional lamps. And, should the Commission decide to establish the baseline of the commercially available IRC level in Stage 1, there would continue to be opportunity for manufacturers to offer ‘premium’ efficiency products that are above the minimum standard, to differentiate their brand and offer environmentally-conscious consumers more choice.

Greater efficient IRC lamps offer (1) significantly greater luminous efficacy – the same light for less power consumption; (2) significantly reduced heat output which reduces the load on air conditioning systems; and (3) when installing new systems, fewer halogen converter power supplies are needed when compared to standard halogen lamps. As these new and improved IRC coatings become commercialised, these and other benefits will be experienced by households and professional consumers alike.

2.3 Capacity of Industry to Meet Demand

One of the concerns raised in opposition to the acceleration of an IRC regulatory standard for LV directional lamps from Stage 3 to Stage 1 is a lack of manufacturing capacity to meet demand. This issue needs to be reviewed carefully, as it is our understanding after speaking to leading IRC equipment suppliers is that new equipment capacity is being added now, and supply will be able to meet demand. (DSI, 2011; Auer, 2011)

The table below projects forward the EU-27 sales based on data from the PRODCOM database for 2003 through 2009. Using a linear regression curve-fit to that data, these sales are projected to 2013 in order to get an indication of the magnitude of the market when tier 1 is expected to apply. The share of reflector halogens is taken from the Preparatory for lot 19.

Table 2-4. EU-27 LV Halogen Sales from PRODCOM and Forecast to 2013

	Production	Share of HL-LV-R	Production of HL-LV-R
2003	292,828,902	55%	161,055,896
2004	296,338,836		162,986,360
2005	265,057,569		145,781,663
2006	258,768,905		142,322,898
2007	242,590,240		133,424,632
2008	224,265,603		123,346,082
2009	224,909,088		123,699,998
2010 (estimate)	220,000,000		121,000,000
2011 (estimate)	210,000,000		115,500,000
2012 (estimate)	200,000,000		110,000,000
2013 (estimate)	190,000,000		104,500,000

Source: Share of HL-LV-R: Preparatory Study; Production volume: PRODCOM, Product Category: 31501295 Tungsten halogen filament lamps for a voltage <= 100 V (excluding ultraviolet and infrared lamps, for motorcycles and motor vehicles); CLASP forecast using linear regression to project sales for 2007 through 2010.

Bearing in mind the estimated EU-27 demand for about 105 million lamps, Ecos Consulting looked at the lamp and component manufacturers who are engaged in IRC capsule coating technology in Europe. Ecos started by identifying the major IRC producers by region (Ecos Consulting, 2011):

- Germany: Auer, Osram and Philips
- India: ADLT
- Japan: Toshiba
- USA: DSI, GE and Osram

They then estimated the installed and future IRC capacity for Europe (Ecos Consulting, 2011):

Table 2-5. European Manufacturing Capacity for IRC Halogen Capsules

Company	2010	2011	2012
Auer	25 million	40 million	50 million
Philips	~10-15 million	~15 million	~15 million
OSRAM	~5 million	~5 million	~5 million

Source: Ecos Consulting, 2011.

Although the European manufacturing capacity may certainly fall short in 2010 (40-45 million against a demand of 121 million LV halogen lamps), the forward projections are for rapid growth which could be accelerated by various suppliers. For instance, there are other manufacturers of thin-film deposition equipment used in semiconductor and other high-tech industries that could also produce IRC equipment, if the demand for IRC increases.

CLASP believes that if the Ecodesign regulatory level were set at the IRC level for LV reflector lamps, there would be sufficient capacity because (1) the estimates above are not exhaustive capacity estimates for Europe (i.e., there is additional IRC capacity in Europe); (2) manufacturers can subcontract the coating process to a third-party; (3) manufacturers can purchase coated capsules for assembly from an OEM supplier; (4) manufacturers can invest in new manufacturing equipment, and (5) considering the efficiency of the best non-IRC halogen reflectors on the market, we believe that if the efficiency requirement is set at the level of the current typical commercially available IRC, it wouldn't mean that this particular technology would be the necessary to comply. On option (4) on new manufacturing equipment, ADLT estimates that they can produce five to ten machines per year for applying IRCs to halogen capsules, and each machine will have a through-put of 8 to 10 million capsules (Ecos Consulting, 2011). The commissioning time for one of these production lines is approximately 8 months, thus within 1-1.5 years, the capacity could be increased by a further 40-100 million units through equipment sourced from ADLT alone. IRC machines for halogen capsules are being installed this year in both China and India (DSI, personal communication 2011).

Options (2) and (3) in the list above create the potential for European manufacturers to supplement their existing IRC capsule processes through outsourced purchasing from reputable companies. This has the advantage of obviating the need for purchasing new capital equipment while at the same time, will enable energy savings and benefits to be realised sooner by European citizens.

Furthermore, the Preparatory Study was published in 2009, and in that report, the study authors concluded that the IRC level for low-voltage halogen lamps to be the most cost effective[9]. Given that the document was publicly available and widely studied (several hundred interested stakeholders were registered), companies will have had a few years to review their budgets and make planning decisions – whether to invest in IRC equipment for their own in-house production or to investigate options around an OEM supplier who could complement their existing IRC production lines. Given the publication date of 2009, proactive companies who anticipated the Commission may adopt minimum requirements at the LLCC level have been planning for such an eventuality. We believe that it would only be fair to reward those manufacturers who banked on a quick adoption of such requirements, instead of penalizing them for preparing where some others have not.

2.4 Patent Risk is Mitigated by Cross-Licensing

The issue of patents has been raised by the European Lamp Confederation (ELC) as one reason why it opposes the early adoption of an IRC level for low-voltage directional lamps. This issue was investigated by Ecos Consulting, and presented in their report published earlier this year. [10] According to Ecos, patent research from early 2011 has revealed that no singular patent would act as a barrier to any manufacturer intending to produce IRC lamps. (Ecos Consulting, 2011)

ELC expressed concern over this conclusion, noting that there were "pending patent cases that may become relevant for Europe". ELC also commented that the Ecos report fails to study pending patent cases that may become relevant, covering product and production improvements. It is important to note, however, that the scope of work for the Ecos study did not include an exhaustive review of active patents and pending applications. Indeed, such a legal survey would be expensive and time consuming.

CLASP questions whether an active and pending patent survey is necessary. In our view, manufacturers have already resolved issues around the cross-licensing of patents on capsules and

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[9] "The best performer in terms of LCC is option 3 [IRC low voltage halogen reflector], reducing costs by 17% compared to the base-case." See table 7-11, Key results of the improvement option analysis for the base-case HL-LV-R on p. 537 of the Preparatory Study.

[10] ECEEE report on "Evaluating the potential of halogen technologies"; available at: http://www.eceee.org/Eco_design/products/directional_lighting/halogen_technologies_report

coatings – a scan of all the major lamp manufacturer's catalogues today shows that they are all actively marketing IRC low-voltage halogen lamps to their customers. We are therefore unsure whether it would be a useful exercise to conduct an exhaustive patent review on technologies that are incorporated into lamps that are already commercially available. Given the fact that manufacturers already cross-license and produce lamps that perform at the level we are proposing be adopted at Stage 1, then we question whether this critique of the proposed regulatory measure is warranted.

2.5 Other Methods of Improving Efficacy

IRC is one proven method of improving a lamp's efficacy, but there are other technologies and approaches that impact on the performance of directional halogen lamps and which can be explored as alternative pathways to energy-efficient designs. Some of these other factors include:

- Halogen capsule geometry and filament placement: the optical geometry of a halogen capsule must be conducive for the reflection of infrared light back from the surface of the capsule onto the filament. This is necessary for overall system efficiency improvement, as the reflected infrared light will be adsorbed by filament, transferring its energy.[11]

- Fill gas composition and pressure: changing the fill gas to xenon or krypton to reduce convective heat loss from the capsule and increasing the pressure of the gases inside the halogen capsule will both affect tungsten evaporation rates and result in a more efficacious halogen lamp. Xenon is currently used in some IRC halogen lamps[12] which, instead of using the very best of one improvement option, use a combination of approaches to achieve their high efficiency.

- Reflective coating: a critical component of a filament-based directional lamp is the reflective coating which is incorporated into part of the lamp's interior (or exterior) for the purposes of directing and controlling light. There are several materials that can be used to create reflective coatings in directional lamps, the most common being aluminium. Other materials that can be used include silver and gold, which are rare metals and thus have a high cost. The spectral reflectivity of gold is 78.7%, 98.2% for silver and 91.4% for aluminium. Silver is the most efficient reflective material for reflector lamps, however aluminium is much less expensive and does not suffer from the same oxidation/blackening problem that can affect some silver coatings.[13]

- Filament design: experimental work has demonstrated an approach to improving filament-based lamp efficiency through the use of photonic bandgap materials made in a crystal lattice structure. By controlling the lattice spacing, photonic bandgap materials will reflect a specific range of wavelengths while transmitting all other frequencies of electromagnetic energy. Combined with a microcavity resonator, these photonic bandgap materials could tailor emissions to the visible spectrum. These radiators inherently improve incandescent light emission by avoiding the production of infrared radiation in the first place.[14]

For Stage 1, CLASP is suggesting that the Commission adopt the IRC level for low-voltage halogen lamps. Defining a minimum efficacy level for the first tier that would correspond to a fairly modest

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[11] Manufacturer catalogues, Personal Communication with DSI and Auer Lighting, September 2011
[12] Manufacturer catalogues
[13] Personal communication with Auer Lighting, September 2011
[14] US Lighting Market Characterization, Volume II: Energy Efficient Lighting Technology Options, 2005

efficiency level for commercially available IRC low-voltage halogen lamps (i.e., equivalent to what will be required in Australia starting in April 2012[15]). A higher, more ambitious level could be considered for Stage 3, where manufacturers take advantage of the best IRCs available at that time and/or one or more of technology options listed above.

2.6 Suggested Requirements for Low Voltage Halogen Lamps

For the reasons discussed throughout this chapter, IRCs for LV halogen lamps is a cost-effective, commercially available, cross-licensed, proven technology, and it would be appropriate for the Commission to adopt a level of requirement corresponding to current typical IRC lamps starting in Stage 1 and thereby enable Europe to benefit from these energy savings for three additional years – almost 7 TWh of savings over the lifetime of the lamps sold.[16] MEPS for directional lamps have been under discussion for many years, enabling European manufacturers to prepare and consider their options. The Ecodesign Preparatory Study on lot 19 part 2, published in 2009 identified IRC for LV halogen as having the most favourable LLCC among the options considered. This finding is particularly compelling considering the fact that the price differential used in the Preparatory Study for IRC lamps is approximately double the price difference observed in 2011 and the operating hours used in the calculation are unusually low for the room types where these lamps are typically installed. As we have shown, using a more realistic price differential and operating hour assumption, the payback period for a household or professional installation drops to less than one year. So not only did the Preparatory Study find that the IRC lamps provided the most favourable LLCC, but these lamps also demonstrated better performance per lumen-hour in terms of total energy consumption, global warming potential, mercury emissions and electricity costs.

Furthermore, if the Commission were to take this step in Stage 1, it would be consistent with the regulatory level recently adopted in Australia.[17] Starting in April 2012, there will be a cap on wattage of low-voltage directional lamps that would prevent the sale of any lamps over 37 W (nominally 35 W, allowing for average actual tested values). Light output must be at least 500 lm (measured in a 180 degree cone), which is essentially an IRC lamp or possibly an exceptionally well designed non-IRC lamp. CLASP suggests that the Commission consider establishing a similar wattage cap on these same lamps for Europe. If not, there is a risk that manufacturers will simply produce brighter lamps at the same rated wattage as opposed to ones that save energy.

