Review study on the stage 6 requirements of Commission Regulation (EC) No 244/2009.

Final Report

SPECIFIC CONTRACT No ENER/C3/2012-418 LOT 2/01/SI2.645913

Implementing Framework Contract No ENER/C3/2012-418-Lot 2

VHK (pl)/ VITO for the European Commission

Delft/Brussels, 14.6.2013

Legal disclaimer:

The sole responsibility for the content of this report lies with the authors. It does not necessarily represent the opinion of the European Community. The European Commission is not responsible for any use that may be made of the information contained therein.

This report has been prepared by the authors to the best of their ability and knowledge. The authors do not assume liability for any damage, material or immaterial, that may arise from the use of the report or the information contained therein.

Contents

ACRONYMS

CFL	Compact fluorescent lamps
CRI	Colour Rendering Index
DLS	Directional light sources
E14, E27	Screw-type lamp caps for general purpose lamp
ELC	European association of lighting manufacturers, now part of LightingEurope
G4, GY6.35	Low-voltage halogen lamp types, 2 pin cap, single ended
G9	Mains-voltage halogen lamp, 2-pin cap, single ended
GLS	General Lighting Service (a.k.a. incandescent lamp)
h	Hour
Hg	Mercury
HL	Halogen
IR, IRC	Infrared, Infrared coating
LED	Light Emitting Diode
LOR	Light Output Ratio
lm, Φ	Lumen, unit of luminous flux Φ
LV	Low Voltage (typical 12V)
MOCVD	Metal Oxide Chemical Vapour Deposition
MV	Mains Voltage (typical 230V)
NDLS	Non-directional light sources
P	Rated power
R	Electrical Resistance
R7s	Mains-voltage linear halogen lamp, double ended
Ra	Colour rendering index, unit
SCHER	Scientific Committee on Health and Environmental Risks
SCENHIR	Scientific Committee on Emerging and Newly Identified Health Risks
UV	Ultraviolet (subtypes UVA, UVB, UVC)
V	Volt
W	Watt

Important notice:

Note that the long term scenarios presented in this report are inherently prone to large uncertainties and the outcomes are only to be regarded as indicative.

Without diminishing its responsibility for the end result, the study team is grateful for the many valuable contributions received from technical experts inside and outside the EU.

Page intentionally left blank

1. INTRODUCTION

1.1. Assignment

This document is the final report on the impacts of a Review of the stage 6 requirements (hereafter 'Stage 6') of Commission Regulation (EC) No 244/2009 (hereafter 'the Regulation').

The main reason for the timely review is to provide planning security for industry and consumers (i.e. for buying luminaires designed for halogens). Different from expectations at the time of the conception of Stage 6 there are currently no mains-voltage ('MV') halogen lamps on the market that would meet the Stage 6 requirements and it is highly uncertain whether halogen lamps meeting the qualification will be on the market when Stage 6 will apply, i.e. by 1 Sept. 2016. As it was not the intention of the legislator to phase-out mains-voltage halogen lamps –a popular replacement of the phased-out incandescent lamp for various reasons– the basis of the decision-making on Stage 6 in 2008-2009 needs to be evaluated against the latest insights today, in the beginning of 2013.

The study entails a restricted impact analysis on priority aspects, including market sales, EU employment, environment, health and in particular effects on light-sensitive patients, and possible replacement technologies (if any). The impact analysis should specify the impacts for at least two scenarios: keeping the stage 6 requirements in force or abolishing the stage 6 requirements.

Draft reports in various stages of finalisation are to be delivered in the period Feb.-May 2013. A technical expert meeting took place 26 April 2013, discussing a draft intermediate report (see Annex I). Technical assistance activities on the subject may be provided up to 16 April 2014, if required, or any earlier date indicated by the Commission services.

More details on the assignment can be found in Annex A. The required contractor statements concerning the right to deliver results are incorporated in Annex B.

1.2. Stage 6 Requirement

On 18 March 2009, Commission Regulation (EC) No 244/2009, implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps[1] (hereafter 'the Regulation') was published.

In Article 3 it sets requirements for Non-Directional Light Sources (NDLS), specified in Annex II of the Regulation, in 6 stages.

The first 4 stages, with requirements applying from the 1st of Sept. 2009, 2010, 2011 and 2012, eliminate low-efficacy ('incandescent') lamps in subsequently lower lumen output-levels[2]. At the moment –after stage 4 of 1 Sept. 2012 also phasing out lamps with output <450 lumen– all general purpose incandescent lamps with output >60 lm should have been phased-out from the EU market.

[1] OJ L 76, 24.3.2009, pp. 3-16

[2] 'low-efficacy' intended here for lamps where the rated power P exceeds the maximum rated power Pmax (in W) at a given rated luminous flux (Φ, in lm) with for non-clear lamps $P_{max}=0.24\sqrt{\Phi}+0,0103\Phi$ and for clear lamps in stages 1 to 5 $P_{max}= 0.8 * (0,88\sqrt{\Phi}+0.049\Phi)$.

In 2009, stage 1 also set minimum functionality requirements for Compact Fluorescent Lamps (CFLs) and –in one group– light sources that are neither CFLs nor Light Emitting Diodes (LEDs). This latter group of non-CFL/LED lamps mainly includes the NDLS halogen lamps.

Stage 5, which applies from 1 Sept. 2013, is in fact the second stage in setting minimum functionality requirements regarding minimum rated lamp lifetime/lamp survival factor at 6000 h, lumen maintenance, number of switching cycles, starting time, heat-up time to reach 60% of lumen output, premature failure rate, UVA+UVB radiation, UVC radiation, lamp power factor and –for CFLs only– the colour rendering index (Ra).

Most significantly, with respect to stage 1, stage 5 tightens the requirements for the service life and lifetime functionality.

For CFLs the survival factor at 6000 h goes from ≥0.5 to ≥0.7, lumen maintenance at 2000 h is increased by 3%-points and specified at 6000 h (≥70%), the number of switches-before-failure is doubled or tripled, starting time should be 50-100% faster, the maximum heat-up time to reach 60% of lumen output is reduced from 60 to 40s (with some allowance for CFLs with mercury in the form of amalgam where it should only be <100 s) and the lamp power factor should improve from ≥0.5 to ≥0.55 (at P <25W).

Particularly relevant for the Stage 6 review is the Stage 5 requirement for non-CFLs/LEDs. Here, the Regulation requires that from 1 Sept. 2013 the rated lamp lifetime will go from ≥1000 h to ≥2000 h. This is relevant, because for filament lamps there is a distinct technical relationship between on one hand the current through the filament and the lifetime (more current, lower life expectancy) and on the other hand the current and the luminous output (more current, more lumen). This will be elaborated in the technical analysis.

In stage 6, that is currently set to apply from 1 Sept. 2016, the Regulation sets more stringent efficacy requirements for clear lamps. Instead of the maximum rated power Pmax (in W) being $0.8 * (0.88\sqrt{\Phi}+0.049\Phi)$, where Φ is the rated luminous output (in lm), the rated power of clear lamps will then have to be less than a Pmax of $0.6 * (0.88\sqrt{\Phi}+0.049\Phi)$, which equals the lower limit value of the 'B' energy label class. The exceptions to stage 6 requirements (hereafter 'Stage 6') are clear lamps with type G9 and R7s cap. A 'G9' is a 2-pin cap, with heart-to-heart distance 9 mm, for use in a mains-voltage (220-240V in the EU) halogen lamp, typically of reduced dimensions. An 'R7s lamp' is double-capped mains-voltage (220-240V in the EU) linear halogen lamp where the lamp caps are cylindrical with a diameter of 7 mm. (see Figure 1). The rationale for this exception was explained in the lot 19 preparatory study[3], i.e. in 2009 there were no Stage 6-conform halogens lamps available for all luminaires with G9 and R7s sockets. High-efficiency halogen lamps as known in 2008 relied on a low voltage transformer and such compact shapes (G9, R7s) did not allow incorporating it in a retrofit solution.

Please note that for high lumen output lamps (Φuse ≥ 1300 lumen), the proposed stage 6 requirement ($0.6 * (0.88\sqrt{\Phi}+0.049\Phi)$) does not follow the class B formula ($0.6 * 0{,}07341\Phi$) in the new EU Energy Label classification 874/2012. Nevertheless, as the term 'B class' is a popular and well-known denomination for lamps that meet stage 6 requirements in Regulation 244/2009, this document will also often use 'B class' whenever lamps are 'Stage 6 conform'.

[3] www.eup4light.net

Figure 1. Stage 6 exceptions: R7s lamp (left) and G9 lamp (right)

Article 7 of the regulation stipulates that the '*Commission shall review this Regulation in light of technological progress no later than five years after entry into force and present the result of this review to the Consultation Forum*.'

The date of entry into force is 13 April 2009 (20 days after publication in the OJ, 24.3.2009) and thus the review date is 13 April 2014. This is well before the implementation date of Stage 6 (1.9.2016) and thus the review is explicitly to deal with the appropriateness of the Stage 6 measure as announced in the 244/2009 Regulation.

As mentioned, the underlying study looks at the impacts of either going through with the Stage 6 measure or abolishing it.

2. TECHNICAL ANALYSIS

2.1. Product Scope

Stage 6 applies to clear lamps, which by definition excludes CFLs and other non-clear lamps. It evidently also applies to lamps that are still allowed on the market, which by definition excludes all general purpose incandescent lamps with luminous output ≥60 lm. Finally, the Stage 6 does not apply to clear lamps with G9 and R7s caps (exceptions).

So Stage 6 has a potential impact on

- low-voltage ('LV') non-directional halogen lamps (see figures 2a and 2b, including description of main features), and
- mains-voltage ('MV') non-directional halogen lamps (see figures 3a and 3b), excluding G9 and R7s.

Figure 2a. Non-directional low voltage halogen capsules class C*. Caps: G4 (left), GY6.35 (right). Common power range from 6 to 75 W. Common voltage range: 6-48 V (most popular: 12 V and 24V). Rated product life 1500-4000 h (to be restricted to ≥2000h after 1.9.2013). Prevalently used with external reflector in spot-lights (ceiling, furniture, etc.), desk-lamps and small decorative lamps. Declared as energy label classes 'C'. Consumer list prices of A-brands, including tax, up to € 3.5 per unit (class 'C') or € 4.5 per unit (class 'B'). Street prices of grey-brands, including tax, as low as € 1.1 per unit (class 'C').*

***Figure 2b. Non-directional low voltage halogen capsules class B**. Common power range from 20 to 60 W. Rated product life 4000 h (to be restricted to ≥2000h after 1.9.2013). Prevalently used with external reflector in spot-lights (ceiling, furniture, etc.), desk-lamps and small decorative lamps. Declared as energy label class'B'. Consumer list prices of € 4.5. Those lamps rely on a spherical envelope with infrared coating and reflection for heat recovery to increase lamp efficacy.*

***Figure 3a. Non-directional mains voltage halogen lamps class C.** Popular type names: 'Eco-classic' (Philips, OSRAM), 'HaloGLS' (GE). Shapes: classic bulb, candle, twisted candle, ball, tubular. Caps: screw-type (E14, E27 as in picture) or bayonet-type. Common power range 18-28-42-53-70-105 W. Rated product life 1500-2000 h (to be restricted to ≥2000h after 1.9.2013). Voltage in EU: 220-240 V (hereafter '230 V'). Prevalently used as replacement lamp for incandescent lamps. Declared energy class 'C'. Consumer list prices of A-brands, including tax, up to € 3.5-4 per unit. Street prices of grey-brands, including tax, can be found as low as € 1.5 per unit.*

***Figure 3b. Non-directional mains voltage halogen lamps class B.** This lamp was brought on the market in a 20 and 30 Watt version by Philips in 2008. Philips production stopped in 2010, reportedly for lack of commercial success. The retail price was € 9.95 and declared life time 3000 h. The lamp was fully dimmable. A voltage transformer was incorporated in order to host a class B low voltage halogen lamps(figure 2b).Currently Chinese-made lamps exist with similar design (i.e. with transformer), similar price and –as far as could be assessed-- similar lack of commercial success; it could not be ascertained whether these lamps meet the class B requirements.*

Apart from the general differences between the two product groups ('LV' and 'MV') specified in the text with the figures above, there are a number of functional/technical differences that are particularly relevant when evaluating the impact of Stage 6:

- Technical feasibility of meeting Stage 6 requirements
- Lock-in and replacement characteristics in case of Stage 6 requirements.

These will be discussed hereafter.

2.2. Lock-in and replacement effect

Lock-in effect from caps and luminaires:

LV halogens are specific for the fixtures that are designed for such lamps taking into account physical dimensions, as well as the photometric, electrical and thermal behaviour including related safety requirements. As a consequence, once an end-user owns a fixture with e.g. a G4 or GY6.35 socket he/she is more or less required to buy a lamp with G4 or GY6.35 cap for the lifetime of the fixture..

Some MV HL lamps have similar lock-in effects and prevent to retrofit a lower efficiency MV HL lamp with a 'Stage 6-conform' lamp[4]. Especially, very compact luminaires with G9/R7s sockets can have such a lock-in effect and were thus exempted from meeting Stage 6 requirements (see Figures 4 and 5). This lock-in effect is related to space, weight and/or thermal limitations of LEDi lamps and/or electronic converters, see also the section on retrofit LED lamps. Figures 6 and 7 show G9 and R7s lower efficiency MV HL lamps and their more efficient retrofit options. The more efficient options do not fit for example luminaires in Figure 4 and 5. More lamp technical data on available retrofit G9/R7s options is included in Annex G.