Finally, CLASP encourages the Commission to also take into account the current trend in the low-wattage directional lamp market, where consumers are shifting from 12 V MR-16's to 230 V MR-16's. The 230 V (called MV in the Preparatory Study) directional lamp types are inherently less efficient than the 12 V (LV) directional lamps because of the filament and the technology's performance at higher voltage. In order not to accelerate that trend of new installations shifting away from LV directional lamps due to an IRC regulatory level for low-voltage products, the Commission may also choose to bring forward the Xenon-filled requirements for line-voltage halogen lamps.

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[15] Personal communication with Steven Beletich, 8 August 2011

[16] Estimate of energy savings based on assumed 100 million units sold per year for 3 years, half of which are forced to move from 50 W to 35 W, and a lifetime of 3000 hours, that equates to 6.75 TWh of savings.

[17] Steven Beletich, personal communication

3 Premium Regulatory Level for Directional Lamps at Stage 3

CLASP believes it would be reasonable for the Commission to consider adopting an ambitious regulatory measure for all directional lamps in Stage 3. The level could be set such that only the best performing IRC halogen lamps can reach it, and reasonably good quality LED directional lamps. We believe this level is necessary and appropriate because: (1) LED technology is rapidly evolving and surpassing all competing lighting technologies; (2) IRC halogen has proven its capability in the market and still has more improvement potential demonstrated in the laboratory; (3) higher regulatory requirements at Stage 3 appear to be economically justified; and (4) an ambitious regulatory level at Stage 3 will result in significant energy savings in Europe.

3.1 Improvements in LED Technology

One of the technologies that people know is going to continue to exist and be part of the future lighting market is LED. The Commission would be wise to establish a regulatory level in Stage 3 that encourages innovation and pushes R&D departments to focus on energy efficiency of their LED products.

LEDs have been in commercial production since the 1960's, but only started to be used in general illumination application in the last decade. Since then, R&D investment in this technology has been increased significantly, and the benefits of this research can be shown in the figure below. LED technology continues to improve, and at the package level (pictured), the ability to convert electrons into photons far exceeds that of all other lighting technologies. By 2020, US DOE expects the luminous efficacy of the best products to be over 250 lm/W, which is 10 times better than a 25 lm/W HIR LV halogen and more than twice as efficient as a T5 or T8 linear fluorescent lamp (approx. 90-110 lm/W).

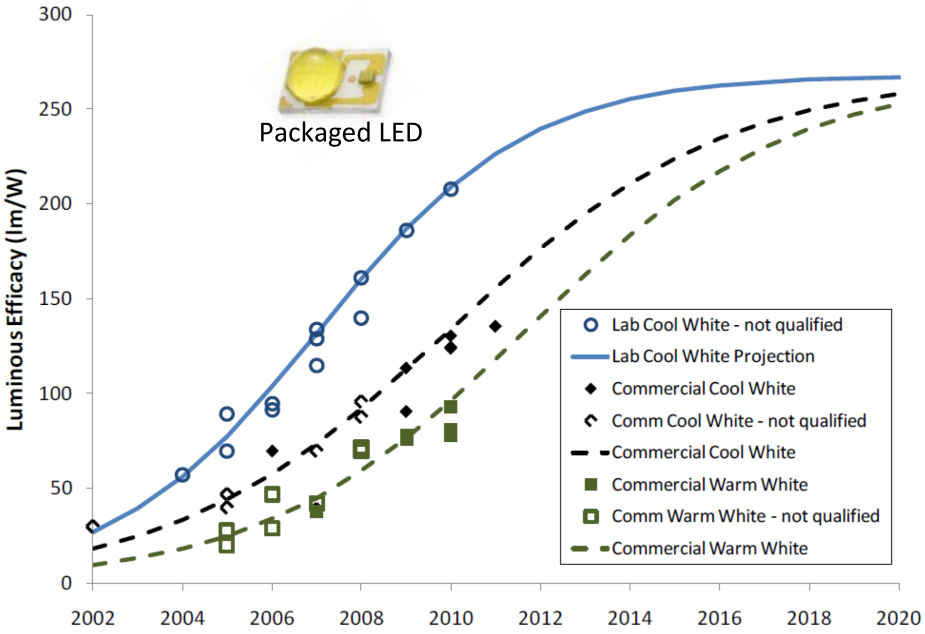


Figure 3-1. Packaged LED Performance Actual Products and 2020 Forecast

Incorporating these packaged LEDs into lamps and luminaires results in a reduction in system performance. The following table presents DOE's estimate of LED luminaire performance today and projected to 2020. LED efficacy is presented in the first row of this table, and then its performance is degraded as losses from the driver, fixture and other factors, resulting in a system efficacy value in the bottom two rows. The *system* efficacy values being envisaged for 2015 – which is 1-2 years before Stage 3 in the Commission's draft Working Documents – are between 123 and 139 lm/W.

Table 3-1. Summary of LED Luminaire Performance Targets

Metric	2010	2012	2015	2020
Package Efficacy – Commercially Available Warm White (lm/W, 25°C)	92	141	202	266
Thermal Efficiency	86%	86%	88%	90%
Efficiency of Driver	85%	86%	89%	92%
Efficiency of Fixture	85%	86%	89%	92%
Resultant luminaire efficiency	62%	64%	69%	76%
Luminaire Efficacy – Commercial Warm White (lm/W)	57	91	139	202
High Current Luminaire Efficacy – Commercial Warm White (lm/W)	44	74	123	202

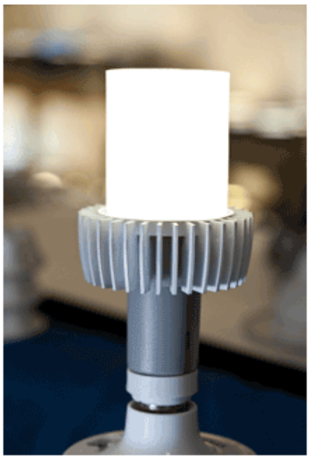
Source: US DOE, 2011: Multiyear Program Plan for Solid State Lighting, FY2011. Table 5.5: Summary of LED Luminaire Performance Targets (at operating temperatures)

[1] Efficacy projections for warm white luminaires assume CCT=2580-3710K and CRI=80-90.

[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.

While these efficacy target levels may appear to be ambitious at first, prototype products already exceed this performance level. On August 1, 2011, Cree announced a "21st Century Lamp" that delivers more than 1,300 lm at 152 lm/W.[18] Having a system performance of 152 lm/W is better than the 123 to 139 lm/W forecast by DOE for 2015. When interviewed about this lamp, one of Cree's co-founders said, "Not long ago, fixture efficacy of 100+ lm/W was impossible, but Cree is shipping fixtures at 110 lm/W today. We calculate that if fully deployed, LED lighting at 150 lm/W could bring a 16.5 percent reduction in the [United States] electric-energy consumption, returning it to 1987 levels." In order to achieve this level of performance, Cree is capitalising on advancements in LEDs, optical performance, drivers and power supplies. Optimising each element enables this level of performance to be achieved.



Finally, as the technology improves and companies get better at designing and building these products, manufacturing costs will start to come down and those savings will be passed along to consumers. The figure below provides an indication of the rate at which retail prices are expected to decline, making LED replacement lamps more affordable and payback periods more competitive. In this figure (DOE, 2011), a price-curve is plotted which depicts a white-light LED replacement lamp for a 13W compact fluorescent lamp. These prices represent the average retail sales price. On the log-plot of the Y-axis, the OEM price drops from €145 in 2008 to €7.55 in 2015, at which point LEDs will be over 120 lm/W, and the value proposition will be compelling.

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[18] Cree Inc. press release, 1 August 2011: http://www.cree.com/press/press_detail.asp?i=1312203835951

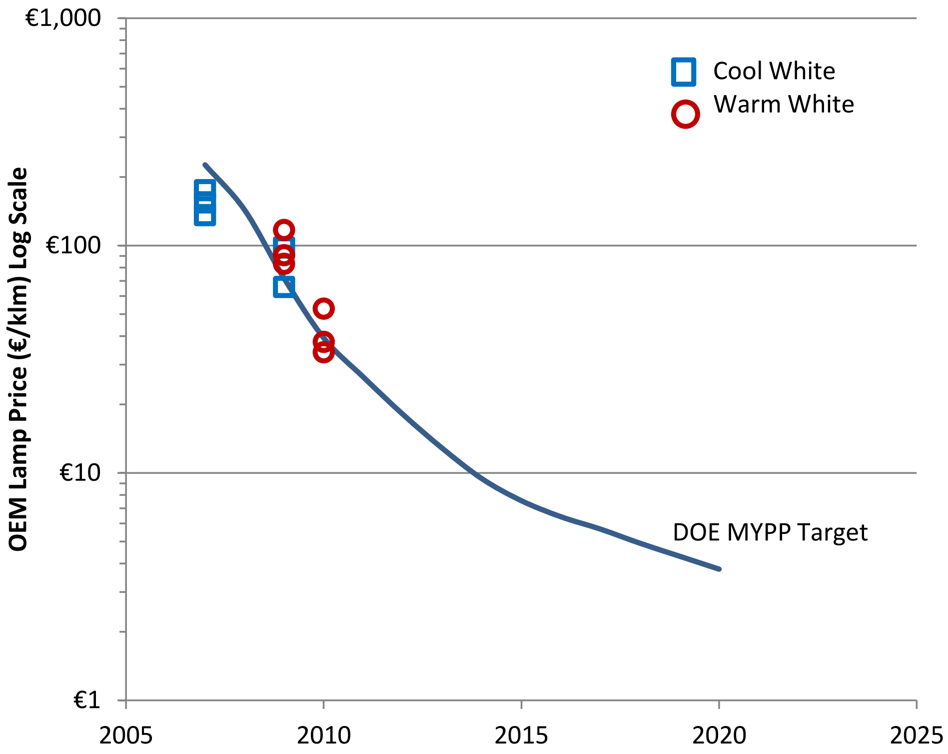

Figure 3-2. LED Lamp OEM Price Reduction Plot to 2020
Source: US DOE, SSL Multi-year Programme Plan, 2011; converted to Euro per kilolumen (€/klm) using the 2010 average exchange rate of $0.755/€.

Thus, in terms of average performance and average cost, the US DOE's most recent Multiyear Programme Plan, which is developed in collaboration with the National Electrical Manufacturers Association's (NEMA's) Next Generation Lighting Industry Alliance (NGLIA), indicates that by 2015, it would be reasonable to expect 123-139 lm/W and €7.55 per kilolumen ($10 per kilolumen). We will use these performance values in section 3.4 where we calculate the payback period for these lamps.

3.2 Improvements in IRC Halogen Directional Lamps

In section 2.2 of this report, CLASP discusses the performance of IRC coatings, and the fact that there are still significant efficacy improvements to be commercialised by lamp manufacturers. Taking into account the potential for a low-voltage, optically optimised halogen capsule and best available IRC coating, it is possible for directional IRC lamps to achieve efficacy values greater than 30 lm/W for directional lamps – more than double the standard incandescent lamp.

Greater efficient IRC lamps offer (1) significantly greater luminous efficacy – the same light for less power consumption; (2) significantly reduced heat output which reduces the load on air conditioning systems; and (3) when installing new systems, fewer power packs are needed when compared to standard halogen lamps. As these new and improved IRC coatings become commercialised, these and other benefits will be experienced by households and professional consumers alike.

3.3 Cost-Effective Stage 3 Regulation for Directional Lamps

Understanding that the Stage 3 requirements would only take effect in 2016 at the earliest, in the table below, we perform a cost-effectiveness calculation using the assumptions given in the table. In the first scenario, we consider a 'business as usual' case where the Commission does not regulation directional lamps in Stage 1, or has only a fairly unambitious requirement. In the second scenario, we consider a case where the Commission adopts the IRC requirement at Stage 1. The lamp lifetimes are shown, the operating hours are held constant at 800 hours per year (2.2 hours per day, in line with Australia) and the electricity price is held constant. To calculate the price differential between the baseline lamp and the more efficient LED replacement, we used the 2011 prices and subtracted them from the predicted USDOE price point of €7.55/klm[19] ($10/klm) in 2015.

Taking all this into account in our calculations, we found that there are significant energy savings in both scenarios – somewhere between 22-34 kWh per year, which equates to €2.27-5.68 of savings, depending on whether the calculation is performed using the Eurostat average domestic electricity price or the average commercial/industrial price. The payback periods justifying a higher level at Stage 3 (potentially an LED level) are also very attractive – all of them being at 18 months or less.

Table 3-2. Cost-Effectiveness of LED Directional Lamps in 2015 (Hypothetical Case)

Variables	**Scenario 1 MR-16 (BAU)**		**Scenario 2 MR-16 (IRC at Stage 1)**	
	Standard Halogen	**LED replacement**	**IRC Halogen**	**LED replacement**
Lamp Wattage	50 W	7.6 W[1]	35 W	7.6 W[1]
Lamp Lifetime	3000 hours	20,000 hours	5000 hours	20,000 hours
Hours Use/year[2]	800 hours		800 hours	
Cost of Electricity[3]	€0.1037 to 0.1676/kWh		€0.1037 to 0.1676/kWh	
Incremental price[4]	E5.42		€1.72	
Annual Savings with IRC		33.92 kWh €3.52-5.68		21.92 kWh €2.27 to 3.67
Simple Payback		0.95-1.54 years (4% of LED lamp life)		0.47-0.76 years (2% of LED lamp life)

[1] Assumes 1000 lumens of light at 131 lm/W, the average of 123-139 lm/W

[2] Range of operating hours, from EuP Preparatory Study, Lot 19, part 2, Table 2-15; and for an average Australian household operates 2.25 hours/day.

[3] Held constant at the 2011 price for domestic and commercial/industrial from Eurostat:http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-10-046/EN/KS-QA-10-046-EN.PDF

[4] The incremental price is the difference between the retail price of a standard lamp (or an IRC lamp) and the projected retail price of an LED replacement lamp in 2015. The price of a 1000 lumen LED lamp in 2015 is given by DOE as USD10 = €7.11. The baseline MR-16 is €1.69 and the IRC Lamp is €5.39 (see Table 2-2 in this report). The price differentials are therefore

In its review of the economics of this option, CLASP found that the LED directional replacement for an MR-16 lamp is cost effective under both scenarios, even in the case where the IRC level is made a Stage 1 requirement.

Using electricity prices from the latest available report of Eurostat, the average purchase prices and the operation hours reported in the Ecodesign study[20], we calculated payback periods between 1 and 4 years for households and 0.5 to 2 years for professional consumers. In both instances these payback periods are well within the service life of the IRC directional lamp, meaning the additional cost of an IRC lamp is recovered within the lamp lifetime.

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[19] Average exchange rate for 2010 of US Dollars to Euros: $0.755/€.

[20] The Ecodesign study reports average purchase prices of 1.5€ for non-IRC and 7€ for IRC low voltage halogen, and operation hours of 500 hours/year for the residential sector and 1800 hours/year for non-residential.

3.4 Significant Energy Savings from Ambitious Stage 3 Regulation

For the Stage 3 regulation of directional lamps, CLASP suggests that the Commission consider an approach that starts to prepare the market for next generation technologies. It is well known and understood that the efficacy of a filament-based light source with the same lifetime and operating voltage will have different efficacy values across its wattage ratings. In other words, all else being equal, a 60 W incandescent lamp is less efficacious than a 100 W incandescent lamp. Similarly, a 35 W IRC halogen is less efficacious than a 50 W IRC halogen.[21]

This general trend relating efficacy and wattage is not true of ballast/driver-operated lamps. For non-filament based lamp types, there is no underlying physical principle governing the relationship between wattage and efficacy. Thus, it is possible to purchase a 13 W CFL with an efficacy of 65 lm/W and a 26 W CFL with twice the light output, but operating at essentially the same efficacy. This is true as well for high-intensity discharge lamps and for LED-driven lamps, where the system (i.e., lamp and ballast / driver) does not follow any consistent trend between the operating wattage of the lamps and the system efficacy.

CLASP is therefore suggesting that for the Stage 3 requirement (for 2016) on directional lamps, the Commission seeks to adopt an even more ambitious efficacy requirement. Adopting a more stringent Stage 3 requirement will discourage the use of low wattage, inefficient filament-based lamps which would easily be replaceable with LED-based solutions offering equal or better light output and significantly longer operating life. It would simplify everyone's understanding of the regulation and ease the burden on market monitoring, verification and enforcement officers working in the various Member States.

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[21] The reason higher wattage filament lamps have higher efficacy values is because the lamps are designed with thicker filament wire (to accommodate the increase in current at the fixed voltage), and the thicker wire will allow for a slightly higher filament temperature which shifts the light emission from the filament to emit more visible light and slightly less infrared light. In addition, a thicker filament will create a thicker "boundary layer" of hot gas around the filament which reduces conductive heat loss from the filament, thus providing an additional boost to efficacy.

4 Halogen Converter Regulatory Level at Stage 1

CLASP strongly endorses the Commission's proposal to adopt a 92.5% efficiency requirement for halogen converters at Stage 1, and potentially an even higher level at Stage 3. We support the Commission's proposal because: (1) energy-efficient halogen converters are widely available in the market; (2) the energy savings potential of a regulation on these products; and (3) the cost-effectiveness of this measure for consumers. CLASP also fully supports the Commission's proposal in the Working Documents to require that halogen converters: (1) be able to operate at all power loads, ranging from 15% to 100% of their nominal output power; and (2) for certain models, have a no-load power consumption of 0.5W when the lights are switched off. Both of these requirements are reasonable and appropriate.

4.1 High Efficiency Converters Are Widely Available

The halogen converter market is already undergoing a transition away from magnetic voltage converters to electronic converters. For various reasons including principles fundamental to their design, electronic converters are substantially more efficient than the traditional magnetic designs, and thus end-users benefit from this technology up-grade. The figure below illustrates this point, containing a scatter plot of magnetic and electronic halogen converters. The data presented include models from an Australian study in 2005[22] and European manufacturer catalogues. Presenting full load efficiency with maximum power rating, it shows that the low power magnetic models are significantly less efficient than their electronic counterparts. At higher power ratings, the magnetic models can reach the proposed requirement, but at the lower power ratings they would be phased out in favour of better technology.

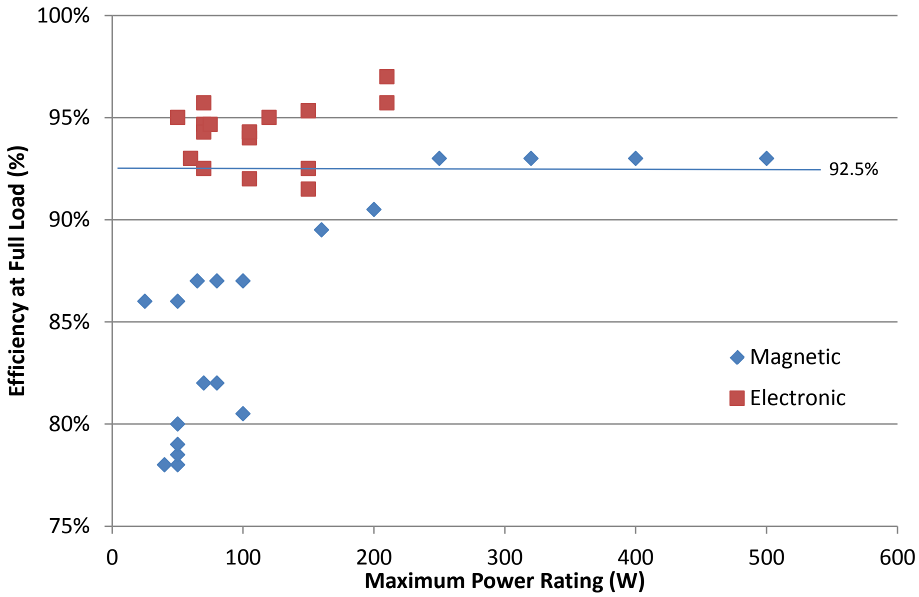

Figure 4-1. Magnetic and Electronic Halogen Converters, Efficiency vs. Rated Power
Sources: Mark Ellis and Steve Beletich, 2005; Manufacturer Catalogues.

Furthermore, it should be noted that there is no loss in utility or features associated with this technological shift to electronic converters. In fact, the electronic converters tend to be smaller, lighter and less materials-intensive. Depending on the design, there are models that are capable of

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[22] Mark Ellis & Associates, Steven Beletich Associates (2005) Analysis of the Potential for Minimum Energy Performance Standards for Power Supply Units for Extra Low Voltage Tungsten Halogen Lighting, Final Report.

being operated on dimmers, and indeed, some incorporate dimming circuits within their own control electronics. The efficiency gains are substantial (discussed in the next section) – and for a home that uses MR-16 lamps for general illumination of a room, there would be hundreds of Watts of energy savings realised through this measure.

One of the concerns raised by industry at the July 5 Consultation Forum meeting was that achieving this efficiency value across all power ratings would not be possible. CLASP does not agree with this position, as our research seems to indicate the opposite: (1) electronic halogen converters can easily achieve these efficiency ratings at the lower power ratings where magnetic designs do not; and (2) investing in better transformer design and construction may well result in low wattage magnetic halogen converters able to comply.

Magnetic halogen converters are made in two forms – “E-I” construction, which is the most common (and least efficient), and toroidal construction, which is more common at higher wattages. Generally, toroidal transformers are several efficiency points higher than EI-transformers – for example, approximately 5% more efficient for a 60 W converter. Toroidal transformers are shaped in a continuous ring, and are therefore more difficult to wind. For this reason, toroidal transformers are primarily used in the larger wattage rating applications.

CLASP understands that EI halogen converters can be improved by using better quality core steel to reduce losses. This includes constructing the core with thinner laminations of metal and less magnetic flux resistance. This higher grade of steel is more expensive – approximately four times more than the standard steel per pound, making designs that incorporate this material 1.5-2 times more expensive than an equivalent toroidal transformer with standard grade core steel.[23] In addition to looking at core material, the use of low resistance windings, including larger diameter wire will also reduce losses.

While these are feasible solutions for improving the performance of magnetic halogen converters, it may be the case that a materials-intensive approach to achieving efficiency may not be the most cost-effective path for reducing energy losses for businesses and consumers. Thus, if they were designed, it would become clear that the electronic halogen converter is the least expensive method for achieving efficient performance. Plus, since electronic converters can be built with a secondary output of high-frequency AC or DC voltage, they can be installed in many different applications. For example, in their comments to the Commission on the first draft of the Working Documents, ELC highlighted the fact that “electronic convertor type control gear with high frequency output cannot be used when the distance of the lamp from the control gear exceeds 2 metres.” This statement is correct, but omits to mention that an electronic converter type control gear with a bridge rectifier or other means of converting high-frequency AC into DC would be able to be used in a configuration where the distance between the lamp and the control gear exceeded 2 metres.

4.2 Energy Savings Potential is Significant

The installed stock of halogen lighting converters was analysed in the 2007 Preparatory Study on power supplies and battery chargers. In that study, it was estimated that the installed stock of halogen lighting converters in Europe was 20 million units, and that 30% of these were magnetic and 70% were electronic. This means that the number of installed magnetic converters is approximately 6 million and the number of electronic converters is approximately 14 million. The Preparatory

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[23] Lot 7 Ecodesign Preparatory Study on Battery Chargers and External Power Supplies, BIO Intelligence Service, January 2007.

Study estimates that the baseline efficiency of the magnetic converters is 80% and the efficiency of the electronic converters is 92.5%. The study also states that the most commonly sold wattage magnetic converter is the 60 W. All of these seem to be reasonable assumptions, and we use them in our calculation presented in this section.

The operating hour estimate for halogen lighting in the Preparatory Study was 10 hours per day. No reference is provided for this estimate, which we consider to be too high. We are concerned that the energy savings potential calculations in the preparatory study might be overstating the benefit to the European Union because the operating hours are significantly higher than reality.