Figure 4. Crystal luminaire[5] with G9 lamps and class C lamp lock-in effect

[4] Lot 19 preparatory study Final report, p. 109, www.eup4light.net

[5] Swarovski- VERVE luminaire

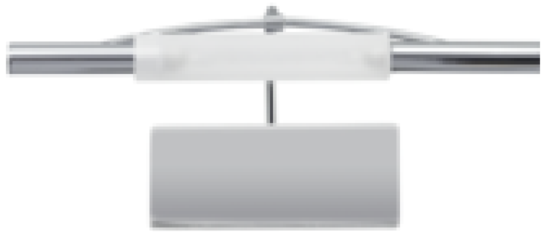


Figure 5. Wall luminaire[6] with R7s lamps and class C lamp lock-in effect

Figure 6. G9 lamp lock-in effect and efficient retrofit lamp restrictions from LEDi GU9 (left, length MV HL G9 (left, length 68 mm, diameter 28 mm, weight 32 g, 460 lm) versus MV HL G9 (right, length 43 mm, diameter 14 mm, 220 lm)

Figure 7. R7s lamp lock-in effect and efficient retrofit lamp restrictions from CFL R7s (left, length) LEDi R7s(middle) versus MV HL R7s (right)

[6] Ergo-leuchten

Replacement characteristics of LED lamps:

The main limitations from replacement LED lamps come from their thermal characteristics and power supply requirements. As opposed to halogen lamps LED lamps suffer from high temperatures and therefore they cannot radiate much heat loss such as halogen lamps with infrared radiation. This has limited the amount of lumen that could be incorporated in retrofit solutions. LED lamps also need a current source and they cannot directly be connected to a voltage source, neither in low (12 V) nor in high voltage circuit (230 V) without some form of electronic circuit. Due to their high efficacy this electronic circuit is more compact compared to the higher-efficiency mains voltage halogen retrofit (Figure 2b). The size and complexity of this circuit can also vary with additional lamp technical requirements such as power factor, dimmability and lamp flicker (100 Hz). So overstating technical requirements such as power factor, dimmability and lamp flicker might also conflict with compactness and cost of retrofit solutions. Therefore in its role as a replacement for incandescent lamps, a momentary practical limit of MV LEDs –again mostly felt in non-residential applications– is the maximum light output of incandescent-shaped LED bulbs, which at the moment is limited to 700-800 lumen for average lamps, but the technical expert meeting also new lamps exceeding 1000 lumen output (see Annex I).

Also for R7s/G9 LED retrofit lamps the lumen output of lamps available on the market is low, see Annex G lamps 43 and 50. For example a R7s 300 Watt reference base case halogen lamp has a typical lumen output of 5000 lm, while a state of art LED retrofit lamp has only 600 lm (Figure 6). Therefore for high wattage R7s MV HL, LED lamps should not be expected to become a valuable retrofit option in the short term.

LED lamps are dimmable but not all of them, especially those in the lower price range.

At the moment there are e.g. LED lamps (Figure 8) with G4 and GY6.35 caps and suitable for 12 V that could be used as replacements at roughly 25 times the rated product life of the mini-halogens (50 000 h versus 2000h) and 4-6 times the energy efficacy (65-75 versus 12-15 lm/W) but also 5 times the price (€ 9-11 versus € 1.5-2 per unit). Although specific market data are lacking, the high price of the LED replacements might still be a considerable barrier for widespread use of LED replacements in G4 and GY6.35 applications. Other replacement barriers may be the possible space restrictions (not every LED-G4 fits every G4 luminaire), compatibility with dimmers, problems with oversized transformers and possible problems with low lumen output and heat management. In the technical expert meeting lighting control manufacturer's association CECAPI stresses control problems, especially with existing installations, that may be expected from phasing out MV retrofit halogen lamps from the market too soon (see Annexes I and N).

Figure 8. Example of 2.2 W LED replacement lamps for 20W mini-halogen G4 (left[7]).

Major competitive edge of MV halogen replacements over LED replacements is their lower purchase price (factor 3-10, depending on lumen output and retail source[8]) and over CFLs that

[7] LedItLight G4 12V 2.2W 66lm_W 147 lm 50 000 h. energy class 'A'. Source: www.olino.org. Price (Feb. 2013) at www.LedItlight.nl is € 11.50/unit incl tax. (presented as replacement for mini-halogen G4 20 W)

their light characteristics (colour rendering, colour, start time) are more similar to incandescents and for many users more appealing.

Disadvantage of the MV halogens is the considerably lower product life of at best 2000h versus 15 000 - 50 000h of the LEDs and the lower luminous efficacy in lm/W. These disadvantages negatively affect especially --and most noticeably for the consumer-- the monetary life-cycle costs and maintenance effort in fixtures with high operating hours. Although specific sales and market penetration data are lacking, this makes it plausible that MV halogen replacement lamps particularly find their way to sockets with low operating hours (e.g. 200-300 h/a) and many switches (short start time) or to lamp sockets for fixtures where the light characteristics are considered essential.

In some applications the light source also should provide a glitter effect, such as in crystal luminaires or reflection on glossy surfaces such as silver cutlery. This glitter effect could not be obtained by CFL lamps, but new types of LED lamps are brought on the market (see Figure 9) that could support this optical effect.

Figure 9. Example of 3 W LED replacement lamps (left) for 15Wclear GLS (right).

Technically, MV LEDs can be a suitable replacement for MV-HL lamps as regards most important features: immediate ignition, clear bright light, no UV, no mercury, etc..

Colour rendering is good (up to CRI 95 Ra), but not 'CRI 100' [9] like the MV-HL lamp, which has so far not been perceived as a critical difference. ENEA and other technical experts stress the importance of the trade-off between colour rendering (CRI) and efficacy in lm/W (see Annexes I and N).

Another LED-problem, which will probably not be noted in a residential setting but may become evident where several LED lamps light the same area in non-residential areas, are the small light colour differences that may occur between production batches and individual LEDs (measured in MacAdam ellipses[10]).

For the market introduction the availability of good quality products is essential, the variation in performance of LED sources in the market is large and this might threat consumer

[8] IKEA prices (Feb. 2013, UK) Up to 100 lumen lamps, prices as low as € 4 /unit. Lamp 200 lumen: € 6. Lamp 400 lumen: € 9 (£7). Note that these IKEA lamps are not dimmable, have a relatively low luminous efficacy of 40 – 45 lm/W and a relatively low claimed life expectancy of 20 000h. http://www.ikea.com/gb/en/catalog/products/30222486/

[9] CRI (Colour Rendering Index) is a measure of how well the lamp represents the colour of objects, people, etc. to the human eye. The reference is a filament lamp and thus an 'ideal' colour rendering index of 100 Ra can be achieved by halogens. For the currently best LEDs the CRI is 95 Ra (http://ledlight.osram-os.com/2011/04/high-color-rendering-index-cri-led-lights/).

[10] Ellipse-shaped colour region in a chromaticity diagram where the human eye cannot see the difference with respect of the colour at the centre of the ellipse. MacAdam ellipses are used e.g. in standards for describing acceptable colour deviation between LED lamps/luminaires of the same model (1 step=1 ellipse area; 2step=2 concatenated ellipse areas, etc.)

confidence. Therefore trusted brands or a quality label[11] can play an important role in broadening the LED market introduction.

The characteristics of LED lamps which could be a barrier in MV HL replacement are expected to improve over the coming years. The table below shows the projections of the US Department of Energy in terms of efficacy improvement of LED packages for the coming years.

Table 1. LED metrics roadmap (Source: US DoE 2012 MYPP[12])

Metric	Unit	2011	2012	2013	2015	2020
LED Package Efficacy (warm white)	lm/W	97	113	129	162	224
LED Package Price (warm white)	$/klm	12.5	7.9	5.1	2.3	0.7
LED Package Efficacy (cool white)	lm/W	135	150	164	190	235
LED Package Price (cool white)	$/klm	9	6	4	2	0.7
OEM Lamp Price	$/klm	33	23	16.5	10	5

Notes:

1. Projections for cool white packages assume CCT=4746, 7040K and CRI=70-80, while projections for warm white packages assume CCT=2580, 3710K and CRI=80-90

2. All efficacy projections assume measurements at 25°C with a drive current density of 35 A/cm2

3. Note that MYPP projections are based on price, not cost

From the US DoE trends and an anchor point of 58 lm/W in 2012 representing the EU average MV LED retrofit, CLASP constructed an efficacy projection in lm/W, showing that LED efficacy will more than double before 2020. Background data to the anchor-point of 58 lm/W in 2012 are given in Annex P, whereby it should be considered that the average and not the best lamps are to be represented.

The table below combines the efficacy figures with the MV LED retrofit (500 lumen) price projections by lighting manufacturer's association LightingEurope up to 2020 and –estimated by VHK—a plausible extrapolation of these prices up to 2025.

Table 2. MV LED retrofit lamp, efficacy and price projections EU 2012-2025
(sources: for efficacy CLASP 2013, based on US DoE MYPP projections; for EU lamp consumer prices incl. VAT (500 lm lamp) up to 2020 LightingEurope; 2021-2030 prices, extrapolation VHK)

Year	2012	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030
lm/W	58	93	99	105	112	118	125	130	134	138	142	169
price in €	18.0	10.0	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	2.5

Note that the LED price, according to the Premium Light project study (see comments ANEC/BEUC in Annex O), is a major barrier for consumers and thus the timing of forcing consumers to buy MV LED retrofits is very important.

In the technical expert meeting organic LEDs (OLEDs) were mentioned as a possible replacement technology for MV-HL retrofits. OLEDs are in a much earlier development stage than LEDs and they are a promising in terms of their potential efficacy (lm/W), but it is too

[11] http://iet.jrc.ec.europa.eu/energyefficiency/residential-lighting/european-led-quality-charter
[12] US Department of Energy (DoE), EERE, Solid-State Lighting Research and Development: Multi-Year Program Plan, April 2012.

early to tell whether and when they will be suitable replacement for MV-HL lamps. Such an assessment, with any certainty, cannot be expected in near future and thus OLEDs are not taken into account in this report.

Replacement characteristics of CFL lamps:

Disadvantages of the MV halogens are the considerably lower product life of at best 2000h versus 6 000 - 15 000h of the CFLs and the lower luminous efficacy. These disadvantages negatively affect especially - and most noticeably for the consumer - the monetary life-cycle costs and maintenance effort in fixtures with high operating hours. Although specific sales and market penetration data are lacking, this makes it plausible that MV halogen replacement lamps particularly find their way to sockets with low operating hours (e.g. 200-300 h/a) and many switches (short start time) or to lamp sockets for fixtures where the light characteristics are considered essential.

In some applications the light source also should provide a glitter effect, such as in crystal luminaires or reflection on glossy surfaces such as silver cutlery. This glitter effect could not be obtained by CFL lamps.

CFLs also have other functional disadvantages compared to MV-HL lamps such as lower colour rendering (CRI), longer start up time and limited amount of switching cycles.

However for mercury emissions, a substance that is a necessary ingredient for a CFL (legal limit is now 3.5 mg per CFL) but not for the MV-halogen, the total mercury emission balance of product and electricity use is very much in favour of using CFLs over MV-HLs.[13]

Replacement option using the proposed G9 exception in stage 6:

Finally, in the context of possible replacement options, it is relevant that adapters exist, brought on the market by the German firm Paulmann GmbH that allow to use G9 lamps, which are exempted from the minimum requirements in regulation for Stage 6, as incandescent replacements in standard E27 or E14 screw-base sockets. The socket is typically sold with various secondary glass bulb shapes.

Figure 10. Paulmann E14-socket for G9 halogen lamp with various shapes of bulbs (retail price approx. € 6.25 incl. tax[14])

[13] Currently the average EU mercury emission of power generation is around 0.016 mg Hg per kWh electricity. For a 10 W CFL, operating 600 h per year (5 kWh/yr) during 10 years this means a mercury emission from electricity generation of 96 mg, to which a maximum of 3.5 mg needs to added (if no mercury is recovered, which is not usually the case) to come to a total of 99.5 mg Hg. For the same number of hours (6 000h) you need 50W halogen lamps for the same light output, emitting 480 mg Hg or almost 5 times more.

The conclusion is that this E14/E27 to G9 adapter potentially constitutes a loophole for the Stage 6 requirements.

2.3. Technical feasibility of mains voltage Stage 6-conform halogen lamps

Halogen lamps, just as the incandescent lamps that were phased-out, are filament lamps. Basically, their higher efficiency over incandescent lamps stems from the use of different materials, which allow it to operate the filament at a higher temperature and thus generating more electromagnetic radiation in the visible spectrum (a.k.a. 'light') per unit of electric power input. These different materials are used for the filament (tungsten), the more heat resistant glass capsule (quartz), filling of the glass bulb (halogens like argon, xenon, krypton) and bulb coating e.g. Infrared (IR) coating. During the burning-process the filament is consumed until ultimately it fails (breaks). A halogen lamp has a kind of 'recycling process' wherein halogen gas combines with tungsten atoms as they evaporate and redeposit them on the filament. Most halogen filament lamps can be operated in any burning position, however this so-called recycling process requires a horizontal burning position for some types of halogen lamps (e.g. some types of R7s lamps).

A preliminary review of the market on 3/2012 did not reveal any clear filament mains voltage lamp (MV-HL) that meet the requirements of stage 6. There was a product on the market from one of the European manufacturers several years ago, see Figure 3b, however it isn't commercialized anymore today. The missing of a Stage 6-conform clear filament lamp could be due to market reasons, most likely such a lamp could not compete with either CFL or LED retrofit lamps in price and efficacy. We assume that lack of market interest is the main reason. Therefore a technical analysis is included hereafter to verify whether or not such a Stage 6-conform lamp is technical feasible.

<u>Trading-off lamp efficacy versus life time, lamp voltage, wattage and colour temperature for filament lamps:</u>

The aforementioned characteristics are interrelated, and cannot be changed without affecting the others[15]. Empirical and physics equations are described in detail in Annex F. According to those equations, reducing the filament lamp life time requirements by a factor 2 could result in increasing efficacy with approximately 10 % ($2^{1,6/13}$-1) (see annex F).The equations in Annex F explain the efficacy differences amongst most of the reference lamps included in Annex G.

For instance, due to the lower mains voltage (120/130 V), the US mains voltage lamps have a relatively higher efficacy and longer product life than the EU 230 V mains voltage filament lamps. This is shown for the US samples in Annex G (lamps 3-7). In Annex H LightingEurope gives a more detailed explanation.

The effect of the voltage also explains why 12 V lamps are far more efficient than 230 V lamps (see lamps 25 and 26 in Annex G).

The physics background relates to the fact that the efficacy of a filament lamp depends on the temperature of the filament, which in turn mainly depends on its electric resistance R (c.p.).To increase the electric resistance R, the filament can be made thinner and longer or the voltage V at a certain electric power intake P can be decreased.

---

[14] http://www.conrad-uk.com/ce/en/product/578218/PaulmannHalogen-lamps-54924-Base-set-E14-Clear/?ref=detview1&rt=detview1&rb=2

[15] Lighting Handbook, 8th Edition, Illumination Engineering Society of Noth America (p. 186), ISBN 0-87995-102-8.

The resistance R is proportional to the length and inversely proportional to the filament's cross section surface area. Making the filament thinner and longer has a detrimental effect on the technical product life: it can sag at high temperatures and short-circuit. Following the equations in Annex F, a 10% improvement of luminous efficacy (in lm/W) of a 230V lamp will half its product life (e.g. from 2000 to 1000 h [16]).

The relationship between voltage V and resistance R at power P is quadratic (formula $P = V^2/R$). For instance, the resistance at 115V (e.g. US) is 4 times lower than at 230V (e.g. EU) for the same power input; likewise the resistance at 12 V ('low' or 'extra-low' voltage) is 378 times lower than at 230V ('medium' or 'high' voltage). Hence, it is much easier for a US main voltage halogen lamp or a European low voltage halogen to be a 'B' class efficacy lamp than for a 230V halogen (without integrated transformer).

Applying infrared-reflective coating on the lamp envelope:

Infrared coating is commonly applied to increase lamp efficacy of low voltage halogen lamps[17,18]. The quartz lamp filament envelope is coated with a multi-layered dichroic coating which allows visible light to pass while reflecting a portion of the infrared radiation or heat back onto the filament, thus contributing to raising its temperature. It is offered by the main lamp manufacturers for more than a decade. The basic principle and patent of infra-red coating technology to increase lamps efficacy is over 35 years old[19]. Infra-red coating is also a mature technology and for example broadly used in double-glazed windows with low-solar-gain Low-E glass. Because this technology is applied for over 20 years no generic intellectual property barriers were expected in the preparatory study[20].

In mains voltage lamps it is more difficult to apply infrared coating due to the long filament wires, e.g. compare figure 2a to Figure 3a. So far only one manufacturer offers an infrared coated 230 V lamp (lamp 17 in Annex G), but this double-ended R7s cap lamp is still energy labelling class C and does not differ much in performance from lamp 38. The double-ended lamp (R7s, see figure 1) would be more suitable than a single-ended lamp (e.g. G9). This applies in general to retrofit E14/E27 lamps based on double-ended halogen capsules, see for example Figure 11. So far, such a retrofit E14/E27 lamp is not on the EU market (230 VAC) yet but at the end of this section a hypothetical calculation will be made to assess what could be expected.

At the technical stakeholder expert meeting on 26 April 2013 an IR-coated lamp was discussed that was recently introduced in the US at a price of $3.50/unit. Apart from IR coating this lamp also features an elliptical capsule. This '2XL' lamp uses US voltage (115-120V), consumes 52W and produces 1650 lumen, i.e. equivalent to the output of a 160-175W incandescent bulb in the EU (see Figure 12 and Annex G). It was suggested to put two burners of this lamp in series to produce a 230V European version that would be Stage 6 conform (see minutes Annex I). Industry objected that the market for such a lamp, with an output equivalent of 300-350W incandescent, would be limited and that –from the physics of the lamp—the realisation of Stage 6 conform lamps in these high power ranges does not imply that it is feasible –at a reasonable cost—for a commercially relevant size (see industry

---

[16] Formula in Annex F: Luminous efficacy (lm/W)= $2^{1.6/13} - 1 = 0.089 \approx 0.1$ or 10%

[17] Preparatory Studies for Eco-design Requirements of EuPs, 'Final report Lot 19: Domestic lighting', 2009, www.eup4light.net

[18] B Class Halogens and Beyond Design Approaches to Complying with Proposed EU Eco-design Domestic Lighting Requirements: A Technological and Economic Analysis, ECEEE, 2008, www.eceee.org

[19] United States Patent 4,017,758 (1977) 'Incandescent lamp with infrared filter'

[20] Preparatory Studies for Eco-design Requirements of EuPs, 'Final report Lot 19: Domestic lighting', 2009, www.eup4light.net

comments on this subject in Annex H). A hypothetical 100W, 3200 lumen lamp has been added as a possible R7s replacement lamp in Annex G as lamp nr. 42. G9 MV HL capsules are single ended and therefore no significant improvement from infrared coating is expected.

Figure 11. E14 halogen lamp with double-ended halogen capsule (model ca. 2005, no longer sold)

Figure 12. E26 halogen lamp21 with double-ended halogen capsule and infrared coating (120 VAC, 50 Watt, 1600 lm)

As regards the intellectual property (IP) rights to IR coating for mains voltage lamps there are some unsolved disputes between ECEEE and the industry, whereby the former claims that there are no real problems. The latter's position is that a requirement of infra-red coating introduces IP issues and a monopoly position of one supplier.

Industry reports that many patents have been filed for IR coatings for Mains Voltage Halogen lamps, but they were never commercialised in the EU as the energy savings are modest (in the order of 5-10% compared to current 'stage 5' lamps) and the additional cost and investments are too high compared to the efficacy gain.

<u>Improving the filament wire:</u>

Another approach for shifting emissions from the infrared to the visible spectrum is the selective emitter high temperature filament technology[22]. Such filaments have a ceramic coating or physical structure that aims to reduce the release of infrared energy from the filament or photonic lattice nanotechnology to achieve a similar effect. Both technologies have never been commercialized in consumer lighting products and will therefore not be further considered.

[21] www.2xbulb.com

[22] B Class Halogens and Beyond Design Approaches to Complying with Proposed EU Eco-design Domestic Lighting Requirements: A Technological and Economic Analysis, ECEEE, 2008, www.eceee.org

Feasibility of Stage 6-conform mains voltage halogen lamp without transformer

In order to explore the concessions that would have to be made in order to realize a low-cost (without transformer) Stage 6-conform mains voltage halogen lamp a hypothetical calculation was made, based on the various sections above. When a MV-HL 48 Watt double-ended lamp of 2000 h (15.6 lm/W) is recalculated to 1000 h and a IR bonus is applied similar to the larger mains voltage type it suggest that 21.2 lm/W efficacy is achievable (see calculated lamp 22 in Annex G). This is still below (-5%) the Stage 6 limit. Further, the extra price for IR coating (typically € 3/unit) might move price sensitive users to CFL lamps.

Incorporating a voltage transformer in the retrofit lamp or developing a retrofit adapter:

Stage 6-conform halogen low voltage lamps (HL-LV) are broadly available, see Figure 2b. They benefit from the low voltage and are able to fully exploit the benefits of infrared coating. Therefore the only proven way so far for mains-voltage halogens (230 V) to achieve the ‘B’ is to use an incorporated transformer which first transforms the current to low-voltage and then sends it through the filament. In 2008 Philips presented the first (and so far only) ‘B’ class mains-voltage halogen with an incorporated transformer (20 and 30 Watt). The product was developed in the EU and produced in China and had a retail price of € 9.95-/unit, which is around the price that would be needed today. Philips stopped the production of the mains-voltage ‘B’ class, which even in 2008 was twice as expensive as the not-cheap CFLs, shortly after its market introduction.

A similar and obvious approach would be to develop an adapter only with a low voltage transformer (E14/E27 to GY 6.35). So far such a product is not on the market and in purchase price it can probably not compete with the E14/E27 to G9 adapter (see Figure 5), which is currently sold at € 6.25. Please note that such an adapter and eventually a complementary transparent cover would cause some additional light loss, similar as a luminaire (characteristic is Light Output Ratio (LOR).

According to the manufacturer’s association LightingEurope[23] it would be technically feasible to produce stage 6 halogen lamps in the form of low voltage burners with infra-red coating in combination with electronics. Nevertheless, due to thermal constraints, the industry states that is only feasible up to till max 60W GLS equivalence (above, thermal issues in existing luminaires would occur). To overcome thermal constraints, very expensive components would be required, resulting in far too high prices for consumers versus LED and current Mains Voltage halogen lamps.

The same source concludes that at the moment no mains-voltage halogen on the market can achieve the requirements from stage 6 of 244/2009, and to produce such a lamp (most likely infra-red coating without electronics) is not realistic due to high technical constraints and high investments resulting in far too high prices for consumers versus LED and current Mains Voltage stage 5 halogen lamps.

Conclusions:

- It is technically feasible to produce 'Stage 6 conform' low-voltage (LV) halogen lamps at competitive production prices.
- It is technically feasible to produce 'Stage 6 conform' mains-voltage (MV) halogen lamps for the EU, but only with an integrated transformer (MV to LV) or at high lumen outputs (equivalent to output of >250-300W incandescent bulbs).

[23] Pers.comm. LightingEurope, 20.3.2013

- It is perhaps technically feasible to produce 'Stage 6 conform' MV halogen lamps for the EU in lower lumen outputs in an ideal production environment and top technology (IRC, quartz, perfect envelope, ultrathin and strong filament)
- It is not technically feasible to produce 'Stage 6 conform' MV halogen lamps for the EU at a competitive price, i.e. consumer price would be comparable to LEDs, and at a reasonable investment level.
- There are possible loopholes for Stage 6 enforcement on MV-HL lamps, such as G9 adapters and special purpose incandescents. The relevance for enforcement, i.e. the probability of consumers using these loopholes, will depend on the price difference between 'Stage 6 conform' lamps and current MV halogen lamps.
- Most experts agree that LED (possibly OLED) is the designated future replacement for MV-HL technology, but at the moment there are a number of technical/functional aspects such as colour rendering, dimmability, etc. and –most importantly-- the LED price that are potential barriers for consumer acceptance. These barriers are expected to be lowered to an acceptable level somewhere in the future, but the timing of forcing MV LED retrofits upon consumers is important.

3. MARKET

3.1. Sales

Industry data on unit sales was received from the Commission services, showing that in the EU-countries in 2012 almost 45 million non-directional low-voltage lamps and 168 million mains-voltage halogen lamps (excl. G9 and R7s [24]) were sold by members of LightingEurope that are producing light sources, previously known as ‘ELC’. These lamp manufacturers include Philips Lighting, OSRAM, GE Lighting, Havells Sylvania, Narva, Verbatim and Toshiba.

Historical ELC data 2009-2012 are shown in the graph and tables below for not only the LV-halogen capsules and MV-halogen incandescent replacements, but also for the incandescent and competing incandescent replacements like the CFLi and, possibly in the future, the MV halogen capsule G9 that can be placed in an adapter.

[24] But including a small share (<10%?) of MV-halogen replacement lamps for GLS-reflector E27/E14 lamps.

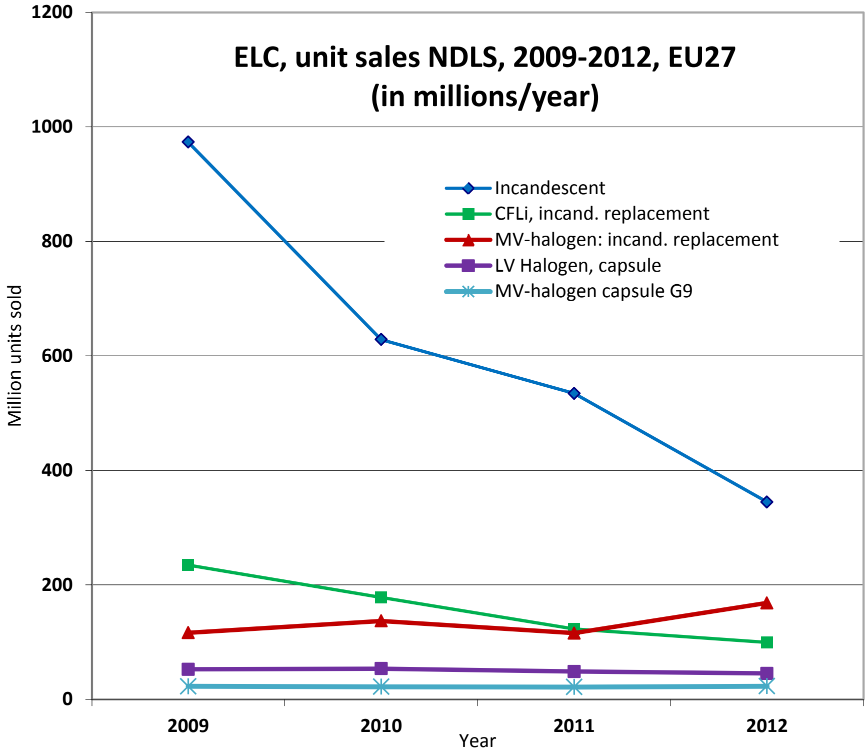


Figure 13. ELC sales of main NDLS types, EU27, 2009-2012 (source: LightingEurope/ELC, 2013)

Table 3. ELC unit sales of NDLS, 2009-2012, EU27

Lamp type	Unit sales (mn)				Index (2009=100)			
	2009	2010	2011	2012	2009	2010	2011	2012
Incandescent lamps: GLS (Including clear/pearl, candles, coloured & decorative)	973	628	534	345	100	65	55	35
Compact fluorescent lamps: Retrofit CFLi	235	178	123	99	100	76	52	42
Tungsten Halogen: Incandescent shape - GLS, Decorative & Reflector	117	137	116	168	100	118	99	145
Tungsten Halogen: LV Halogen Capsule	52	54	49	45	100	102	93	86
Tungsten Halogen: HV Halogen Capsule (G9)	23	22	22	23	100	97	95	101

While previously GLS lamps for the EU market were nearly exclusively produced in and by ELC members, the class C MV-HL seems also to have Chinese competition. Hence ELC data should be expanded with trade data and identifying Chinese manufacturers and importers.

An indication of the non-ELC share, although not exact because various NDLS and DLS categories are mixed, can perhaps be derived from the table below[25] .

[25] Note that intra-company imports of EU-based companies are typically not listed as ‘imports’ but as ‘production’.

Table 4. EU-production and trade filament lamps (source Eurostat, ProdCom, extract 21.2.2013)

PRCCODE & Description	Parameter	2005	2006	2007	2008	2009	2010	2011
27401293 Tungsten halogen filament lamps, for a voltage > 100 V (excluding ultraviolet and infra-red lamps, for motorcycles and motor vehicles)	production, m units	213	200	201	207	160	206	302
	imports, m units	133	155	175	152	143	220	224
	exports, m units	71	53	58	54	50	53	71
27401295 Tungsten halogen filament lamps for a voltage <= 100 V (excluding ultraviolet, etc., as above)	production, m units	265	259	243	224	224	350	300
	imports, m units	152	178	203	155	132	158	166
	exports, m units	92	94	109	95	78	70	69
27401300 Filament lamps of a power <= 200 W and for a voltage > 100 V including reflector lamps (excluding ultraviolet, infrared lamps, tungsten halogen filament lamps and sealed beam lamp units)	production, m units	1608	1303	1500	1130	1051	1012	751
	imports, m units	244	289	339	309	297	364	309
	exports, m units	581	530	589	437	402	536	545

By comparing Eurostat and ELC-data, it can be stated that GLS-lamps for the European market are/were almost exclusively produced in Europe. For halogen lamps in general ELC generally seems to have only 50% market share, but for the NDLS lamps with GLS shape, the market share can be estimated to be 66%. About 8% of the GLS-lamps are directional lamps so it is assumed that the same holds true for the GLS-shaped halogen lamps.