For our calculation of the energy savings potential, we will use the same assumptions that were presented in our payback period calculation for MR-16 lamps, namely 800 hours of use in a household and 3000 hours of use in a professional installation. We will also assume a 50/50 split of the installed stock of magnetic halogen lighting converters between the household and commercial sectors.

Table 4-1. Energy Savings from Converting the 2005 EU-27 Stock to Electronic Converters

Variable	Household Sector	Commercial Sector
Full Load Efficiency - Magnetic	80%	80%
Full Load Efficiency - Electronic	92.5%	92.5%
Number of Units Installed Stock	30,000,000	30,000,000
Operating Hours Per Year	800	3000
Average Rated Wattage	60 W	60 W
Unit Losses for Magnetic Converter/year	9.6 kWh	36.0 kWh
Unit Losses for Electronic Converter/year	3.6 kWh	13.5 kWh
Savings Per Unit Upgrade/year	6.0 kWh	22.5 kWh
Total Savings EU-27 Stock Upgrade	180.0 GWh	675.0 GWh

Overall, Europe can potentially save 855 GWh of electricity by converting its entire installed stock of magnetic halogen converters to electronic.

4.3 Halogen Converter Payback Period for Consumers is Attractive

CLASP conducted a cost-benefit analysis to determine whether the 92.5% efficient level is an appropriate one to adopt in this regulation. Note that the operating hours for the two market segments are lower than the operating hours assumed in the Preparatory Study published in 2007, which were 3650 hours per year). Given those operating hours, the lifetime of the halogen converter is shown to be over 30 years for the household and approximately 10 for the professional installation.

Regarding full-load efficiency, for this calculation, we used two actual halogen converters that are available for sale in 2011, rather than the average of the installed stock as was used in the calculation of EU-27 energy savings in section 4.2 of this report. Thus, the magnetic halogen converter has a full load efficiency of 86%, and the electronic halogen converter has a full load efficiency of 94%. The kilowatt hour savings per year are shown, as 6.7 kWh/ year for the household, and over 25 kWh/year for the professional installation. Taking into account the cost of electricity, the savings per year are shown.

In order to calculate the payback period, we need to establish what the approximate price increase is when a household or professional consumer upgrades from magnetic to electronic converters. We find, in essence, that the price is either the same, or only a few Euros more. Thus for our calculation, we note that the increase in price as a range, from 0 to €5, and the payback period is calculated on that basis. For the household segment, the payback period is somewhere between 0 and 5 years, depending on the first cost differential. For the professional segment, the payback period is somewhere between 0-2 years, again depending on the first cost differential. The table below presents our findings of this analysis.

Table 4-2. End-User Payback Period for Electronic Halogen Converter

	Household	Professional
Operating hours	800	3000
Lifetime of Magnetic Halogen Converter	30+ years	10 years
Lifetime of Electronic Halogen Converter	30+ years	10 years
Full load efficiency, 105 W magnetic transformer	86%	86%
Full load efficiency, 105 W electronic transformer	94%	94%
kWh losses per hour at full load, 105 W magnetic	0.0147	0.0147
kWh losses per hour at full load, 105 W electronic	0.0063	0.0063
kWh savings per annum (electronic replacing magnetic)	6.72	25.20
Cost per unit electricity (€/kWh)	0.1676	0.1037
Electricity saving per annum (€/year)	1.13	2.61
Incremental additional cost of electronic converter (€)	0-5 €	0-5 €
Payback period	<5 years	<2 years

Sources: Manufacturer Catalogues; Australian Study 2006 and CLASP 2011.

It is important to note that the incremental additional cost of going from a magnetic converter to an electronic halogen converter is estimated (in 2011) to be between €0 and €5. At the time of the 2007 Preparatory Study, the authors had already noted that the price of the electronic halogen converters was falling relative to that of the magnetic converters. In fact, the study authors pointed to the rising cost of copper and core steel as two driving factors that were preventing magnetic converters from maintaining their competitive position on price. Now, five years later, in our review of websites selling halogen converters – for equivalent products, there was either no difference in price, or only a few Euros. Further study is needed on pricing, but if the cost differential is zero, then the payback period is instant, and the Commission would be doing its citizens a great service to eliminate magnetic halogen converters from the European lighting market.

In essence, there is strong economic justification for establishing a 92.5% efficiency requirement at Stage 1. In many ways, CLASP views this technology transition away from magnetic halogen converters as similar to the phase-out of magnetic fluorescent lamp ballasts and incandescent lamps. In both cases, a superior technology was in the market, already claiming market share from the incumbent (i.e., inefficient technology), and a regulation was adopted to help ensure that those who do not always conduct full life-cycle cost analysis before installing lighting equipment also benefit from the energy savings potential. Exactly the same regulation is required in this instance, to eliminate the magnetic halogen converters from the market and ensure that only efficient, electronic halogen converters are installed.

4.4 Halogen Converter Operating Range and Standby Power Requirements

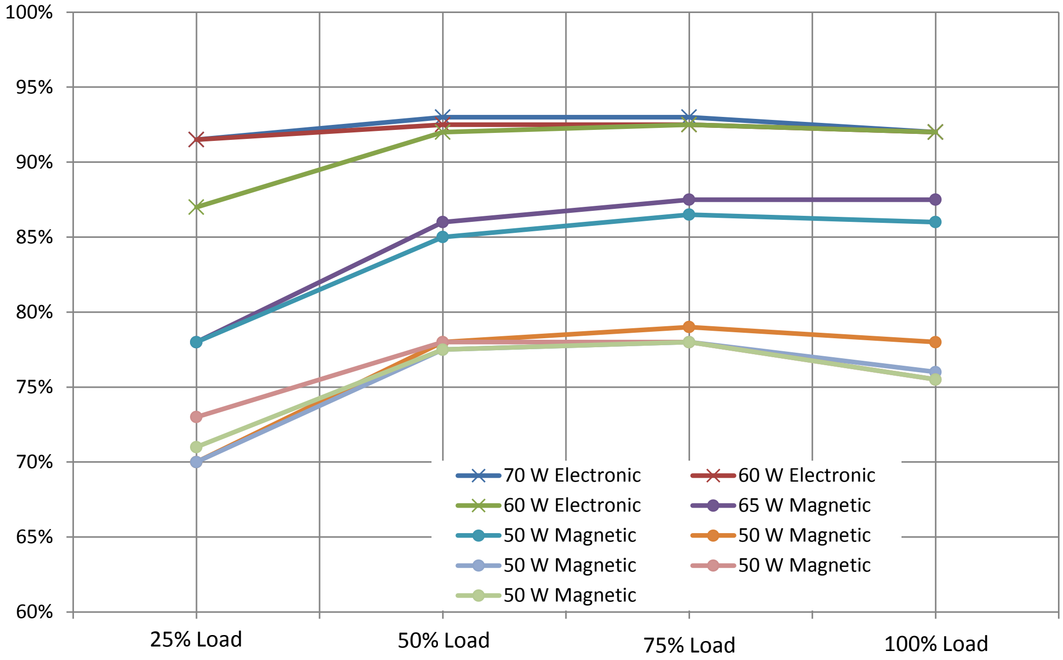
CLASP fully supports the Commission's proposal in the draft Working Documents to require that halogen converters: (1) be able to operate at all power loads, ranging from 15-100% of their nominal output power; and (2) for certain models, have a no-load power consumption of 0.5 W when the lights are switched off. Both of these requirements are reasonable and appropriate.

It is very important that the Commission require halogen converters be able to operate under a wide range of loads. This is not only advantageous from an energy-efficiency point of view, but it is also important from a safety point of view. Lamp manufacturers are already moving to develop LED replacements for MR-16 halogen lamps, and it is likely that over the next 3-5 years, this technology will be perfected and LED lamps will be available that are capable of being installed and operated in these sockets.

One of the critical issues holding back performance of these lamps today is the ability for the LED lamp to dissipate waste heat – particularly as this is a small lamp profile and it is often installed in closed or tightly-fitting fixtures. The easiest way to manage the waste heat is to convert more of the incoming energy into light. Taking advantage of the efficacy gains in LED lighting (see section 3.1), an LED system going from 30 lm/W to 60 or even 90 lm/W will generate one half to one third as much waste heat per useful unit of light. As the waste heat is reduced, longer operating life and better performance will follow, improving the value proposition of LED in this application. However, the power consumption of replacement equivalent LED lamps will also decrease, dropping from 50 W for a halogen lamp to 15 W, 10 W or potentially even lower wattages in the future. By requiring that the converter is able to operate all the way down to 15% of its nominal output power, the Commission will ensure that the converter is able to safely accommodate these replacement lamps during its operating lifetime.

Consider the following graph which shows the efficiency of the halogen power converters at part load performance (25%, 50%, 75% and 100% of rated capacity) in the figure below. In this graph, the electronic halogen converters are depicted with an "X" symbol and all the magnetic converters are depicted with a circle. Compared to the three electronic converters shown, the efficiency of magnetic halogen converters declines faster at lower part-load levels (i.e., 25%). CLASP is concerned that in the absence of a regulation that shifts the halogen converter market from magnetic to electronic designs, the magnetic converters will continue to be installed, and then in the future, in conjunction with high-efficiency LED lamps, the system performance will be lower.

Figure 4-2. Efficiency for 50-70 Watt Halogen Converters (Australia, 2004)



Source: Australian Study, 2006.

The Commission is also proposing to require that certain types of halogen converters (i.e., those that are inserted or designed to be installed between the switch and the supply) will have a no-load power consumption of 0.5 W when the lights are switched off. This requirement is reasonable and necessary, and is consistent with stand-by power regulations that are applied across consumer goods in Europe. CELMA notes that they interpret this requirement to mean that halogen converters which are designed to operate between the switch and the lamp (i.e., those that are not constantly connected to mains power) would not be subject to this requirement. CLASP would agree with this interpretation, if it is indeed possible to ensure that halogen converters designed to be connected on the switched side of the circuit are only used on that side and are never installed on the live side of the circuit.

5 LED Quality Standards Harmonization Effort

In this Chapter of the report, CLASP presents a brief review of global LED quality standards and of several existing labels, to assist the Commission in its effort to define appropriate and proportionate requirements for LED lamps in Europe. There are many quality metrics to consider for LEDs, and although we reviewed ten different publications/documents, not every quality standard included every quality metric. One of the most critical quality measures is efficacy, which quantifies the amount of light an end-user will enjoy for each watt of electricity they must pay for. In addition to this, the quality of the light emitted is also very important, and so colour rendering, correlated colour temperature, colour consistency and colour maintenance are all reviewed. Reliability is another critical factor, and some of the global LED quality programmes incorporate tests to measure lamp lifetime, premature failure rates and frequent switching durability tests. These and other quality standard levels are discussed in this section of the report, with a final suggestion as to what a minimum quality standard level could be for Europe.

The table on the following page presents a summary of the quality metrics contained in each of the LED quality standards reviewed for this report.

Table 5-1. Summary of LED Quality Metrics for Global Standards Reviewed

Requirement / Performance Parameter	Ecodesign Working Document	CELMA / ELC Doc	China GB/T 24908-2010	ELI LED Specification	EU LED Quality Charter	IEC/PAS 62612	UK EST LED Lamps & Modules v2	US EStar LED Specification v1.3	EU eco-label (2011)	Blaue Engel
Efficacy requirements	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
Lamp wattage	**X**	**comments**	**X**	**X**		**X**				
Luminous flux	**X**		**X**	**X**		**X**		**X**		
Lamp life requirements	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
Lumen maintenance	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Premature failure rate at 10% of rated lifetime	**X**	**comments**			**X**		**X**			**X**
Number of switches before failure	**X**	**comments**	**X**	**X**				**X**	**X**	**X**
Colour rendering index (CRI)	**X**	**comments**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Correlated colour temperature (CCT)	**X**	**comments**	**X**	**X**	**X**	**X**	**X**	**X**		
Colour consistency	**X**	**comments**			**X**	**X**			**X**	**X**
Colour maintenance				**X**		**X**		**X**		**X**
Power factor	**X**	**comments**	**X**	**X**	**X**		**X**	**X**		**X**
Starting time	**X**				**X**					
Starting time from cold					**X**					
Warm-up time to x% Φ	**X**									**X**

5.1 Efficacy Requirements

Efficacy is a measure of the light output (i.e., lumen) per unit of energy input (i.e., Watts). The term 'efficacy' is used when referring to light sources because it is not a unit-less dimension like efficiency, instead it represents a measure of the visible light output of the device (i.e., lumen of light) divided by the watts of energy consumed to produce that light (i.e., watts). Efficacy is therefore measured in lumens per watt. The US ENERGY STAR, the Efficient Lighting Initiative (ELI) specification, the EC Joint Research Centre (JRC) LED Quality Charter and China's GB/T 24908-2010 all have efficacy requirements. ELI and China classify the LED lamp products into different types by wattage and CCT rating, establishing a separate efficacy requirement for each classification. The US ENERGY STAR programme followed its requirements for CFLs, by simply classifying products by wattage, irrespective of the CCT. The EC JRC LED Quality Charter divides products by CRI value and for higher CRI products (e.g. CRI>90), the stringency of efficacy requirement is lower, which seems to sacrifice efficacy for better CRI. The EC JRC LED Charter also lists target values from 2011 through 2015. The UK's Energy Saving Trust (EST) LED lamps specification states that LED Lamps should have a rated wattage no greater than 25% of the wattage they are replacing. This is not a discrete lumen per watt efficacy requirement, however, it does provide an indicative requirement of the expected wattage consumption per equivalent lamp light output.

For the three standards that do contain efficacy requirements, the stringency levels are reasonably similar. They all range between 40 and 60 lumens per watt. GB/T MEPS requirement is lower than the US ENERGY STAR, but the Tier 1 (Top Level) requirement is higher, while the Tier 2 (EE Level) is about the same as the US ENERGY STAR.

Table 5-2: Comparison of Efficacy Requirements for LED Lamps

<table>
<tr><th>Standard</th><th>Efficacy Requirements</th></tr>
<tr><td>Ecodesign Working Documents</td><td>
<table>
<tr><td>Application date</td><td>Maximum rated power (Pmax) for a given rated luminous flux (Φ) (W)</td></tr>
<tr><td>Stages 1 to 2</td><td>[formula to calculate energy class equivalent to compact fluorescent lamps, reflector HID]</td></tr>
<tr><td>Stage 3</td><td>[formula to calculate energy class equivalent to top-class LED's 2012]</td></tr>
</table>
<table>
<tr><td colspan="2">Correction factors</td></tr>
<tr><td>Scope of the correction</td><td>Maximum rated power (W)</td></tr>
<tr><td>LED lamp requiring external lamp control gear</td><td>Pmax/1.20
(more stringent than for filament lamps or HID, less than for CFLs)</td></tr>
<tr><td>Lamps other than filament lamps with colour rendering index ≥ 90</td><td>Pmax/0.85</td></tr>
<tr><td>LED lamp with 15° ≤ beam angle < 20°</td><td>Pmax/0.9</td></tr>
<tr><td>LED lamp with 10° ≤ beam angle < 15°</td><td>Pmax/0.85</td></tr>
<tr><td>LED lamp with beam angle < 10°</td><td>Pmax/0.80</td></tr>
</table>
</td></tr>
<tr><td>CELMA/ELC position</td><td>
<table>
<tr><td>Application date</td><td>Maximum rated power (Pmax) for a given rated luminous flux (Φ) (W)</td></tr>
<tr><td>Stages 1-2</td><td>[formula to calculate energy class equivalent to CFLs]</td></tr>
</table>
<p>ELC/CELMA comment: "Stage 3 of Ecodesign efficiency requirements should be deleted from this regulation and included at the review</p>

The consequence of proposed Stage 3 of Ecodesign efficiency requirements would be the phasing out of GU10 lamps in 2013 widely used and accepted by the consumers
A fast phase out of commonly used directional lamps shall be avoided as no suitable alternative lamps are available
This to prevent consumers dissatisfaction because they will be forced to replace their existing luminaires

<table>
<tr><td colspan="2">Correction factors</td></tr>
<tr><td>Scope of the correction</td><td>Maximum rated power (W)</td></tr>
<tr><td>LED lamp requiring external lamp control gear</td><td>Pmax / 1.20
(more stringent than for filament lamps – correction factors for HID and CFLs removed)</td></tr>
<tr><td>Lamps other than filament lamps with colour rendering index ≥ 90</td><td>Pmax/0.85</td></tr>
<tr><td>LED lamp with 15° ≤ beam angle < 20°</td><td>Pmax/0.9</td></tr>
<tr><td>LED lamp with 10° ≤ beam angle < 15°</td><td>Pmax/0.85</td></tr>
<tr><td>LED lamp with beam angle < 10°</td><td>Pmax/0.80</td></tr>
</table>
<p>ELC/CELMA comment: a correction factor for anti-glare capped reflector lamps is missing (AR111/ES111 fe).</p>
</td></tr>
</table>

<table>
<tr><th>Standard</th><th>Efficacy Requirements</th></tr>
<tr><td>China GB/T 24908-2010</td><td>
<table>
<tr><td rowspan="2">Rated Power (Watts)</td><td colspan="3">Efficacy (lm/W) for CCT 4000K, 5000K, 6500K</td><td colspan="3">Efficacy (lm/W) for CCT 2700K, 3000K, 3500K</td></tr>
<tr><td>Tier 1</td><td>Tier 2</td><td>Tier 3</td><td>Tier 1</td><td>Tier 2</td><td>Tier 3</td></tr>
<tr><td>1-5 W</td><td>60</td><td>50</td><td>40</td><td>55</td><td>45</td><td>35</td></tr>
<tr><td>6-10 W</td><td>65</td><td>55</td><td>45</td><td>60</td><td>50</td><td>40</td></tr>
<tr><td>11-25 W</td><td>65</td><td>55</td><td>45</td><td>60</td><td>50</td><td>40</td></tr>
<tr><td>>25 W</td><td>60</td><td>50</td><td>40</td><td>55</td><td>45</td><td>35</td></tr>
</table>
</td></tr>
<tr><td>ELI LED Specification</td><td>
<table>
<tr><td rowspan="2">Input Power (Watts)</td><td colspan="2">Efficacy (lm/W)</td></tr>
<tr><td>CCT: 5000K, 6500K</td><td>CCT: 2700K, 3000K, 3500K, 4000K</td></tr>
<tr><td>1-5 W</td><td>50</td><td>45</td></tr>
<tr><td>6-10 W</td><td>55</td><td>50</td></tr>
<tr><td>11-25 W</td><td>55</td><td>50</td></tr>
<tr><td>25-60 W</td><td>50</td><td>45</td></tr>
</table>
</td></tr>
<tr><td>EC JRC LED Quality Charter</td><td>
<table>
<tr><td></td><td>CRI</td><td>Min efficacy</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td></tr>
<tr><td rowspan="2">NDLS</td><td>>80</td><td rowspan="4">lm/W</td><td>61</td><td>65</td><td>70</td><td>75</td><td>80</td></tr>
<tr><td>>90</td><td>52</td><td>55</td><td>60</td><td>65</td><td>70</td></tr>
<tr><td rowspan="2">DLS</td><td>>80</td><td>50</td><td>55</td><td>60</td><td>65</td><td>70</td></tr>
<tr><td>>90</td><td>40</td><td>45</td><td>50</td><td>55</td><td>60</td></tr>
<tr><td colspan="8">NDLS = Non Directional Light Source; DLS = Directional Light Source
In the future, 2012 to 2015 targets might be revised according to the development in LED efficacy. Any revision will be discussed and approved at least 6 month before the entry into force</td></tr>
</table>
</td></tr>
<tr><td>IEC/PAS 62612</td><td>N/A</td></tr>
<tr><td>UK EST LED Lamps and Modules v2.0</td><td>LED products shall have a rated wattage no greater than 25% of any lamp it is claimed to replace.</td></tr>
<tr><td>US ES LED Specification v1.3</td><td>For non-standard LED lamps and replacement LED lamps, luminous efficacy:
LED lamp power Minimum Efficacy
< 10 W 50 lm/W
>=10 W 55 lm/W</td></tr>
<tr><td>EU eco-label (2011)</td><td>10 % better than the lumen per watt value according to Class A</td></tr>
</table>

Standard	Efficacy Requirements
Blaue Engel	The power consumption index (EGN) of the lamp during the minimum service life time 6.000 hours shall meet the following requirements: • EGN ≤ 10.16 + 0.291 × Ra, where • EGN = power consumption index of electric energy (electricity consumption) EGN_{Z85}, determined according to Appendix 1, para. 2.1 and • Ra = general colour rendering index averaged over the minimum service life time $Ra_{Bil.N1.M}$, determined according to Appendix 1, para. 2.1.

We believe it is crucial to maintain requirements for stage 3 in the regulation. Our view on this point is developed in chapter 6 of this report.

Considering the efficacy requirements of the EC JRC LED Quality Charter and the very rapid evolution of LED products, CLASP believes that the minimum efficacy requirement in 2016 should be set no lower than 80 lm/W. This level of performance is half the performance rating of the forecasted typical commercial LED lamp in 2016.

5.2 Lamp Wattage Requirements and Luminous Flux Requirements

The luminous flux requirements in these standards relate to light output performance. China's GB/T 24908-2010 and IEC/PAS 62612 both have the requirement that the measured light output shall not be less than 90% of the rated luminous flux (i.e., light output). The US ENERGY STAR specification for "omnidirectional" lamps (i.e., emitting light in all directions, simulating to the light distribution pattern of an incandescent GLS lamp) provides the minimum levels of light output relative to the nominal wattage of the lamps being replaced. In other words, if an LED lamp is designed to replace a 100 W incandescent lamp, its luminous flux would have to be at least 1,600 lumens. The following table presents the requirements from the programmes reviewed for this parameter.

Table 5-3: Lamp Wattage Requirements and Luminous Flux Requirements for LED Lamps

Standard	Lamp Wattage Requirements	Luminous Flux Requirements
Ecodesign Working Document	The batch shall be considered to comply with the requirements laid down in this Regulation if the average results of the batch do not vary from the limit, threshold or declared values by more than 10%. For retrofit LED, the average power required by the luminaire when operating the retrofit LED lamps shall be at most 105% of the average power required by the luminaire when operating the discharge lamps.	For retrofit LEDs: The average illuminance level in all of the selected representative points of the reference surface shall be at least 95% of the average illuminance level measured with the discharge lamps.
CELMA/ELC position	None: ELC/CELMA comment: procedure too complex for effective market surveillance - There are preconditions in standards on the requirements that a batch has to meet	
China GB/T 24908-2010	Shall be between 85% to 115% of the rated wattage, or within 0.5 W.	Measured value shall be greater than 90% of the rated value.