Based on the preceding assumptions, the EU sales of non-directional, GLS-shaped MV-HL-lamps were calculated as in the following table:

Table 5. Unit sales of GLS-shape MV-HL NDLS, 2009-2012, EU27

	MV-HL GLS-shape, sales in million units			
	Lighting Europe NDLS+DLS	Total EU NDLS+DLS	Total EU NDLS	**Total EU NDLS**
2009	116.52	176.54	162.42	**162.42**
2010	137.09	207.71	191.10	**191.09**
2011	115.82	175.48	161.44	**161.44**
2012	168.37	255.11	234.70	**234.70**
Total 2009-‘12				**750**

The MV-HL lamps entered the market in significant numbers only in 2008. Therefore, considering an average product life of 2000h and an operating time of 500h/year, the sales over the 4 year period 2009-2012 period can be assumed to constitute the ‘stock’, i.e. the number of sockets where GLS-lamps were replaced by MV-HL lamps.

Over the 2013-2014 period the MV-HL stock will be expanded, as the remaining installed GLS lamps will need to be replaced at the end of their product life. At an average installed period of 2 years –1000 h operating life, 500h/a operation-- the 534 million GLS sold in 2011 will need to be replaced in 2013 and the 345 million GLS sold in 2012 will need to be replaced in 2014 (see table 2), bringing the total to 879 million. Assuming that 8% are DLS, a total of 13-15% of the GLS-C sockets will be filled by CFLi or LEDi lamps and there is an unknown percentage of special purpose GLS-lamps, it is plausible that around 600 million of the additional ex-GLS sockets in 2013-2014 will be filled by MV-HL lamps. Together with the sockets from the period 2009-2012 this brings the stock of MV-HL lamps to around 1 350 million units/sockets.

The table below gives an overview of assumed sales and stock over the 2009-2016 period.

Table 6. MV-HL sales and stock EU 2009-2016, in million units

Year	ex-GLS free for MV-HL retrofit	MV-HL sales 66% EU industry	MV-HL stock	MV-HL discarded after 4 years
2009	163	163	163	-
2010	191	191	354	-
2011	162	162	516	-
2012	234	234	750	-
2013	380	543	1 130	163
2014	220	411	1 350	191
2015		162	1 350	162
2016		234	1 350	234

3.2. Market scenarios

Two market scenarios were developed: One for abolishing Stage 6 requirements (‘SC1’) and one for keeping Stage 6 requirements (‘SC2’).

In the latter case the Stage 6 requirements are enforced in September 2016 and –as has been argued in the technical analysis-- can only be fulfilled by an expensive MV-HL alternative with transformer at around € 10 (if there is an industry willing to produce them) many people will switch to LEDs, G9 adapters, special purpose lamps or –for the higher lumen outputs and even if it is not a clear lamp—CFLs. In that case a split-up LED/G9 adapter/special purpose/CFL of 60/10/10/20% is assumed.

Alternatively, in case the Stage 6 requirement is abolished there will still be a large influence of LEDs replacing MV-HL lamps, but the transition is expected to be more moderate. In its ‘Lighting the Way 2012’ report, McKinsey & Company predicts that in 2016 the market value share of halogen lamps (including low voltage and directional) will fall over 25% in 2016 with respect of 2012 (from 17% to 13% market share); in 2020 it is expected to drop again by more than 50% with respect of 2016 (from 13% to 6% market share). The projections of the industry association Lighting Europe, shown in the table below, are not very different from McKinsey as regards the strong growth of the LED market particularly regarding the period 2016-2020.

Table 7. LightingEurope projections LED market value share (pers.comm. 20.3.2013)

GLS 25-40-60-100W	2012	2016	2017	2018	2019	2020
Market share LED	6%	15%	20%	30%	45%	60%

Following the above, it can be assumed that without the Stage 6 requirement, around 40-50% of the 1350 million GLS-retrofit sockets mentioned earlier will have been filled by LEDs in 2020. The other half is filled by MV-HL lamps, generating replacement sales. Sales of MV-HL lamps will diminish by 20-30% annually due to competition with LED, until it will be (close to) zero in around 2024-2025.

The tables below give the quantitative assessment for the two scenarios, from the perspective of unit sales and stock.

Table 8. Market scenario 2017-2025 Abolishing Stage 6, in million units

Year	sockets free for retrofit* ex MV-HL	MV-HL sales	LED retro sales	MV-HL stock	LED retro stock	MV-HL discarded (after 4 years)
2017	337	287	50	1 300	50	337
2018	337	267	70	1 230	120	337
2019	337	232	105	1 125	225	337
2020	337	197	140	985	365	337
2021	287	117	170	815	535	287
2022	267	67	200	615	735	267
2023	232	14	218	397	953	232
2024	197	7	190	207	1 143	197
2025	117	0	117	90	1 260	117

*=longer term average, starting from 1350/4 = 337 mln. units replacement sale/year

Table 9. Scenario 2017-2025, Keeping Stage 6

Year	sockets free for retrofit, from ex MV HL or ex Other retro	LED retro sales	Other retro* sales	LED retro stock	Other retro* stock	Other retro discarded (after 2, 4, 12 yr)
2017	337	203	135	203	135	-
2018	337	203	135	405	270	-
2019	337	203	135	608	404	-
2020	337	203	135	810	540	-
2021	90	90	0	900	450	90
2022	90	90	0	990	360	90
2023	90	90	0	1080	270	90
2024	90	90	0	1170	180	90
2025	90	90	0	1260	90	90

*=CFL (50% of ‘other retro’ units, 12 yr life), G9+adapter (25%, 4 yr), special purpose GLS (25%, 2 yr)

4. ENVIRONMENTAL IMPACT

4.1. Previous assessments

In the preparatory study[26] and the impact assessment[27] for the Regulation 244/2009 the effect of the Stage 6 requirement, as it was perceived in 2008-2009, was projected to be very close to what was called scenarios 2b and 2c.

Scenario 2c was mainly based on an improved halogen mains voltage lamp with xenon gas filling, which was a recent technology at the time and was believed to enable the halogens to reach the energy label C-class at stage 6.
Scenario 2b was based on an improved mains voltage halogen lamp with both xenon gas filling and IR coating and incorporated transformer to reach the energy label B-class at stage 6.
The corresponding savings over a base case GLS are included in lamps 10 (-25%) and 12 (-43%) in Annex G.

The likely impact of the examined scenarios is summarised in the following table. The last row, added in the underlying study, relates to the expected effect of Stage 6 (the difference between scenario 2b and 2c):

Table 10. Annual and accumulated electricity cost savings in 2020

Sub-Option	Annual savings in 2020			Accumulated savings 2009-2020		
Scenario	Electricity savings (TWh)	Cost savings (billion €)	CO_2 emiss. Reduction (Mt)	Electricity savings (TWh)	Cost savings (billion €)	CO_2 emiss. Reduction (Mt)
2b (including stage 6)**	38.6	5.2	15.4	399	54	160
2c	33.1	4.5	13.2	314	43	126
Difference of 2b and 2c - Stage 6	*5.5*	*0.7*	*2.2*	*85*	*11*	*34*

*** 6 Stages (for sub-option 2b): 2009, 2010, 2011, 2012, 2013 and 2016*

This 2009 analysis suffered from a very limited availability of market data and the decision on the final regulation including deviations from the recommended policy options. It could not anticipate the commercial failure of class 'B' mains-voltage halogens (with integrated transformer) and did not consider the implementing requirements to limit luminaires with class C lock-in effect (G9, R7s). Meanwhile, on the positive side, the scenario did not anticipate the full impact of LED lamp retrofits.

For full details on the scenario consult the lot 19 preparatory study[28]. Amongst others there are also differences in assumptions and regulations in exceptions and luminaire lock-in effects but they are not relevant for the review discussed in this document.

[26] Tichelen, P. van (VITO) et al., Preparatory study Lot 18/19: Domestic lighting - Part 1 Non-Directional Lamps, 2009; documentation available on www.eup4light.net

[27] SEC(2009) 327, COMMISSION STAFF WORKING DOCUMENT accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps, FULL IMPACT ASSESSMENT. Brussels, 18.3.2009

[28] Tichelen, P. van (VITO) et al., Preparatory study Lot 18/19: Domestic lighting - Part 1 Non-Directional Lamps, 2009; documentation available on www.eup4light.net

4.2. Energy scenarios

Taken into account the updated market data of the previous section, the impact on energy consumption in the two energy scenarios is given in the tables below.

The difference between the two scenarios is 35 TWh electricity saving over the 2016-2060 period when keeping Stage 6. A saving of 35 TWh, at 0.35 $MtCO_2$/TWh[29], means a CO2 abatement of 12.2 $MtCO_2$.

The largest difference between the two scenarios is in the year 2020 and amounts to 9.4 TWh (18.6 versus 9.2) saving when keeping Stage 6. At 0.36 $MtCO_2$/TWh this amounts to a CO_2 abatement in 2020 of 3.4 $MtCO_2$.

Table 11. Energy Scenario 2017-2025 Abolishing Stage 6

Year	MV-HL stock	LED retro stock	LED retro sales	LED retro efficacy	LED power at sales (at 500 lm)	MV-HL stock energy use (at 36 W, 500 lm)	LED retro stock energy use	Total
	m units	*m units*	*m units*	*lm/W*	*W*	*TWh/yr*	*TWh/yr*	*TWh/yr*
2016	*1350*			*93*	*5.4*	*24.3*	*0.0*	***24.3***
2017	1300	103	50	99	5.1	23.4	0.1	**23.5**
2018	1230	120	70	105	4.7	22.1	0.3	**22.4**
2019	1125	225	105	112	4.5	20.3	0.5	**20.8**
2020	985	365	140	118	4.2	17.7	0.8	**18.6**
2021	815	535	170	125	4.0	14.7	1.2	**15.8**
2022	615	735	200	130	3.9	11.1	1.5	**12.6**
2023	397	953	218	134	3.7	7.1	2.0	**9.1**
2024	207	1143	190	138	3.6	3.7	2.3	**6.0**
2025	90	1260	117	142	3.5	1.6	2.5	**4.1**
2026	0	1350	90	148	3.4	0.0	2.7	**2.7**
2026-2060		1350		128	3.9		93.0	**93.0**
Total 2016-2060, in TWh accumulative						**146.1**	**106.9**	**252.9**

[29] See MEErP 2011, value approximately for 2025.

Table 12. Energy scenario 2017-2025, Keeping Stage 6

Year	**MV-HL stock**	**Other retro* stock**	**LED retro stock**	**LED retro sales**	**LED power at sales (at 500 lm)**	**MV-HL stock energy use (at 36W)**	**Other retro stock energy use (at 27W*)**	**LED retro stock energy use**	**Total**
	m units	*m units*	*m units*	*m units*	*W*	*TWh/yr*	*TWh/yr*	*TWh/yr*	*TWh/yr*
2016	*1350*	*0*	*0*	*0*	*0*	*24.3*	*0.0*	*0.0*	***24.3***
2017	1013	135	203	203	5.1	18.2	1.8	0.5	**20.6**
2018	675	270	405	203	4.7	12.2	3.6	1.0	**16.8**
2019	338	404	608	203	4.5	6.1	5.5	1.4	**13.0**
2020	0	540	810	203	4.2	0.0	7.3	1.9	**9.2**
2021		450	900	90	4.0		6.1	2.1	**8.1**
2022		360	990	90	3.9		4.9	2.2	**7.1**
2023		270	1080	90	3.7		3.6	2.4	**6.0**
2024		180	1170	90	3.6		2.4	2.6	**5.0**
2025		90	1260	90	3.5		1.2	2.7	**3.9**
2026		0	1350	0	3.4		0.0	2.7	**2.7**
2026-2060			**1350**		4.3			101.8	**101.8**
Total 2016-2060, in TWh accumulative						**60.8**	**36.4**	**121.3**	**218.4**

*=CFL (75% of 'other retro' units, 9W), G9+adapter (25%, 40W), special purpose GLS (25%, 54W) ; weighted avg. 27W

5. EMPLOYMENT

5.1. Introduction

This section concentrates on the employment in manufacturing non-directional MV-HL incandescent replacement lamps, which is the part of industry that is most jeopardised when it will turn out that it is technically/economically not possible to produce stage 6-conform halogen lamps (see technical analysis).

For the non-directional LV-HL lamps it is assumed that production will shift to stage 6-conform lamps without negative consequences for the EU workforce. Also other halogen production, like G9, R7s and directional halogens, will not be affected by Stage 6. Employment at head and sales office and distribution centres is also not considered, because if Stage 6 provokes the phasing out of MV-HL non-directional lamps they will be replaced by other products that require distribution, commercialisation and management.

5.2. Negative employment impacts Stage 6

This section looks at the negative employment impacts of maintaining Stage 6 requirements in case these requirements are not met and thus MV NDLS halogens will effectively be phased out, i.e. current production stops. This has to be set against possible positive impacts in par. 5.3. To eliminate bias as much as possible, estimates of employment effects were made based on three different sources: Information in the public domain, information obtained from industry (LightingEurope) and information obtained from trade unions (Sustain Consult for IGM).

Employment in MV-HL production of manufacturers

OSRAM (DE), lighting division of Siemens[30], manufactures MV NDLS ‘Eco Classic’ halogen lamps in the EU, in Molsheim (F). The Molsheim plant was restructured after the phase out of GLS (incandescent) lamps. It now offers jobs to around 320 people and has been reported to be hiring new staff. In 2011 OSRAM invested € 4.5 million in new non-directional halogen lamp production. The ‘burners’ (the small halogen source inside the secondary envelope of an MV-HL lamp) for OSRAM’s ‘Eco Classic’ halogens are produced in Eichstätt, Germany. In July 2012, OSRAM brought a new production line on line for ‘burners’. In October 2012, OSRAM announced to invest € 10 m in another new production line of ‘burners’ at the Eichstätt plant. Reportedly, with the 25 new jobs from this latter production line that is planned to be operational in the summer of 2013, the Eichstätt-workforce can be kept at the current level of 700 jobs. There is no official figure, but it seems likely that in Eichstätt a few hundred jobs are linked to component-production for MV-HL lamps for mainly the EU-market[31]. The filaments for the burners are produced in Bruntál, Czech Republic.

Philips is producing MV DLS ‘Eco Classic’ halogen lamps in Pabianice, Poland, using the halogen ‘burners’ produced in its plant in Aachen, Germany. Employment figures are not in the public domain, but it is estimated that a stop to the production of MV-halogens would mean the loss of around 300 indirect jobs in Poland and a similar number of (indirect) jobs in Aachen’s burner manufacturing. The filaments for the burners are produced in Turnhout, Belgium.

In Hungary, General Electric (GE Lighting), has laid off thousands of workers, but it seems that –notably with the introduction of new production lines for ‘EcoGLS’ halogens— restructuring has slowed with respect of the plans. The new products and production lines of energy saving MV-halogens reportedly have kept some 460 people employed, mainly at the Nagykanizsa plant.[32]

Havells Sylvania has 'brought back' its LED-production from Asia to Europe. Its plant in Tienen, Belgium (240 employees) is actually producing LED directional lamps for the EU market. The company mentions that personnel costs are only a small part of production costs and their decision makes a lot of business sense, in terms of being close to the market and close to high-class R&D. Nonetheless, EU employment at Havells Sylvania, would be negatively affected if directional MV Halogen lamps would be banned from stage 6, as the burner technology is the same as non-directional MV Halogen lamps.

In total, the study team estimates that the production of non-directional MV halogens provides an estimated 3300 jobs with the 3 large lamp manufacturers in the EU, of which roughly half in component manufacture (burners, glass, filament, caps). Checked against the economic data this is a plausible number.[33] Also against the indications of the lighting manufacturers and the trade unions, discussed in the next section, this is plausible.

---

[30] In 2011 Siemens failed to bring OSRAM as an independent company on the stock exchange.

[31] Other Eichstätt jobs (OSRAM’s ‘Halogen Standort’) are linked to halogen automotive lamps, projector lamps, directional lamps, etc..)

[32] http://www.ge.com/europe/downloads/GE_restructuring_rescheduled_01_02_12.pdf

[33] Given EU27 HL-MV sales 2012 of 168 m units, which might result in around € 200 m of revenues at manufacturing selling prices. Assuming a sector average of around 0.1-0.15 m revenue per direct job, this results in 1500-2000 jobs. Add 1000-1500 jobs in the supply chain (glass, filaments, caps, sub assembled ‘burners’).

Lateral jobs on MV-HL production sites of manufacturers at risk

The study team cannot estimate how much the economic survival of an EU production site or production line depends on the contribution of the EU market for MV-HLs. It may well be that if an important part of the capacity, e.g. in component production, disappears the rest of the production at that site becomes uneconomical. In that context only indications of the industry and the 'direct employment affected' number of the trade unions can be given as an indication.

The manufacturer's association LightingEurope sees that if the mains-voltage halogens will be phased out, approximately 4350 jobs will be jeopardized only from lamp manufacturers organized in LightingEurope. This figure includes the jobs directly related to the production of halogen lamps, inlcuding internal component manufacturing (glass, metal, bases etc.) but excluding the (external) jobs indirectly linked to the operation (raw materials, components, packaging material etc.) as supplier/subcontractor.

The trade unions estimate that 4 165 direct jobs would be affected by keeping Stage 6 (Sustain Consult for IGM, see Annex J). As a total number this is close to the indications by the lamp industry. Although for some sites there are unknown factors (CZ, HU), the IMG estimate is approximately in line with the estimate of Lighting Europe. Of this, IMG estimates that there are around 3 300 jobs in the MV HL production and 900 jobs will be lost as a direct lateral effect, i.e. the closing of a whole site because the MV HL production at that site is phased out. The number of 3 300 jobs is similar to the VHK estimate based on public domain sources.

Figure 14. Direct employment impact MV Halogen Production & Direct Suppliers.

Indirect jobs at suppliers and subcontractors

Apart from direct jobs also the indirect unemployment effect, i.e. jobs lost to external contractors (repair and maintenance, catering, manufacturing of machines), to external component suppliers, upstream suppliers of raw materials, etc. are to be taken into account. The indirect job loss is difficult to assess. Available methods include

- the I/O analysis, based on the macro-economic input-output tables to derive a direct/indirect ratio ;
- process analysis, based on the detailed micro-economic assessments per plant and
- a maximum estimate based on economic sector data.

The first method results, according to IGM, in a direct/indirect jobs ratio of 2.4 and thus, eliminating some double counting, a loss of 7054 indirect jobs. Together with the direct job loss mentioned above, this would result in a negative employment impact of 11 219 jobs. Subtracting from this some 500 jobs that IMG estimates as positive employment impact, the net number of jobs affected would then amount to 10 700.

The second method is very labour-intensive and severely handicapped by the confidentiality of detailed company data.

The third method, of which IGM gives an example in its ‘plausibility check’ (see Annex J, Appendix 4) starts from specific sector data, hence is already more accurate than the first method, and uses the average EU labour costs per employee (+corporate profit per employee) on one hand and the total annual turnover (minus profit) in the EU. The ratio between these two parameters gives the maximum total number of EU jobs that could potentially be affected. The number of indirect jobs follows from a subtraction of this total. The labour costs per employee, i.e. the gross income, employer contributions and corporate profit, is set at around € 35 000 (see economics section). IMG estimates the annual turnover of the MV HL production at € 200 million, to be increased by around € 55 million for the loss[34] of the lateral production at the affected sites. This gives a maximum total number of EU jobs affected of 7 285. [35] Subtracting the direct jobs, this gives an estimate of 3 120 indirect jobs.

The study team thinks that, given the limitations in data availability, the lower estimate of the third method is the most reliable and the 3120 indirect jobs at suppliers and subcontractors is the best estimate for a maximum number of jobs involved.

This means that a (maximum) negative employment linked directly and indirectly to MV HL production in the EU of around 7 300 net jobs is estimated. Minus the positive impact of 500 jobs, this leaves a net (maximum) of 6 800 EU jobs affected. This is the basis of the calculations in the economics section in this report.

5.3. Positive employment impacts Stage 6

The European Union is an important producer of MV halogen retrofit lamps worldwide, producing for most of the EU-market and –through GE Lighting-- the Northern American market.

Maintaining Stage 6 requirements, will give a very compelling incentive to the industry to intensify its research and development efforts until 1 Sept. 2016 to try to make an affordable ‘B’ class MV-HL feasible and maintain its market share, and thereby employment, in this segment. Apart from securing jobs at the major lamp manufacturers, this could create also jobs with suppliers, such as IR coating specialist Auer Lighting[36] and others.

Alternatively, if the industry does not succeed, this would create market opportunities for other ‘incandescent retrofits’ that would meet the requirements. Notably these will be, where the clarity of the bulb is not critical, CFLs with integrated ballasts (‘CFLi’) or MV LEDs with integrated driver (‘LEDi’). These alternatives have been discussed in the market and technical sections.

However, the possible positive employment impact from a switch to LED or CFLi is extremely modest.

There is little CFL production in Europe left[37] and many users will be reluctant to replace the clear MV-HL lamps with the non-clear CFLs. In as much as CFLs will be able to fill a part of the possible gap, Asian employment stands to gain the most.

---

[34] Assumed to be outsourced outside the EU

[35] 255 000 000/ 35 000.

[36] Auer Lighting, Bad Gendersheim (DE), formerly the German lighting components business of Schott AG, is a leading supplier of high quality lighting components for such solutions. Since 2007 Auer is a subsidiary of Advanced Lighting Technologies Inc. (ADLT)[36]. At the time of the take-over, Auer employed 500 people in production, sales and administration roles and had a turnover of approximately $74 million. Developing reflector solutions for high-efficiency (energy class B) halogen lamps for lamp manufacturers is only a part of their business.

[37] The ELC data in the market section shows that in 2011, EU27, around 123 million CFLs were sold by ELC-members. Of this, an unknown share was produced by extra-EU plants of the ELC-manufacturers. Eurostat’s

Most of the market gap is expected to be filled by LED light sources. Also there, Asian manufacturing is dominant:

- There is no production of LED wafers for general lighting in the EU. The only active EU production site of LED wafers is at OSRAM in Regensburg(D), but according to IGM the LEDs are used for special applications (laser, medical, sensors, IR) and too expensive for general lighting.
- The production of LED lamps in the EU is very limited, Havell's Sylvania being an exception. Most 'European' lamps from smaller brands, e.g. Lemnis, LedItLight, etc., are at best designed in the EU but produced outside the EU.
- In the production of manufacturing systems for LED wafers German Aixtron AG is a world market leader and there may be –although disputed by IGM- some positive impact.

All in all, the positive employment effect of Stage 6 requirements is very limited and the estimate is that no more than 500 jobs would be created is plausible.

In balance, between the positive (500) and negative (max. 7300) job impacts, it is thus estimated that a maximum of 6800 net jobs are at risk when keeping the Stage 6 requirements.

5.4. Wider employment and economic perspective

It is not easy to predict the wider repercussions, also in terms of economics and employment, of reversing a political decision that was taken in 2008-2009. Especially in this case, where producers have shifted the work force from a product that was phased-out to a new product that is known to be phased-out in the future, any decision will set an example for other sectors that are or will be subject to Ecodesign measures.

This is particularly the case where this decision was also taken in a global context where a large number of countries around the world committed themselves to realizing energy efficient lighting.

On the short term, reversing a decision requires an adequate communication strategy. On the longer term, if a possible amendment of Stage 6 is perceived as the EU structurally wavering in its support for the most energy efficient lighting solution it might affect the worldwide LED market.

In this context, the Swedish Energy Agency points at the strategy of Japan to completely ban all non-LED lamps, including linear and compact fluorescents, by 2020 (see Annex O). Also in the US, 'Solid State Lighting' (LED, OLED) is an important part of energy policy and the analytical efforts and research resources of the US in this field far exceed those of the EU. Also several other Asian countries like China and Koreas have far-reaching plans in promoting LED lighting.

Nonetheless, there is no doubt –as stated in the technical section—that in due time MV LED lamps will replace MV halogen lamps.

In other words, the 6 800 net jobs currently linked to EU MV halogen manufacturing will eventually be lost. The scenario analysis merely calculates whether they should be lost by the

---

Prodcom data shows a total apparent consumption (production+imports-exports) of CFLs in EU27, 2011, of around 450 million units (PRCCODE 27401530 Fluorescent hot cathode discharge lamps, excluding ultraviolet lamps and excluding with double ended cap). EU-based CFL production is reported in Piła, Poland (Philips) and in Hungary (GE Lighting).

end of 2016 (keeping Stage 6) or whether they will gradually disappear over the 2016-2025 period (abolishing Stage 6).

Another question is whether the extra time from abolishing stage 6 will be enough for the industry to try to save some of these jobs by moving to other products (innovation) or relocation of sites from outside the EU back to the EU.

Both questions mentioned above make a difference not only in social policy but also in economics (see next section).

6. ECONOMICS

As regards the overall economics for governments and market actors of keeping or abolishing the Stage 6 requirements it is impossible, especially over the long product life of the LEDs of at least 40 years (>20 000h product life, 500h/year operation), to make any quantitative analysis, no matter how sophisticated, with some certainty. And in that case, a very simple analysis might be just as good. The following paragraphs treat various economic aspects that may play a role in political decision making.

6.1. Payback period

The Payback Period, in years, is an economic parameter in investment decision making and – simply put—calculates how long it takes before the discounted gain in running costs equals the extra investment costs of two (or more) alternative options. The application of this parameter in Ecodesign analysis is explained in MEErP 2011.[38]

In case the two options have the same product life, the payback period is the ratio between the extra investment and the total discounted gain in running costs over product life. If --as is currently the case-- the discount rate equals the escalation rate, then explicit discounting to Net Present Value can even be omitted.

In case the two options do not have the same product life, the discounting can still be omitted, but otherwise the above simple method is not valid. The calculation of a 'payback period' then entails the point period in time where the accumulated write-off of the shorter-lived product (e.g. MV HL) plus its running costs equals the purchase cost plus running costs of the longer-living product (e.g. LED).

The table below illustrates the case, using 2016 parameters for LED and MV-HL retrofit lamps. The MV-HL lamp has 36W power (500 lm, 14 lm/W), 2000h product life and a list purchase price of € 3. The equivalent LED lamp is expected to have 5.4 W power (500 lm, 93 lm/W), 20 000 h product life and a list price of € 10. Both are assumed to have an operating time of 500h per year and thus the MV-HL uses 18 kWh/year (€ 3.96/year in electricity at a 2016 electricity rate of € 0.22/kWh) and the LED lamp uses 2.7 kWh/year (€ 0.60/year at the same rate). Both the discount rate and the escalation rate are 4% (Present Worth Factor PWF = Product Life).[39]

[38] Kemna, R., Methodology for the Ecodesign of Energy-related Products, VHK for the European Commission, 2011.

[39] the effect of discounting of multiple MV-HLs purchased in the future, which works in favour of MV-HL in terms of payback, is small and therefore not taken into account.

Table 13. Calculation of 'payback period' of LED versus MV HL retrofit lamp, basis EU 2016* (numbers in constant 2016 Euro)

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
LED price	€ 10.00					
LED accumulated running costs	€ 0.60	€ 1.20	€ 1.80	€ 2.40	€ 3.00	€ 3.60
LED total	€ 10.60	€ 11.20	€ 11.80	€ 12.40	€ 13.00	€ 13.60
MV-HL accumulated write off (price/4)	€ 0.75	€ 1.50	€ 2.25	€ 3.00	€ 3.75	€ 4.50
MV-HL accumulated running costs	€ 3.96	€ 7.92	€ 11.88	€ 15.84	€ 19.80	€ 23.76
MV-HL accumulated total	€ 4.71	€ 9.42	€ 14.13	€ 18.84	€ 23.55	€ 28.26
accumulated cash saving LED vs. MV HL	-€ 5.89	-€ 1.78	€ 2.33	€ 6.44	€ 10.55	€ 14.66

The table above illustrates that, using 2016 parameters and list prices, the expected ‘payback period’ of LED versus MV HL lamp is around 2.4 years at 500h/yr. At an operating time of 250h per year, instead of 500h per year, the payback period would be 4.2 years.