<table>
<tr><th>Standard</th><th>Lamp Wattage Requirements</th><th>Luminous Flux Requirements</th></tr>
<tr><td>ELI LED Specification</td><td>Test wattage shall be within ± 15% of rated wattage.</td><td>The initial luminous flux measured after the ageing time shall be not less than90% of the rated luminous flux.</td></tr>
<tr><td>EC JRC LED Quality Charter</td><td>Reference to IES LM-79-2008</td><td>Reference to IES LM-79-2008</td></tr>
<tr><td>IEC/PAS 62612</td><td>Shall not exceed the rated wattage by more than 15%.</td><td>Shall not be less than 90% of the rated.</td></tr>
<tr><td>UK EST LED Lamps and Modules v2.0</td><td>N/A</td><td>N/A</td></tr>
<tr><td>US ES LED Specification v1.3</td><td>N/A</td><td>For non-standard type: 200 lumen;
For omnidirectional replacement lamps: Lamp shall have minimum light output at least corresponding to the target wattage of the lamp to be replaced as shown below. Target wattages between the given levels may be interpolated.
<table>
<tr><th>nominal wattage of lamp replaced</th><th>minimum initial light output</th></tr>
<tr><td>25 W</td><td>200 lumens</td></tr>
<tr><td>35 W</td><td>325 lumens</td></tr>
<tr><td>40 W</td><td>450 lumens</td></tr>
<tr><td>60 W</td><td>800 lumens</td></tr>
<tr><td>75 W</td><td>1,100 lumens</td></tr>
<tr><td>100 W</td><td>1,600 lumens</td></tr>
<tr><td>125 W</td><td>2,000 lumens</td></tr>
<tr><td>150 W</td><td>2,600 lumens</td></tr>
</table>
</td></tr>
</table>

This parameter is more of a quality tolerance than a requirement. CLASP’s view is that the tolerance for lamp wattage and luminous flux should both be kept low (i.e., more restrictive), otherwise there is a risk that the real efficacy of the lamps be significantly lower than the rated value.
As mentioned in our answers to the Commission’s questions in view of the Technical Forum of September 2011, we commend the Commission’s efforts to look into tighter tolerances on performance metrics of regulated products, to help ensure that the European Community benefits from the regulation as intended.

5.3 Lamp Life Requirements

Compared to other lamps, LED lighting products can have a very long lifetime and to properly validate (i.e., test) the performance of an LED lamp over these timelines would exceed the lifecycle of the product, due to the rapid changes in LED and driver technology. Three of the standards reviewed have lamp lifetime requirements, with China’s GB/T 24908-2010 and the UK EST both having requirements for lifetime of at least 25,000 hours and 15,000 respectively. The UK EST standard defines lamp lifetime as that of the lamp/module L70, F50 point (average lumen maintenance 70% and/or 50% lamp failure), while other standards do not have specific descriptions.

The IEC and US ENERGY STAR specifications control life performance by setting requirements for lumen maintenance and do not have specific requirements for lifetime.

Table 5-4: Comparison of Lamp Life Requirements

Standard	Lamp Life Requirements
Ecodesign Working Documents	For LED lamps, lamp lifetime (Lx,Fx) means the period of operation time during which a given fraction of the total number of lamps (Fx) provide more than a pre-defined percentage of the rated luminous flux (Lx). Rated lamp lifetime at 50% lamp survival and 70% lumen maintenance: from Stage 1: ≥ 15000 hr; ≥ 10000 hr for retrofit LEDs with integrated control gear
CELMA/ELC position	Rated lamp lifetime at 50% lamp survival and 70% lumen maintenance: from Stage 1: ≥ 10000 hr for all lamps (including MR16); ≥ 15000 hr for end-user replaceable LED modules
China GB/T 24908-2010	Average lifetime shall be no less than 25,000 hr
ELI LED Specification	Must have a minimum rated lifetime of 25,000 hr when 50% of any large group of sample group fails.
EC JRC LED Quality Charter	Only expressed in terms of lumen maintenance requirements: Rated lamp lifetime at 50% lamp survival and 70% lumen maintenance: ≥ 15,000 hr Rated lamp lifetime at 95% lamp survival and 85% lumen maintenance: ≥ 1000 hr
IEC/PAS 62612	N/A
UK EST LED Lamps and Modules v2.0	The manufacturers declared life shall be that of the lamp/module L70, F50 point (average lumen maintenance 70% and/or 50% failure to light). This shall not be less than 15,000 h
US ES LED Specification v1.3	Minimum life requirement: 15,000 hours to 70% lumen maintenance (L70) for Decorative lamps (section 7B); 25,000 hr for all other lamp types.
EU Eco-label (2011)	Rated lamp lifetime at 50% lamp survival and 70% lumen maintenance: ≥ 15000 hr
Blaue Engel	Rated lamp lifetime at 50% lamp survival and 85% lumen maintenance: ≥ 6000 hr

LEDs are often permanently integrated into the luminaire. In such cases we believe it would make sense to have more stringent requirements for lifetime and Switching Withstand. The risk of consumer dissatisfaction could be much higher if it is found that the whole luminaire needs to be replaced because of a poor quality LED system.

In general, our view is that the regulation should keep pace with the technology, and thus it will make sense for consumers to upgrade their lighting systems early – i.e., before the end of lifetime of these LED systems, due to the increase performance that will then be available 5 or 10 years later.

5.4 Lumen Maintenance Requirements

Lumen maintenance is a measure of the rate at which a lamp's lumen output deteriorates over its operating life. Mathematically, lumen maintenance is expressed as a percentage of the luminous flux of a lamp at a given time in its life divided by the lamp's initial luminous flux. The lumen maintenance test is a very important part of evaluating an LED lamp's life performance, as the lifetime testing would be very hard or impossible due to the fact that good quality LED products could last up to 50,000 hours, which represents more than 5.5 years of continuous operation. The table below provides the requirements for lumen maintenance.

The IEC standard does not have mandatory requirements for lumen maintenance, but instead creates five categories that describe the different lumen maintenance values. The UK EST requires that maintenance for lifetimes greater than 15,000 hours shall be derived from the measurements taken up to and including the 15,000 hour values. China's GB/T 24908-2010 establishes three test time points, at 3000 hours, 6000 hours and 70% of rated life, and establishes requirements of lumen maintenance relative to the initial lumen output. The US Energy Star also has a requirement around lumen maintenance, stating that lamps must emit at least 70% of their initial lumen output after 25,000 hours of service (approximately 3 years of continual operation). The EC JRC Quality Charter sets two time points for lumen maintenance, which are 1000 hours and 15,000 hours, with requirements of lumen maintenance value and failure rate respectively.

Table 5-5: Comparison Lumen Maintenance Requirements

Standard	Lumen Maintenance Requirements
Ecodesign Working Documents	Expressed in terms of Rated lamp lifetime at 50% lamp survival and 70% lumen maintenance ≥ 15000 hours ≥ 10000 hours for retrofit LEDs with integrated control gear
CELMA/ELC position	≥ 10000 hours for all lamps (including MR16) ≥ 15000 hours for end-user replaceable LED modules
China GB/T 24908-2010	≥92% at 3000 hours; ≥88% at 6000 hours; ≥70% at 70% of rated lifetime.
ELI LED Specification	(Taking initial value as 100%), the luminous flux of the lamp must be (no less than) 96% at 3000 hours, and (no less than) 91.8% at 6000 hours. Luminous flux shall be measured according to IEC/PAS62612
EC JRC LED Quality Charter	$L_{70}F_{50}$ ≥15,000 hours: Maximum 50% lamps having lumen maintenance below 70% after 15,000 hours; $L_{85}F_{05}$ ≥ 1000 hours: Maximum 5% lamps having lumen maintenance below 85% after 1000 hours.
IEC/PAS 62612	Luminous flux decrease at 25% of rated lifetime (max 6000 ours) as % of 0 h value, and category. 10 % Cat A 20 % Cat B 30 % Cat C 40 % Cat D 50 % Cat E
UK EST LED Lamps and Modules v2.0	Expressed in terms of declared life: shall be that of the lamp/module $L_{70}F_{50}$ point (average lumen maintenance 70% and/or 50% failure to light). This shall not be less than 15,000 hours, no maximum applies. Maintenance for lives greater than 15,000 hours shall be derived from the measurements taken up to and including the 15,000 hour values.
US ES LED Specification v1.3	≥ 70% lumen maintenance (L70) at 25,000 hours of operation
EU eco-label (2011)	80% at 9,000 hours

We support the proposal in the Commission's draft Working Documents, which are consistent with the JRC Quality Charter.

5.5 Premature failure rate at 10% of rated lifetime

Some of the quality documents reviewed address premature failure rates, specifying either a maximum sample percentage failure at a certain point in time or a minimum requirement to meet. The standards for China (GB/T 24908-2010), the ELI LED specification, the IEC/PAS 62612, the US ENERGY STAR LED specification v.1.3 and the EU Eco-Label (2011) do not contain any requirements around premature failure rates.

Table 5-6: Comparison of Premature Failure Rate Requirements

Standard	Premature failure rate at 10% of rated lifetime
Ecodesign Working Document	2% at 10% of rated life in hours
CELMA/ELC position	ELC/CELMA comment: difficult requirement, performance could only be verified after a considerable long life span
EC JRC LED Quality Charter	2 years guarantee
UK EST LED Lamps and Modules v2.0	There shall be no more than one actual electrical failure within the first 3,000 hours.
Blaue Engel	2% Premature failure rate: The lamp survival factor shall be recorded for 20 samples of the lamp after a burning time of 400 h in the so-called long switching cycle; according to CIE 97:2005 and taking into account Appendix 1, para. 2.2.2.3. The requirement shall be considered met if not more than one lamp fails during measurement.

CLASP considers this requirement to be important to prevent potential consumer dissatisfaction and a change back to less efficient technologies. If the industry considers this requirement too difficult to verify, we suggest this requirement be "redesigned". The level proposed in the Ecodesign Working Document of 2% at 10% rated life seems to be reasonable and aligned with similar requirements from other quality standards.

Given the standard size of the tested sample (20 lamps), the way compliance is defined could be even more crucial than the number of hours after which premature failure rate is measured. We are ready to discuss the possibilities during and after the Technical Subgroup meeting.

5.6 Switching Withstand Test Requirements

The Switching Withstand test is designed to ensure that the lamp being tested will not fail prematurely or have problems starting or reduced light output as a result of frequent switching. The IEC standard incorporates this parameter as part of Endurance for Built-in Electronic Ballast. The differences between the Chinese, ELI and US ENERGY STAR standards are primarily around the “on and off” time and the number of cycles. Some tests may be needed to provide practical evidence for a persuasive harmonized requirement. Note that the EC’s JRC LED Quality Charter, the IEC/PAS 62612 and the UK Energy Savings Trust LED Lamps and Modules v.2.0 do not contain any switching withstand testing requirements.

Table 5-7: Comparison of Switching Withstand Test Requirements

Standard	Switching Withstand Test Requirements
Ecodesign Working Document	7,500 cycles (5,000 cycles for retrofit LED with integrated control gear)
CELMA/ELC position	ELC/CELMA comment: to be defined by 30 sec on/30 sec off – according to IEC PAS 62612, the number of cycles should equal half rated lamp life time in hours.
China GB/T 24908-2010	Cycle for 15,000 times and every time 0.5 min on, 0.5 min off. LED lamp shall remain alight for at least 15 minutes after cycling completion.
ELI LED Specification	At least 12,500 cycles (50% of lamp life) based on cycle of 30 sec off and 30 seconds on.
US ES LED Specification v1.3	Lamp cycled once for every two hours of required minimum L70 life.
EU eco-label (2011)	Greater than the rated lifetime in hours (Rated lamp lifetime at 50% lamp survival and 70% lumen maintenance: ≥ 15000 hours)
Blaue Engel	20,000 cycles

CLASP supports CELMA’s proposal, which is in line with existing regulations.

5.7 Colour Rendering Index Requirements

The CRI is a measure of the ability of a light source to accurately reproduce colours when compared with a reference lamp. Although CRI is measured differently in the Americas (by reflectivity) versus Europe (by spectral composition), it is still a measurement that is accepted and used to describe the performance of light sources worldwide. Each of the five standards compared has a minimum CRI requirement.

The following four standards – China GB/T 24908-2010; EC JRC LED Quality Charter, ELI, UK EST v.2.0 and US ES v.1.3 – each have a requirement of minimum 80 CRI. In addition to this minimum CRI value, the US ENERGY STAR rating also requires that the R9 value be greater than zero. The IEC standard has a slightly different requirement, looking at changes in the CRI over the operating life of the lamp. The IEC requires that two tests for CRI be conducted – one initial measurement and one at 25% of rated lamp life (maximum 6000 hours of operation), and that the two values shall not decrease by more than 5 points from the rated value.

In general, LED standards have much higher attention to colourimetry than CFL products and colour parameters remain a major issue for LED in the future standard development.