Using 2021, i.e. the median year of the 2016-2025 period, the parameters would change again considerably. The LED lamp would then cost € 7/unit, the electricity rate would be € 0.266/kWh [40] and LED efficacy will be 125 lm/W. The result is a payback period of 1.4 years at 500 h/yr and 2.4 years at 250h/yr.

The table below summarizes the results for the years 2012, 2016 and 2021.

Table 14. Payback periods, in years, LED vs. MV-HL retrofit 2012-2016-2021

operation hours per year	investment year		
	2012	2016	2021
500 h/year	5.0	2.4	1.4
250 h/year	8.8	4.2	2.4

6.2. Consumer expenditure

Based on the technical and price data in Chapter 2, the market scenarios in Chapter 3 and the energy scenarios in Chapter 4, the consumer expenditure for abolishing or keeping Stage 6 can be established. The tables below give an overview.

[40] In constant 2011 euros

Table 15. Consumer expenditure Scenario Abolishing Stage 6

Year	Energy use	Energy costs (€0.22/kWh)	MV-HL sales	MV-HL sales	LED sales units	LED price	LED sales value	total lamp sales	total purchase +energy
	TWh/yr	*€bn*	*m units*	*€bn*	*m units*	*€/lamp*	*€bn*	*€bn*	*€bn*
2016	24.3	**5.3**	*234*	*0.4*		*10.0*		***0.4***	**5.7**
2017	23.5	**5.2**	287	0.4	50	9.0	0.5	**0.9**	**6.1**
2018	22.4	**4.9**	267	0.4	70	8.5	0.6	**1.0**	**5.9**
2019	20.8	**4.6**	232	0.3	105	8.0	0.8	**1.2**	**5.8**
2020	18.6	**4.1**	197	0.3	140	7.5	1.1	**1.3**	**5.4**
2021	15.8	**3.5**	117	0.2	170	7.0	1.2	**1.4**	**4.8**
2022	12.6	**2.8**	67	0.1	200	6.5	1.3	**1.4**	**4.2**
2023	9.1	**2.0**	14	0.0	218	6.0	1.3	**1.3**	**3.3**
2024	6.0	**1.3**	7	0.0	190	5.5	1.0	**1.1**	**2.4**
2025	4.1	**0.9**	0	0.0	117	5.0	0.6	**0.6**	**1.5**
2026	2.7	**0.6**		0.0	90	4.5	0.4	**0.4**	**1.0**
2026-2060	93.0	**20.5**		0.0	0		0.0	**0.0**	**20.5**
Total	**252.9**	**55.6**		**2.1**	**1350**	**6.5**	**8.8**	**10.9**	**66.5**

Table 16. Consumer expenditure Scenario Keeping Stage 6

Year	Energy use	Energy costs (€0.22/kWh)	Other retro* sales	Other retro* sales	LED retro sales	LED price	LED sales	total lamp sales	total purchase +energy
	TWh/yr	*€bn*	*m units*	*€bn*	*€bn*	*€/lamp*	*€bn*	*€bn*	*€bn*
2016	**24.3**	**5.3**				*10.0*		***0.4***	**5.7**
2017	**20.6**	4.5	135	**0.4**	**203**	9.0	1.8	**2.2**	**6.7**
2018	**16.8**	3.7	135	0.4	203	8.5	1.7	**2.1**	**5.8**
2019	**13.0**	2.9	135	0.4	203	8.0	1.6	**2.0**	**4.9**
2020	**9.2**	2.0	135	0.4	203	7.5	1.5	**1.5**	**3.5**
2021	**8.1**	1.8	0	0.0	90	7.0	0.6	**0.6**	**2.4**
2022	**7.1**	1.6	0	0.0	90	6.5	0.6	**0.6**	**2.1**
2023	**6.0**	1.3	0	0.0	90	6.0	0.5	**0.5**	**1.9**
2024	**5.0**	1.1	0	0.0	90	5.5	0.5	**0.5**	**1.6**
2025	**3.9**	0.9	0	0.0	90	5.0	0.5	**0.5**	**1.3**
2026	**2.7**	0.6	0	0.0	90	4.5	0.4	**0.4**	**1.0**
2026-2060	**101.8**	22.4		0.0			0.0	**0.0**	**22.4**
Total	**218.4**	**48.1**		**1.6**	**1350.0**	**7.3**	**9.8**	**11.4**	**59.4**

*=CFL (50%), G9+adapter (25%), special purpose GLS (25%) average price €3

**=MV-HL, last year of sales (at €1.50)

The scenario calculation shows a saving of consumer expenditure of around €7 bn (in constant 2016 euro) or almost 11% over the 2016-2060 period when keeping the stage 6 requirements.

The saving comes from € 9.4 bn lower running costs over the period 2017-2025. Over the following period 2026-2060 the running costs are €1.9 bn higher when keeping Stage 6, because the purchased LEDs are on average 12% less efficient. Thus the net saving on running costs over 2016-2060 is €7.5 bn. The total acquisition costs of the LED lamps when keeping Stage 6 is €1 bn or 11% higher, because the LED lamps were bought sooner and thus more expensive. On the other hand, the repeat sales of MV-HL lamps is avoided and thus in total the acquisition costs when keeping Stage 6 is just €0.4 bn higher.

6.3. Unemployment costs

The unemployment costs of abolishing versus keeping the Ecodesign Stage 6 requirements are calculated on the socio-economic data per job given in the table below and the net (maximum) number of 6800 EU jobs related directly and indirectly to the MV HL production, calculated previously.

Table 17. Average EU unemployment costs MV Halogen retrofit production, per job (basis 2011) [IGM*]

	unit	*average*	
Loss of state income			
gross income per person 2011	***€/pp.yr***	**25 370**	
employee tax and social security contributions	***%***	**37.1%**	
employer social security contributions	***%***	**27.5%**	
state loss of tax and contributions	***€/pp.yr***	**16 389**	*(A)*
Extra state & employer spending			
state unemployment benefit			
average support period	***months***	**12**	
avg.% of former income as support	***%***	**59%**	
total benefit over support period	***€/pp***	**15 023**	*(B)*
other			
employer severance rate**	***€/pp***	**14 632**	*(C)*
state social security pay after support period	***€/pp.yr***	**6 292**	*(D)*
Total costs			
in support period (fixed)	***€/pp***	**46 044**	*(A+B+C)*
after support period (per year)	***€/pp.yr***	**22 680**	*(A+D)*

in addition: loss of corporate tax income (unknown, but believed to be negligible)

*= Sustain Consult for IGM, 2013 (see Annex J), supplemented with indicative employer social contributions (EU taxes database). Weighted average calculated by VHK.

**=employer severance rates are corporate tax deductable, so effectively 25% is state loss and 75% industry loss

For the scenario calculation it is assumed that employment linearly depends on the EU production and sales that were established in the market section. This means that in case of keeping the Stage 6 requirements, manufacturers are assumed to stop MV-HL production will stop and basically all 6 800 EU jobs are lost after 2016. Also in case of abolishing the Stage 6 requirements, the market analysis assumes that market forces, in combination with the technical and functional improvements of LEDs and possibly OLEDs, will cause a phase-out of European MV HL production, but that it will take place gradually over the period 2016-2025. For the initial economic calculation it is thus assumed that before 2016 and after 2025 the employment effects between the two scenarios is the same. Thus the economic calculation of abolishing Stage 6 ('SC1') and keeping Stage ('SC2'), given in the table below, relates only to the 2016-2025 period (10 years).

Table 18. Unemployment costs: Abolishing (SC1) versus keeping (SC2) Stage 6 requirements

year	HL sales		HL jobs		SC1 costs related to year of employment loss (negative=gain)									total costs	
	in units		nr.		in 000 euro									in 000 euro	
	SC1	SC2	SC1	SC2	2017	2018	2019	2020	2021	2022	2023	2024	2025	SC1	SC2
2016	234	234	6800	6800											
2017	287	-	8340	-	-70848									- 70 848	367 880
2018	267	-	7759	-	-35424	26735								- 8 689	157 080
2019	232	-	6742	-	-35424	13368	46786							24 730	157 080
2020	197	-	5725	-	-35424	13368	23393	46786						48 123	157 080
2021	117	-	3400	-	-35424	13368	23393	23393	106940					131 670	157 080
2022	67	-	1947	-	-35424	13368	23393	23393	53470	66838				145 038	157 080
2023	14	-	407	-	-35424	13368	23393	23393	53470	33419	70848			182 467	157 080
2024	7	-	203	-	-35424	13368	23393	23393	53470	33419	35424	9357		156 400	157 080
2025	0	-	0	-	-35424	13368	23393	23393	53470	33419	35424	4679	9357	161 079	157 080
														769 969	1 624 520
										difference SC2-SC1					**854 551**

The table shows a difference between the scenarios of around 854 million euros in total unemployment costs over the review period[41]. Of this, over 90% will be at the expense of the state, i.e. the tax payer, and the rest will be at the expense of the companies involved in lost profits (industry severance payments are the same in both scenarios).

The above calculation assumes that the extra time that is given to the industry when abolishing Stage 6 will not help the industry in finding new employment for the affected sites, e.g. through innovation (e.g. OLEDs) or bringing LED lamp production to the EU. This is a pessimistic scenario. In a more optimistic scenario, the extra time will allow the industry to keep at least part of the employment at the affected sites.

[41] Naturally, the relative cost difference between the two scenarios becomes smaller when the review period is extended, but 10 year period is assumed to be adequate.

Amongst others for reasons of confidentiality it is not possible to obtain a statement from manufacturers regarding their future plans in this area. Nevertheless, a cautious estimate is that the extra time of abolishing Stage 6 will give the companies the opportunity to save 20-30% of the jeopardized employment through innovation in combination relocation measures. The case of GE Lighting in Hungary seems to indicate that through new product development some part of employment can be maintained and the case of Havell's Sylvania implies that it need not be uneconomical to 'bring back' LED lamp manufacturing to the EU.

In terms of cost, this would raise the difference between SC1 and SC2 to around 1.07 billion euros for the period 2016-2025 (assuming 25%).

Note that also for the years after 2025 a structural difference, depending on the developments in e.g. social security systems, of around 30-50 million euros per year would be maintained between the two scenarios. For instance, in 2030 the difference would be around 1.27 billion euros, in 2040 1.67 billion euros and in 2060 –the projected end-of-life of the LED lamps—of 2.47 billion euros.

6.4. Summary

The table on the next page summarizes the monetary and policy costs and benefits of keeping versus abolishing Stage 6 over the period 2016-2060.

The overall monetary balance for the three major stakeholder groups is €4.8-€6.1 bn in favour of keeping stage 6, but the balance is different for each stakeholder group. For government there is a gain of 34.5 TWh electricity saving (peak 9.4 TWh in 2020) and a carbon emission abatement of 12.2 MtCO2 equivalent (3.4 MtCO2 in 2020). On the other hand there are socio-economic costs of an estimated minimum of €0.8 million, following an instantaneous job loss of a maximum net 6800 jobs in 2016 instead of a gradual job loss over the 2016-2025 period, with at least a theoretical possibility to retain some of the jobs. In market surveillance certain loopholes will be problematic. For the industry the current stage 6 will mean the exchange of a profitable EU-based manufacturing for probably imports from extra-EU suppliers and less time to possibly maintain some jobs at the EU sites. The consumers stand to gain all monetary benefits, but will have to invest a bit more and deal with possible functional/technical deficiencies of the designated LED replacement technology.

Not shown are possible repercussions or benefits outside the strict lighting sector, because they are hardly quantifiable and outside the restricted scope of the study. But they will play a role in political decision making.

Table 19. Cost-benefit overview of keeping Stage 6 versus abolishing Stage 6, period 2016-2060

Stakeholder	Costs	Benefits
Member States	- Financial policy**: €0.8 to 2.3 bn** extra unemployment costs and lost income over initial period; - Social policy: **6800 jobs** lost **at once** in 2016 versus **5100 to 6800** jobs lost **gradually** over 2016-2025. - Market surveillance problems: **Loopholes** in enforcing Stage 6 requirements (G9 adapter, special purpose lamps)	- Energy policy: **34.5 TWh** electricity saving over the period, of which **9.4 TWh** in 2020. - Climate policy: **12.2 MtCO2** saving over the period, of which **3.4 MtCO2** in 2020.
EU industry	- Competitiveness: loss of EU-based lamp manufacturing; - Innovation/ relocation: less time to possibly create/maintain jobs at affected EU sites (saving 25% of jobs).	
Consumer	- Higher acquisition costs **€ 0.4 bn** - Higher running costs of LED lamps over 2026-2060: **€ 1.9 bn** - Longer payback period for LED vs. HL: **2.4 versus 1.4 years** - Possible functional deficiencies LED retrofit in initial period (dimmability, CRI, lumen output, etc.)	- Lower running costs over 2016-2025 period: **€ 9.4 bn**
Total monetary impact	**€3.1 - €4.6 bn**	**€9.4 bn**

7. HEALTH ISSUES

7.1. Introduction

Since the publication of the Commission Regulation 244/2009 on ecodesign requirements for non-directional household lamps, several alleged health concerns regarding artificial light have been brought to the attention of the Commission by stakeholders:

- Effects of ultraviolet radiation (UVR) of artificial lighting to the skin and retina of healthy people.
- Influence of blue light and ultraviolet radiation on photosensitive patients
- Effects of flicker of lamps on diseases as epilepsy and migraine.
- Effects of artificial lighting on the light-sensitive symptoms in some patients with such diseases as chronic actinic dermatitis and solar urticarial..
- Effects of artificial (blue) light on the day-night rhythm.
- Differences in effects of various types of lighting, especially concerning the different light spectrum.

In addition, there are several alleged health concerns related to mercury exposure from accidental breaking of CFLs.

In one way or another, these concerns perceived by the general public were related to the phased-out incandescents and the most affordable alternative at the time: the compact fluorescent lamp.

This discussion is relevant for the Stage 6 requirements, because many of the concerned parties were set at ease by the fact that after the phase-out of the incandescent lamps they could still rely on the halogen-replacement lamps that provided a similar light to the incandescent lamp, i.e. almost without UV or flicker. Should the Stage 6 provoke also the elimination of the mains-voltage halogen replacement lamp, there would be no alternative (especially for the higher lumen outputs where there are even no LED replacements) for those suffering from any of the above diseases, if indeed –and this is the subject of this section— there is actually a real health risk.

7.2. Health risks related to light sensitivity

In 2008 the Scientific Committee on Emerging and Newly Identified Health Risks (SCENHIR) adopted an opinion on the influence of artificial light on light sensitivity[42]. Since the publication of the Commission Regulation on ecodesign requirements for non-directional household lamps in 2009, more professional expertise and facts relating to light sensitivity and potential health aspects have been brought to the attention of the Commission. Therefore, SCENHIR revised its former (2008) opinion in the report Health Effects of Artificial Light of March 2012[43].

In the 2008 study, SCENHIR paid attention to aggravation of symptoms of patients in various conditions. The 2012 study was set up with a broader objective and paid attention to potential health impacts caused on the general public by artificial light, aggravation of pathological conditions and risk estimates and mitigations. Elements of the artificial light which were studied are: blue light, UV radiation and flicker of artificial light sources. The complete conclusion of the report can be found in Annex D; a summary is given below.

SCENIHR did not find evidence of considerable risks for lamps in normal situations. Short term UV effects from artificial lighting on healty people is thought to be negligible. Halogen lamps produce a small amount of UVR, similar to the amount that CFL's produce. LED's do not produce or emits UV. Both CFL's and LED's can replace halogen lamps.

Lack of data on UV exposure prevents a proper assessment of long-term risks. For patients exeptionally sensitive to UV and/or blue light exposure (250 000 EU citizens, SCENIHR 2008), there might be risks from all light sources with significant UV and/or blue light emissions. For UV-sensitive patients, LEDs and double envelope CFL and HL lamps are a solution. In any case, regarding a possible need for separate UVA, UVB or UVC radiation limits for tungsten halogen lamps and other light sources that emit UV radiation, the Scientific Committee considers that there is no scientific basis for making such specific recommendations beyond the established dose limits. SCENIHR also concludes that chronic exposure to blue light from improperly used lamps could, in theory, induce photochemical retinal damage. There is however no evidence that this constitutes a risk in practice.

As regards flickering, SCENIHR states that there is no scientific evidence available to evaluate if conditions such as Irlen-Meares syndrome, myalgic encephalomyelitis, fibromyalgia, dyspraxia, autism, and HIV infection are influenced by the lighting technologies considered (e.g. incandescent, LED, halogen, CFLs).

[42] http://ec.europa.eu/health/archive/ph_risk/committees/04_scenihr/docs/scenihr_o_019.pdf
[43] http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_035.pdf

SCENHIR states, in its opinion of March 2012, that it is advisable to make sufficient information available, on the emitted spectrum of individual lamp models, to healthcare professionals and their patients in order to enable them to choose their optimal lighting solutions.

7.3. Health risks related to mercury exposure from accidental breaking of CFLs

The Scientific Committee on Health and Environmental Risks (SCHER) published their opinion on Mercury in Certain Energy-saving Light Bulbs in May 2010[44] and on Mercury in certain Energy-saving Light Bulbs – Exposure of Children in March 2012[45]. These studies paid attention to the possible health effects of emission of mercury due to accidentally braking of CFL lamps.

The SCHER opinion of May 2010 states that health risks for adults due to CFL breakage is unlikely. As regards the risk for children the 2012 SCHER report considers that '*short peak inhalation exposures to peak Hg-concentrations in air occurring as a result of accidental breakage of CFLs and intakes of Hg above the tolerable daily intake (TDI) for a very limited time are unlikely to pose a health risk.'*

7.4. Latest update of information on lighting-related health issues

In the underlying study new information was sought on health topics related to artificial lighting, since the publication of the SCENIHR report. The search included scientific research institutes, national health organisations and patient's organisations. A list of institutes and publications that were checked for new developments can be found in Annex D.

The conclusion is that only a few scientific research publications were published over the past years and only a limited number of research projects, which potentially could result in new insights, is ongoing. As it stands today, the conclusions from the latest SCENHIR and SCHER reports are still valid.

[44] http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_124.pdf
[45] http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_159.pdf

ANNEXES

ANNEX A: SUMMARY ASSIGNMENT

This underlying impact analysis follows the Request for Services[49] issued 25/01/2013 in the context of the Framework Contract mentioned above. It concerns one assignment aimed at carrying out review study on the stage 6 requirements of Commission Regulation (EC) No 244/2009, and more specifically:

- review the stage 6 requirements of Commission Regulation (EC) No 244/2009;
- collect and evaluate relevant data about the lamp types affected by stage 6 such as, but not limited to, market sales, impact on employment in EU, environmental impact, impact on light-sensitive patients, and possible replacement technologies (if any);
- conduct an impact analysis for at least two scenarios: keeping the stage 6 requirements in force or abolishing the stage 6 requirements;
- prepare and submit an intermediate report by 22 February 2013;
- prepare and submit a finalised intermediate report by 15 March 2013, including the full impact analysis of both scenarios using the collected data;
- conduct a stakeholder meeting in April (exact date to be determined);
- prepare and submit a draft final report including the stakeholder comments by 16 May 2013;
- finish the review study by latest 16 April 2014;
- revise the reports on the Commission's request and send an amended version within 5 days;
- and provide technical assistance such as for discussions in the Consultation Forum, the interservice consultation in the Commission, and discussions in the Regulatory Committee.

The activities followed stipulations as set out in:

- the specifications of the Framework Contract, specifically points I.4. (Payments and implementation of the Contract) of Annex I - Special Conditions, and its Annex I(b) - Specific Contracts,
- the methodology described in the Contractor's Technical Proposal of the Framework Contract (hereafter 'CTP'), which amongst others takes into account:
    - relevant parts of the Directive 2009/125/EC (recast) of 21 October 2009 establishing a framework for the setting of ecodesign-requirements of energy-related products (hereafter 'Ecodesign Directive');
    - relevant parts of the Directive 2010/30/EU (recast) on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (hereafter 'Labelling Directive');
    - European Commission, Impact Assessment Guidelines of 15 January 2009, SEC(2009)92 (hereafter 'IAG 2009').

This review study involves an analysis to help the preparation of a review of Commission Regulation (EC) No 244/2009 by providing supplemental analysis and formalisation of the results in autonomous reports.

In general, review studies should constitute updates of the existing preparatory studies, following the Methodology for Ecodesign of Energy-related Products (MEErP, 2011).

In this particular case, the Contracting Authority has indicated to require a limited impact analysis on priority subjects rather than a full review as indicated in the CPT.

[49] Request for Services, ener.c.3.dir(2013)71719, dated 25 January 2013 for a review study on the stage 6 requirements of Commission Regulation (EC) No 244/2009

Activities involve: desk-research, technical analysis, mathematical modelling, stakeholder consultation, drafting of reports, technical assistance to the Commission Policy Officer(s) (by e-mail, phone, meetings, etc.). Information required for the analysis will be based on publicly available material and/or material received from the Commission or stakeholders[50].

The contractor will assist the Commission on these activities where requested, within the boundaries of available overall budget.

All activities are to be pursued in close collaboration with the Commission Policy Officer(s). The Commission will provide the contractor(s) with all relevant information material at the outset of the study and will keep the contractor informed of any new developments during the study.

The activities for this specific contract are performed by Van Holsteijn en Kemna B.V. (VHK), project leader, and the Vlaamse Instelling voor Technologisch Onderzoek NV (VITO). VHK is project-manager, editor of the reports and researcher for issues regarding health and employment. VITO's activities concern the technical and market analysis.

The Commission will provide VHK with all relevant information material at its disposal at the outset of the study and will keep VHK informed of any new developments during the study.

[50] VHK will not conduct **new** medical, environmental or consumer studies. VHK shall use only already existing information.

ANNEX B: STATEMENT ON THE RIGHT TO PUBLISH

I, René B.J. Kemna, representing the VHK-VITO consortium, party to the contract 'Review study on the stage 6 requirements of Commission regulation (EC) No. 244/2009, specific contract No. ENER/C3/2012-418 LOT 2/01/SI2.645913 implementing framework contract No. ENER/C3/2012-418-Lot 2', warrants that the Contractor holds full right to the delivered Impact Analysis report preparing the Review on the stage 6 requirements of Commission regulation (EC) No. 244/2009, of which the main report (excl. Annexes delivered at the responsibility of the respective authors) is free of any claims.

20 May 2013, Brussels

René B.J. Kemna

ANNEX C: EU ENERGY LABEL CLASSIFICATION FOR ELECTRICAL LAMPS (SUMMARY)

In accordance with:

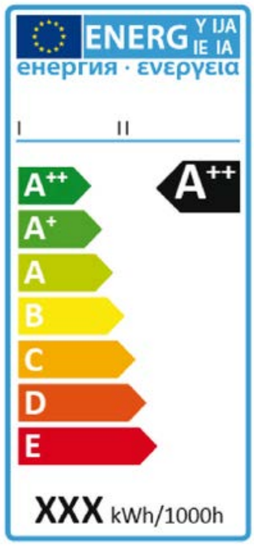
COMMISSION DELEGATED REGULATION (EU) No 874/2012 of 12 July 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires, OJ L 258, 26.9.2012, p. 1-20.

Entry into force and application

The delegated regulation mentioned above enters into force 16.10.2012 and applies (mandatory) from 1.9.2013 for non-directional and directional lamps.

Until 1.9.2013 the 1998 lamp energy label[51], with classes A-G but otherwise the same class limits and similar calculation method as the new label, applies for non-directional lamps.

Basic label design (cf. ANNEX I)



I
II
III
IV

Classification by Energy Efficiency Index EEI (cf. ANNEX VI)

Table 1. Lamp energy efficiency classes

Energy efficiency class	Energy efficiency index (EEI) for non-directional lamps	Energy efficiency index (EEI) for directional lamps
A++ (most efficient)	EEI ≤ 0,11	EEI ≤ 0,13
A+	0,11 < EEI ≤ 0,17	0,13 < EEI ≤ 0,18
A	0,17 < EEI ≤ 0,24	0,18 < EEI ≤ 0,40
B	0,24 < EEI ≤ 0,60	0,40 < EEI ≤ 0,95
C	0,60 < EEI ≤ 0,80	0,95 < EEI ≤ 1,20
D	0,80 < EEI ≤ 0,95	1,20 < EEI ≤ 1,75
E (least efficient)	EEI > 0,95	EEI > 1,75

[51] According to COMMISSION DIRECTIVE 98/11/EC of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps, OJ L 71, 10.3.1998, p. 1-8

Calculation method for EEI

EEI = P_{cor} /P_{ref}

where:

P_{cor} is the rated power (P_{rated}) for models without external control gear and the rated power (P_{rated}) corrected in accordance with Table 2 for models with external control gear. The rated power of the lamps is measured at their nominal input voltage.

P_{ref} is the reference power obtained from the useful luminous flux of the model (Φ_{use}) by the following formulae:

- For models with $\Phi_{use} < 1300$ lumen: $P_{ref} = 0,88\sqrt{\Phi_{use}} + 0,049\Phi_{use}$
- For models with $\Phi_{use} \geq 1300$ lumen: $P_{ref} = 0,07341\Phi_{use}$

Please note that for high lumen output lamps ($\Phi_{use} \geq 1300$ lumen), the proposed stage 6 requirements (0.6 * (0.88√Φ+0.049Φ)) of Regulation 244/2009 did not follow the class B formula (0.6 * 0,07341Φ) of Regulation 874/2012.

For non-directional lamps, the useful luminous flux (Φ_{use}) is the total rated luminous flux (Φ in lm). For directional lamps Φ_{use} is the flux in a 120 degree cone (non-filament lamps with beam angle ≥90° and warning that they are not suitable for accent lighting) or a 90 degree cone (other directional lamps).

Table 2. Power correction if the model requires external control gear

Scope of the correction	Power corrected for control gear losses (P_{cor})
Lamps operating on external halogen lamp control gear	$P_{rated} \times 1,06$
Lamps operating on external LED lamp control gear	$P_{rated} \times 1,10$
Fluorescent lamps of 16 mm diameter (T5 lamps) and 4-pin single capped fluorescent lamps operating on external fluorescent lamp control gear	$P_{rated} \times 1,10$
Other lamps operating on external fluorescent lamp control gear	$P_{rated} \times (0,24\sqrt{\Phi_{use}} + 0,0103\Phi_{use}) /(0,15\sqrt{\Phi_{use}} + 0,0097\Phi_{use})$
Lamps operating on external high-intensity discharge lamp control gear	$P_{rated} \times 1,10$
Lamps operating on external low pressure sodium lamp control gear	$P_{rated} \times 1,15$

The weighted energy consumption (E_c) is calculated in kWh/1 000 h (from P_{cor}).

The graph and table on the next page illustrate the maximum electric (corrected) power allowed per labelling class.