Table 5-8: Comparison of Colour Rendering Index Requirements

Standard	Colour Rendering Index Requirements
Ecodesign Working Document	≥ 80 (90 if claimed to be retrofit to halogen or incandescent lamp)
CELMA/ELC position	> 80 (ELC/CELMA comment: apply tolerance from IEC 62612, this has to be applicable for all technologies) >65 for outdoor and industrial applications
China GB/T 24908-2010	Greater than 80
ELI LED Specification	CRI should be at least 80, as measured in accordance with CIE13.3.
EC JRC LED Quality Charter	CRI > 80
IEC/PAS 62612	Two measurements for CRI: Initial and at 25% of rated lamp life (maximum 6000 hours). Neither of the two values shall decrease by more than 5 points from the rated CRI value.
UK EST LED Lamps and Modules v2.0	Greater than 80.
US ES LED Specification v1.3	Minimum CRI (Ra) of 80. In addition, the R9 value must be greater than 0.
EU eco-label (2011)	> 85
Blaue Engel	> 80

Having a lower CRI requirements for outdoor and industrial applications, would in CLASP's view be acceptable. The value proposed by CELMA of 65 CRI is better than high and low pressure sodium lamps, two technologies that are commonplace in these applications.

5.8 CCT Requirements

The CCT is a measurement addressing the appearance of the light output relative to a theoretical black body heated to high temperatures. CCT is measured in degrees Kelvin (K). The performance standards for LEDs generally define six popular CCT ratings – 2700 K, 3000 K, 3500 K, 4000 K, 5000 K and 6500 K. The only difference is the US ENERGY STAR rating, which defines these six plus two additional ones at 4500 K and 5700 K. Other than these two additional CCT ratings in ENERGY STAR, the CCT ratings for China's GB/T, ELI, EC JRC LED Quality Charter, the UK EST, the US ENERGY STAR and the IEC are the same. The table below presents the CCT requirements in the five standards.

Table 5-9: Comparison of CCT Requirements

<table>
<tr><th>Standard</th><th>CCT Requirements</th></tr>
<tr><td>Ecodesign Working Document</td><td>2600-3200 K for retrofit to halogens or incandescent lamps</td></tr>
<tr><td>CELMA/ELC position</td><td>Same, but for retrofit LED lamps for *directional* household halogen lamps</td></tr>
<tr><td>China GB/T 24908-2010</td><td>
<table>
<tr><th rowspan="2">Nominal CCT</th><th colspan="2">Colour coordinates</th><th rowspan="2">Target CCT</th></tr>
<tr><th>x</th><th>y</th></tr>
<tr><td>6500 K</td><td>0.313</td><td>0.337</td><td>6430 K</td></tr>
<tr><td>5000 K</td><td>0.346</td><td>0.359</td><td>5000 K</td></tr>
<tr><td>4000 K</td><td>0.380</td><td>0.380</td><td>4040 K</td></tr>
<tr><td>3500 K</td><td>0.409</td><td>0.394</td><td>3450 K</td></tr>
<tr><td>3000 K</td><td>0.440</td><td>0.403</td><td>2940 K</td></tr>
<tr><td>2700 K</td><td>0.463</td><td>0.420</td><td>2720 K</td></tr>
</table>
</td></tr>
<tr><td>ELI LED Specification</td><td>Must comply with IEC/PAS 62612</td></tr>
<tr><td>EC JRC LED Quality Charter</td><td>CCT shall be in the interval 2600-3500 K. The rated colour shall preferably be one of the three values:
• F2700 (2720 K, X=0.463, Y=0.420)
• F3000 (2940 K, X=0.440, Y=0.403)
• F3500 (3450 K, X=0.409, Y=0.394)</td></tr>
<tr><td>IEC/PAS 62612</td><td>The rated CCT shall preferably be one of the following six values:
2700 K, 3000 K, 3500 K, 4000 K, 5000 K or 6500 K
<table>
<tr><th rowspan="2">Colour Indication</th><th rowspan="2">CCT</th><th colspan="2">Colour coordinates</th></tr>
<tr><th>x</th><th>y</th></tr>
<tr><td>F 6500</td><td>6400</td><td>0.313</td><td>0.337</td></tr>
<tr><td>F 5000</td><td>5000</td><td>0.346</td><td>0.359</td></tr>
<tr><td>F 4000</td><td>4040</td><td>0.380</td><td>0.380</td></tr>
<tr><td>F 3500</td><td>3450</td><td>0.409</td><td>0.394</td></tr>
<tr><td>F 3000</td><td>2940</td><td>0.440</td><td>0.403</td></tr>
<tr><td>F 2700</td><td>2720</td><td>0.463</td><td>0.420</td></tr>
</table>
</td></tr>
<tr><td>UK EST LED Lamps and Modules v2.0</td><td>Must comply with IEC/PAS 62612</td></tr>
</table>

Standard	CCT Requirements
US ES LED Specification v1.3	Lamps must have one of the following CCTs below: CCT x y 6500 K 0.3123 0.3282 5700 K 0.3287 0.3417 5000 K 0.3447 0.3553 4500 K 0.3611 0.3658 4000 K 0.3818 0.3797 3500 K 0.4073 0.3917 3000 K 0.4338 0.4030 2700 K 0.4578 0.4101
Blaue Engel	The colour distance between the chromaticity of a sample and the chromaticity of the specified colour temperature at the time t_i in 19 of the 20 test samples shall not be greater than 0.007 units on the CIE 1976 u'v' chromaticity diagram.

The proposed functionality requirements in the draft Working Document are for non-directional and directional lamps. Our position is therefore that this requirement should apply for retrofit lamps that are designed to replace any halogen or incandescent lamp. Should the Commission need to define the various CCT values, we recommend cross-referencing IEC/PAS 62612.

5.9 Colour consistency

Another quality measure of an LED light source is its ability to have consistently similar colours in its sample of the same product. In other words, in a sample of 20 units, this measure quantifies the deviation of the white light emission profiles from the sample of lamps tested. Of the various documents and standards reviewed, the China GB/T 24908-2010, the UK EST standard for LED Lamps and Modules and the US Energy Star specification do not provide explicit guidance on this metric.

Table 5-10: Comparison of Colour Consistency Requirements

Standard	Colour consistency
Ecodesign Working Documents	CCT spread within a 6-step MacAdam ellipse or less
CELMA/ELC position	ELC / CELMA comment: other technologies do not apply CCT, thus it should be kept out for LED; if this cannot be achieved.
ELI LED Specification	The colour tolerance shall be within 7 SDCM from the target values.
EC JRC LED Quality Charter	A tolerance category of 7-step MacAdam ellipse size shall be assigned as maximum spread, which includes (circumscribes) the chromaticity co-ordinates of all LED lamps in the tested sample.

<table>
<tr><th>Standard</th><th>Colour consistency</th></tr>
<tr><td>IEC/PAS 62612</td><td>The measured actual CCT values (both initial and at 25 % of rated lamp life with a maximum duration of 6 000 h) are expressed as fitting within one of 8 categories (see Table below), which correspond to a particular MacAdams ellipse around the rated CCT value, whereby the size of the ellipse (expressed in n-steps) is a measure for the tolerance/deviation of an individual lamp.
<table>
<tr><th>MacAdams ellipse type</th><th>CCT category</th></tr>
<tr><td>All measured CCT’s within a 1-step ellipse</td><td>Cat 1</td></tr>
<tr><td>All measured CCT’s within a 2-step ellipse</td><td>Cat 2</td></tr>
<tr><td>All measured CCT’s within a 3-step ellipse</td><td>Cat 3</td></tr>
<tr><td>All measured CCT’s within a 4-step ellipse</td><td>Cat 4</td></tr>
<tr><td>All measured CCT’s within a 5-step ellipse</td><td>Cat 5</td></tr>
<tr><td>All measured CCT’s within a 6 step ellipse</td><td>Cat 6</td></tr>
<tr><td>All measured CCT’s within a 7 step ellipse</td><td>Cat 7</td></tr>
<tr><td>All measured CCT’s not within a 7 step ellipse</td><td>Cat 8</td></tr>
</table>
</td></tr>
<tr><td>EU eco-label (2011)</td><td>CCT spread within 3-step MacAdam ellipse</td></tr>
<tr><td>Blaue Engel</td><td>The colour distance between the chromaticity of one test sample and the chromaticity of any other test sample at the time t_i in 19 of the 20 test samples must not be greater than 0.006 units on the CIE 1976 u’v‘ chromaticity diagram.</td></tr>
</table>

CLASP supports the Commission’s recommendation in the Working Document at a 6-step MacAdam ellipse or less for the colour consistency requirement.

5.10 Colour Maintenance Requirement

The colour maintenance requirement is based around the concern that poor quality LEDs may experience a noticeable colour shift during their operating lifetime. The ELI, the IEC and US ENERGY STAR all have specifications on this parameter that establish a maximum shift. ELI and the US ENERGY STAR have virtually identical requirements, providing a maximum shift in chromaticity over the lumen maintenance test period of 6000 hours. Both standards require that there be no more than a 0.007 shift on the CIE1976 (u’, v’) diagram. The IEC’s requirement is slightly different, stating that the measured CCT values at the initial and 25% of rated lifetime point (max 6000 hours) shall not move beyond the nominal CCT tolerance category associated with the LED. Three of the standards being compared, the Chinese GB/T24908-2010, EC JRC Charter and the UK EST performance specification do not have a colour maintenance requirement.

Table 5-11: Comparison of Colour Maintenance Requirements

Standard	Colour Maintenance Requirements
ELI LED Specification	The change of chromaticity over the lumen maintenance test period (6000 hours) shall be within 0.007 on the CIE1976 (u’,v’) diagram.

Standard	Colour Maintenance Requirements
IEC/PAS 62612	Both CCT values (initial and at 25 % of rated lamp life, max 6000hr) shall not move beyond the CCT tolerance category described below: Tolerance (categories) on nominal CCT values (Ellipse type) (CCT category) 1-step ellipse Cat 1 2-step ellipse Cat 2 3-step ellipse Cat 3 4-step ellipse Cat 4 5-step ellipse Cat 5 6 step ellipse Cat 6 7 step ellipse Cat 7 >7 step ellipse Cat 8
US ES LED Specification v1.3	The change of chromaticity over the minimum lumen maintenance test period (6000 hr) shall be within 0.007 on the CIE 1976 (u’,v’) diagram.
Blaue Engel	The colour distance between the chromaticity of a test sample at the times t1 3000h and t1 6000h and the chromaticity of the respective same test sample at the time t_i in 4 test samples must not be greater than 0.007 units on the CIE 1976 u’v‘ chromaticity diagram. The variation shall be individually determined for each test sample.

CLASP recognises the value in having a Colour Maintenance Requirement, however there is also a significant cost associated with testing for a sufficiently long duration.

5.11 Power Factor Requirements

Power Factor is defined as the ratio of the real power flowing to the load divided by the apparent power in the circuit. Power factors range from 0-1, and a value closer to 1 means that the device utilizes grid power more efficiently. A low power factor means that there will be higher harmonic currents and higher power losses in the electric utility’s distribution network and power generation infrastructure.

The US ENERGY STAR program has a requirement of a minimum 0.7 for lamps with power consumption greater than 5 Watts. The UK EST requires a minimum 0.7 for mains voltage type LED lamps (Classes 1, 2, 3 and 4), and 0.9 for low voltage types (Classes 21 and 22). China’s GB/T 24908-2010 requires that the power factor for LED lamps to be the same as for CFL. This requirement states that the measured power factor shall be not be less than 0.05 of the nominal rated power factor. EC JRC Charter and ELI has a requirement that power factor shall be greater than or equal to 0.5 at the maximum rated power of the LED lamp. The IEC has no requirement on power factor. Thus, of the standards reviewed, the UK EST standard places the most stringent requirements on power factor.

Table 5-12: Comparison of Power Factor Requirements

Standard	Power Factor Requirements
Ecodesign Working Documents	from stage 1: P ≤ 2 W: no requirement 2 W < P ≤ 5W: PF > 0.4 5 W < P ≤ 25 W: PF > 0.7 P > 25 W: PF > 0.9
CELMA/ELC position	CELMA/ELC comment: “Lamp power factor (PF)” is under discussion. The industry will provide a proposal at the Technical Subgroup meeting.
China GB/T 24908-2010	Actual value should not be smaller than rated value by over 0.05
ELI LED Specification	Power factor shall be ≥ 0.5 at maximum power.
EC JRC LED Quality Charter	The power factor shall at least be 0.5 for lamps of wattage 2-25 W.
IEC/PAS 62612	N/A
UK EST LED Lamps and Modules v2.0	The power factor required shall be: • Class 1, 2, 3 and 4 lamps shall be 0.7. • Class 21 and 22 system shall be 0.9, (High power factor type).
US ES LED Specification v1.3	For lamp power <=5 W and for low voltage lamps, no minimum power factor is required; For lamp power >5 W, power factor must be >= 0.70
EU eco-label (2011)	
Blaue Engel	0.75 (< 25 W) and 0.9 (> 25 W)

In general, we prefer products to have higher power factors such that they do not cause problems in the power distribution network. Therefore, we endorse the proposal by the Commission to set requirements of the power factor for the most common wattage range (5-25 watts) to have a power factor of 0.7. This is consistent with the Blaue Engel and the UK Energy Savings Trust and the US Energy Star LED Specification v.1.3.

5.12 Starting time from Cold and Warm-up time to 60% Φ

This final quality metric for LED lamps addresses the time required for the lamp to start and to warm-up to 60% of full brightness. In the Ecodesign working documents, the starting time was set to be less than half a second and the warm-up to 60% brightness is less than 2 seconds. Most of the other quality standards reviewed did not have requirements relating to the starting time and warm-up. Only those that did are included in the table below.

Table 5-13: Comparison of Requirements for Starting Time and Cold and Warm-up time

Standard	Starting Time	Starting Time from Cold	Warm-up Time to 60% Φ
Ecodesign Working Documents	< 0.5 seconds	-	< 2 seconds
CELMA/ELC position	No change		No change
EC JRC LED Quality Charter	Less than 0.5 seconds	The time to 95% of stabilised rated lumen output after switch-on from cold, at normal room temperature, shall be less than 2 seconds	
Blaue Engel			30 seconds for Warm-up time to 80% Φ

Although we are of the belief that LEDs achieve full brightness within milliseconds of the current being applied, CLASP recognises that there may be other reasons such as drivers, light colour monitors or other electronics that may affect how the lamp ramps up to full brightness. For this reason, and because the time periods seem reasonable, we support the draft proposal of the Commission shown in the table above.

5.13 Summary of recommended requirements for LEDs

In order to assist the Commission in its harmonization effort for global products such as LEDs, CLASP gathered the main quality requirements from the principal existing schemes. We found the Commission's proposals put forth in the Working Document (Ecodesign requirements for directional lamps, light emitting diode lamps and halogen lighting converters, circulated prior to the Consultation Forum meeting of July 2011) to be in line with the main existing standards for several parameters, and we fully support the adoption of such harmonized requirements.

The potentially most controversial issue may be the reliability parameters, for which the verification of compliance may be most problematic. We are ready to discuss this issue during the Technical Subgroup meeting to understand what could be acceptable to the industry and could guarantee consumer satisfaction – and to ensure that this technology actually delivers the predicted savings.

The following table summarizes CLASP's position after a comparison of the Commission's proposal against the main existing schemes.

Table 5-14: Summary of recommended requirements for LEDs

Parameter	Suggestions
Efficacy Requirements	Maintain requirements for stage 3 Minimum 80lm/W in 2016
Lamp Wattage Requirements	CLASP's view is that the tolerance for lamp wattage and luminous flux should both be kept low
Luminous Flux Requirements	
Lamp Life Requirements	The Commission's proposal is in line with several existing schemes. CLASP would also support more stringent requirements for lifetime and Switching Withstand when LEDs are permanently integrated into the luminaire
Lumen maintenance	CLASP supports the Commission's recommendation in the Working Document
Premature failure rate at 10% of rated lifetime	CLASP supports the Commission's recommendation in the Working Document and is ready to discuss a 'redesign' of this requirement to make compliance verification easier
Number of switches before failure	CLASP supports CELMA's proposal, which is in line with existing regulations
Colour rendering index	CLASP considers CELMA's suggestion to be acceptable
Correlated Colour Temperature (CCT)	CLASP supports the Commission's recommendation in the Working Document
Colour consistency	CLASP supports the Commission's recommendation in the Working Document
Colour maintenance	No strong position on this
Power factor	CLASP supports the Commission's recommendation in the Working Document
Starting time	CLASP supports the Commission's recommendation in the Working Document
Starting time from cold	
Warm-up time to x% Φ	

6 The Importance of Stage 3 – a Strategic Plan to Save Energy

CLASP noted that during the July 5 Consultation Forum meeting some participants called for the elimination of Stage 3, and others called for a review cycle in 2014/2015 whereby any provisions adopted for Stage 3 might be revised or overturned based on any economic or technological changes. CLASP does not support either of these recommendations. Instead, our strongly held view is that long-term regulatory planning is an excellent catalyst for stimulation of innovation in product design and developments. CLASP supports the Commission including a mandatory Stage 3 level, not subject to review / amendment at Stage 2, for the following reasons: (1) Stage 3 is a critical part of enabling Europe to achieve its energy savings objective; (2) Stage 3 provides considerable lead-time for companies to plan financial and human resources to prepare for the regulation; (3) Stage 3 would be consistent with other major economies such as the United States and China; and (4) Stage 3 recognises and builds upon a wealth of knowledge around technology trends and forecasts for improvement, ensuring the regulation will still be relevant in the future.

6.1 Why is Stage 3 Important for Directional Lamps?

CLASP believes that there is inherent value in providing industry with certainty and a long-term planning horizon that gives them time to adapt to more stringent MEPS. Our strongly held view is that long-term regulatory planning can be a powerful catalyst for energy saving because long-term regulatory measures enable manufacturers to develop R&D, to address patent cross-licensing, to purchase capital equipment, to train staff and to develop new marketing material and campaigns around their next generation technologies.

The Stage 3 regulation for this Ecodesign product would then become part of the strategic plan for companies that operate in the European lighting markets. By setting an ambitious 2016 regulation for directional lamps, businesses will start to look at investments and resource allocations in 2012 and 2013 to best position themselves for 2016. Some companies may opt to accelerate their innovation cycle and introduce new products into the market ahead of the Stage 3 requirements, capitalising on an opportunity to differentiate themselves as a ‘green’ and ‘eco-friendly’ company.

Strategic planning horizons vary widely – some businesses adopt annual plans while others adopt a 20 year outlook. In order to know where a company is headed, the leadership in the company needs to know where it stands, and then they can plan appropriately to determine how it will get there. Thus the Stage 3 requirement becomes a critical component of the "strategic plan”, adding planning certainty and clarity in the long-term. Company management is then able to anticipate the change and prepare for it, particularly a significant change in the technologies that are allowed to be sold in the market.

6.2 Other Regulatory Entities with Longer-Term Planning

Should the Commission decide to retain the Stage 3 regulation, it would not be out of synch with regulatory practices and scheduling horizons in other major economies. CLASP notes one key example – the United States – who has adopted longer term energy efficient planning strategies for products they are regulating. This leading global economy has recognised the advantages afforded to their constituent companies through providing a longer term regulatory planning horizon.

In the US, DOE is scheduled to initiate a rulemaking in 2014 to consider whether it is technologically feasible and economically justified to make the standards for “general service lamps” higher than the levels established through the Energy Independence and Security Act (EISA) 2007. If DOE's rulemaking does not produce savings that are greater than or equal to the savings from a minimum efficacy standard of 45 lm/W, effective January 1, 2020, then the DOE shall simply adopt the 45 lm/W requirement as the national regulatory standard. The 45 lm/W is a "backstop requirement" and is part of a one-sided analysis to determine whether efficacy levels higher than 45 lm/W are justified. Having this regulation in place, twelve years in advance offers manufacturers a considerable amount of time to plan for the eventuality of at minimum level of 45 lm/W or greater.

6.3 Stage 3 Plans on Known Technology Trends

Manufacturer and government R&D investments into lighting technologies have facilitated a virtually perpetual improvement in efficacy over time. Market forces, driven in part by higher energy prices and customer requests for lower operational and maintenance costs associated with lighting, have contributed to the improvement of existing technologies and indeed, the development of entirely new ones.

The graph below depicts the improvement of lamp efficacy over the last 100 years. Incandescent lighting has not improved since the 1920s, apart from the introduction of halogen and then halogen IRC. Fluorescent lamps have more than doubled their efficacy since their introduction in the 1930's. While most of the curves experience periodic and gradual improvement in efficacy over time, on this graph, the slope of the LED luminous efficacy improvement is extremely steep and rapid, and is anticipated to surpass all other light sources, including those with poor colour rendering such as high pressure sodium and low pressure sodium.

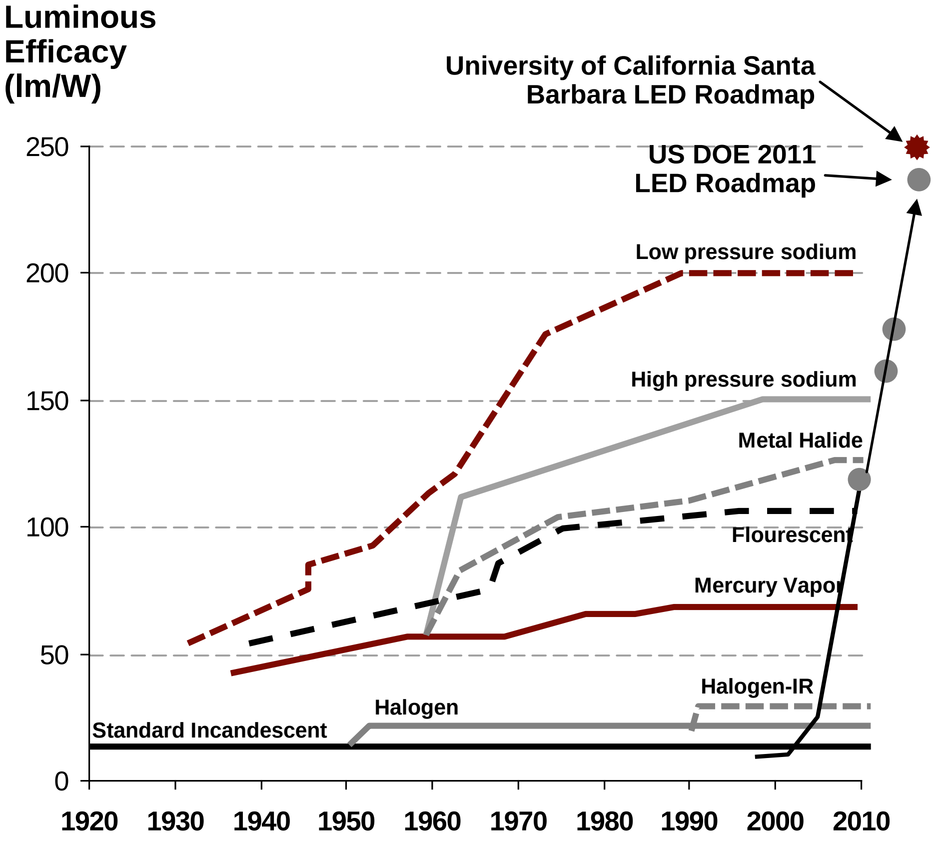


Figure 6-1. One Hundred Years of Lamp Efficacy Improvements
Source: US DOE, SSL Multi-year Programme Plan, 2011.

Against the backdrop of these historical improvements in lighting technology, CLASP firmly believes that the Commission would be wise not only to set a firm Stage 3 requirement that would not be subject to any interim review, but also to set an ambitious one that would recognise on-going innovation in the market, give companies sufficient time to plan and realise significant energy savings for Europe.