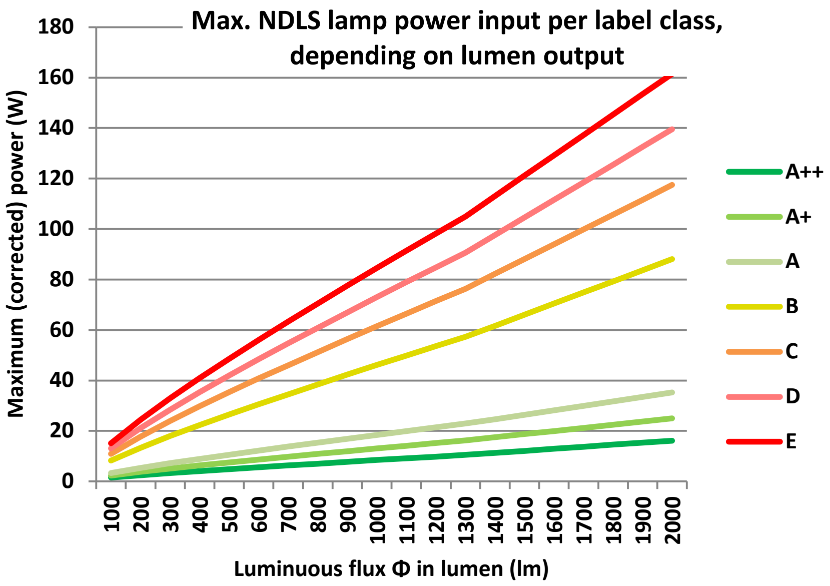


Table 3 . Maximum electric power Pref per energy label class for non-directional light sources

	Luminous flux Φ (lm)																				
lbl	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**	**1900**	**2000**	**EEI≤**
A++	1.5	2.4	3.3	4.1	4.9	5.6	6.3	7.0	7.8	8.5	9.1	9.8	10	11	12	13	14	15	15	16	**0.11**
A+	2.3	3.8	5.1	6.3	7.5	8.7	9.8	11	12	13	14	15	16	17	19	20	21	22	24	25	**0.17**
A	3.3	5.3	7.2	8.9	11	12	14	15	17	18	20	21	23	25	26	28	30	32	33	35	**0.24**
B	8.2	13	18	22	27	31	35	38	42	46	50	54	57	62	66	70	75	79	84	88	**0.6**
C	11	18	24	30	35	41	46	51	56	61	66	71	76	82	88	94	100	106	112	117	**0.8**
D (phase-out)	*13*	*21*	*28*	*35*	*42*	*48*	*55*	*61*	*67*	*73*	*79*	*85*	*91*	*98*	*105*	*112*	*119*	*126*	*133*	*139*	***0.95***
E (old)	*15*	*24*	*33*	*41*	*49*	*56*	*63*	*70*	*78*	*85*	*91*	*98*	*105*	*113*	*121*	*129*	*137*	*145*	*153*	*162*	***1.1***

Table 4. Minimum luminous efficacy (in lm/W) per label class for selected power inputs Pcor

	mains-voltage halogen						low voltage halogen (corr=1.06)					
	18	**28**	**42**	**53**	**70**	**105 W**	**20**	**25**	**35**	**50**	**75**	**EEI**
A++	124	124	124	124	124	124	131	131	131	131	131	**0.11**
A+	49	80	80	80	80	80	54	85	85	85	85	**0.17**
A	34	41	57	57	57	57	38	42	60	60	60	**0.24**
B	**14**	**16**	**19**	**20**	23	23	15	17	19	21	24	**0.6**
C	**10**	**12**	**14**	**15**	**16**	17	11	12	14	16	17	**0.8**
D (phase-out)	*9*	*10*	*12*	*13*	*13*	*14*	*10*	*10*	*12*	*13*	*14*	***0.95***
E (old)	*8*	*9*	*10*	*11*	*12*	*12*	*8*	*9*	*10*	*11*	*12*	***1.1***

ANNEX D: OPINION SCENHIR, MARCH 2012 (FULL TEXT)

This opinion is based on a scientific rationale which has taken into account the relevant scientific literature and other accessible and reliable information on physical and technical characteristics of lighting technologies, principles of optical radiation, as well as biological and health effects of optical radiation. Health effects due to optical radiation have been considered both for the general population and for persons with photosensitive or other pathological conditions. Since the assignment also includes evaluation of possible health effects of various types of lighting technologies, additional data regarding lamp emissions was requested and some were obtained from stakeholders. In addition, for assessment purposes, data regarding exposure patterns was sought, but found to be virtually lacking. This lack of information has seriously hampered efforts to perform specific risk assessments.

We have received some information regarding emission data, which has been used for our evaluation, for more than 180 different lamps. These lamps represent all major lamp types that are used for general lighting purposes (tubular fluorescent lamps; compact fluorescent lamps (CFLs) with and without a second envelope; halogen lamps that are either high or low voltage; high pressure discharge lamps (metal halide and sodium); light emitting diodes (LEDs); and incandescent lamps, although the degree of representativeness is uncertain. Regarding specific lamp types, CFLs are well represented in this collection, whereas LEDs for example have been measured in only a few cases. Based on the lamp emissions, the EN Standard 62471 (and also IEC 62471 and CIE S009, since they are all identical in this sense) categorizes the lamps according to the photo-biological hazard that they might pose. The different hazards are:

1. Actinic UV-hazard for eye and skin.

2. UVA-hazard for the eye.

3. Blue-light hazard for the retina.

4. Thermal retina hazard.

5. IR-hazard for the eye.

Following the standards, emission measurements should be performed according to two approaches; namely at a distance where a light intensity of 500 lx is obtained and also at a distance of 20 cm. Based on these measurements, lamps are then classified according to the "Risk Group" (RG) to which they belong. RG0 (exempt from risk) and RG1 (minor risk) do not pose any hazards during normal circumstances. RG2 (medium risk) lamps also do not normally pose any hazards, due to our aversion responses to very bright light sources or due to the fact that we would experience thermal discomfort. RG3 (high risk) include only lamps where a short-term exposure poses a hazard. Importantly, this classification is based on acute exposure responses (a single day, up to 8 hours) and applies only to individuals of normal sensitivity. It should be noted, with respect to RG3 that the risk classification does not consider either long-term exposures or particularly sensitive persons in the population.

SCENIHR's answers to the questions given in the Terms of Reference are given directly in connection with the questions below:

A: To explore and report scientific evidence on potential health impacts on the general public caused by artificial light of which the main purpose is to radiate in the visible range (as opposed to artificial light where the invisible part of the radiation is the main purpose, e.g.

sun tanning lamps or infrared lamps). The impacts of the light from all available electrical lighting technologies should be studied, both in the visible and invisible range (with specific analyses of the ultraviolet radiation subtypes UVA, UVB and UVC).

A combined assessment of natural and artificial light shows that adverse health effects due to optical radiation can either occur acutely at certain levels of exposure, or after long-term repeated exposures at lower levels. Depending on the effect (endpoint) of concern (e.g. skin burn, skin cancer, retinal damage, cataract) either the intensity or duration of exposure is of most relevance. In general, the probability that artificial lighting for visibility purposes induces any acute pathologic conditions is low, since expected exposures are much lower than the levels where effects are known to occur in healthy people and are also much lower than in typical summer daylight. The available lamp emission data show that for all investigated hazard outcomes, the absolute majority of lamps are classified as Risk Group 0 (RG0; "exempt from risk"). Most of the rare exceptions are classified as Risk Group 1 (RG1; "low risk"). The very few lamps assigned to higher Risk Groups were either measured without the required UV-shielding glass cover, or at a very short distance (20 cm) which is not the intended use distance for this lamp type.

Standard EN 62471 gives limits that are protective against acute effects, while long-term effects are only marginally considered. Thus the emissions in e.g. the UV range may comply with these limits, but may still have an effect on skin carcinoma incidences when a population is subjected to extensive and large scale exposure to these lamps.

A common exposure situation, such as most household lighting, would involve an illumination level which is so low that exposure to potentially problematic radiation is considered negligible (with the possible exception of prolonged task lighting with a lamp close to the body which may lead to UV exposures approaching the current workplace limit set to protect workers from skin and retinal damage). However, according to a worst case scenario developed in the scientific rationale, the highest measured emissions of UV from fluorescent lamps used typically indoors in professional environments, although well below the limits for RG0, could be contributing to the number of squamous cell carcinomas in the EU population. This is in comparison to a hypothetical situation where the same population is not exposed to UV radiation from artificial light indoors. The annual erythemal UV dose expected from the worst case scenario approximately corresponds to the dose one would get from a half week Mediterranean holiday. Fluorescent lamps typically emit less than half of the UV radiation assumed in the worst case scenario. The vast majority of the CFLs tested emit erythemal UV at very low levels, amounting at the most to an extra day of sunbathing a year.

Low levels of UV emissions may occur from certain lamp types (quartz halogen lamps, single- and double-capped fluorescent lamps as well as incandescent light bulbs). These emissions may, in some cases, in particular for certain halogen lamps with poor UV filtering, include UVC in addition to UVA and UVB. UVC is not naturally present on Earth due to the blocking action of the earth's atmosphere, so any emissions from lamps would provide a novel type of exposure. However, most action spectra on skin and eye effects include UVC. Hence, biologically effective doses take UVC into account and are thus considered in the categorization of the Risk Group, as discussed above. However, detectable levels of UVC do signal a considerable overall output of biologically harmful short wavelength UV radiation. Regarding a possible need for separate UVA, UVB or UVC radiation limits for tungsten halogen lamps and other light sources that emit UV radiation, the Scientific Committee considers that there is no scientific basis for making such specific recommendations beyond the established dose limits.

Evidence from *in vitro* experiments suggests that blue light at 10 W/m2 induces photochemical retinal damage (Class II) upon acute (hours) exposure, and animal experiments and *in vitro* studies suggest that cumulative blue light exposure below the levels causing acute effects also can induce photochemical retinal damage. There is no consistent evidence from epidemiological studies regarding the effect of long-term exposure to sunlight (specifically the blue component of sunlight) on photochemical damage to the retina (particularly to the retinal pigment epithelium), which may contribute to age-related macular degeneration (AMD) later I n life. Whether exposure from artificial light could have effects related to AMD is uncertain.

There is no evidence that artificial light from lamps belonging to RG0 or RG1 would cause any acute damage to the human eye. Studies dedicated to investigating whether retinal lesions can be induced by artificial light during normal lighting conditions are not available. Lamp types belonging to RG2 and higher are usually meant to be installed by professionals in locations where they do not pose a risk.

Chronic exposure to blue light from improperly used lamps could, in theory, induce photochemical retinal damage. There is however no evidence that this constitutes a risk in practice. It is unlikely that chronic exposures to artificial light during normal lighting conditions could induce damage to the cornea, conjunctiva or lens.

Besides the beneficial effect of light, e.g. through synchronising the day-night rhythm, there is mounting evidence suggesting that exposure to light at night while awake (especially during shiftwork), may be associated with an increased risk of breast cancer and also cause sleep, gastrointestinal, mood and cardiovascular disorders possibly through circadian rhythm disruption. Importantly, these effects are associated with light, without any specific correlation to a given lighting technology.

B: To update the SCENIHR report on Light Sensitivity (from 23 September 2008) in light of further evidence, and to examine the aggravation of the symptoms of pathological conditions in the presence of lamp technologies other than compact fluorescent lamps (including conventional incandescent and halogen lamps, halogen lamps with improved efficiency and light emitting diode lamps).

The previous SCENIHR opinion on Light Sensitivity (SCENIHR 2008) identified that some pre-existing conditions (epilepsy, migraine, retinal diseases, chronic actinic dermatitis, and solar urticaria) could be exacerbated by flicker and/or UV/blue light. However, at that time there was no reliable evidence that compact fluorescent lamps (CFLs) could be a significant contributor. This conclusion needs updating as more recent studies indicate a negative role for certain CFLs and other artificial light sources (including sometimes incandescent bulbs) in photosensitive disease activity. There are no published data on the effect of exposure of a photosensitive patient to light from halogen lamps.

There is strong evidence that UV and, in some patients visible light, can induce skin lesions of true photo-dermatoses. Although sunlight is reported by most patients as the main trigger of disease activity, occasionally severely affected patients over the range of endogenous (and exogenous) diseases report a provocative role for artificial lighting.

There is a lack of controlled skin provocation studies relating effects to the magnitude and the wavelength components of the light source, although there is evidence that the shorter wavelength light components (blue or UV) tend to be more effective than the longer wavelength components (red) in aggravating pre-existing conditions. Some research work has been conducted in particularly severely affected individuals suffering from photodermatoses such as lupus erythematosus, chronic actinic dermatitis and solar urticaria. This provides good evidence for the aggravation of symptoms related to these pre-existing skin diseases. Such work needs to be confirmed, and also extended using a range of lamp types over a wider range of diseases in greater numbers of patients. Particular attention seems justified for the individual variability of the conditions for aggravation of such diseases. Until such data exist, it seems reasonable to assume that the UV, and in some cases the blue radiation component of artificial lighting in an as yet undefined number of patients, may contribute to the aggravation of symptoms related to their skin disease, and in the case of lupus erythematosus possibly also to the aggravation of their systemic disease.

Generally, double envelope CFLs emit much less UV radiation than single envelope CFLs. Most LEDs in general use emit little or no UV radiation. However, with the considerable variability of UV/blue light components for lighting technologies, even of the same or similar kind, no general advice can be given and individual optimisation of the lighting technology is advised for these patients.

The effect of light is variable depending on the genetic alterations that are causing inherited retinal degeneration. In specific conditions like Stargart disease, the retinal pigment epithelial (RPE) cells are particularly sensitive to Class II photochemical damage, which is induced by peaks at shorter wavelengths. In other retinal dystrophies, light does not exert any aggravating effect. However, since the causative mutation is seldom known to the patient or their family, and because there is no clear correlation between genotype and phenotype, it is recommended for all patients with retinal dystrophy to be protected from light by wearing special protective eyeware that filter the shorter and intermediate wavelengths.

The previous SCENIHR opinion on Light Sensitivity stated that modern CFLs are basically flicker-free due to their electronic high frequency ballasts. However, it was also noted that studies indicated that residual flicker can occur during certain conditions, at times also related to other circuitry like dimmers operated with the light source, in both CFLs and incandescent bulbs. In principle, there can be a residual sinusoidal modulation of the light of any light source at twice the line frequency of e.g. 50-60 cycles. Any light source operated on DC, after transformation from the AC line, is flicker-free. This has been the predominant case for LED operation, but is also applicable to other lighting technologies, e.g. halogen and incandescent lamps. Flicker cannot typically be observed in static settings above about 60-80 cycles, while in conjunction with dynamic scenes, the effect is still visible at higher frequencies.

There is no scientific evidence available to evaluate if conditions such as Irlen-Meares syndrome, myalgic encephalomyelitis, fibromyalgia, dyspraxia, autism, and HIV infection are influenced by the lighting technologies considered in this opinion.

C: *If health risks are identified under points A or B, to estimate the number of EU citizens who might be at risk and identify the level of emission/exposure safeguarding the health of citizens and/or means to mitigate or entirely prevent the impact of the problematic parameter of the light technology in question.*

All healthy individuals may be at some risk from UV radiation and blue light from indoor lighting, albeit to different degrees due to differences in genetic background and in the type of light source used. Short-term UV effects on healthy people are thought to be negligible. A proper assessment of long-term risks due to daily low level UV exposure is not possible because data on actual personal indoor UV exposure are lacking. Due to this knowledge deficit, it would appear advisable to be cautious and to develop worst case scenarios. The worst case scenario examined in this opinion involved workplace/school exposure to double- or single-capped fluorescent lamps in ceiling-mounted open luminaires. This scenario is based on a biologically plausible risk model as it appears to be similar in form for mouse and man (hazards being proportional to age and power of cumulative dose). However, the model parameters for humans are derived from rather crude population-level incidence data, and the worst case scenario had to be based on some simplifying assumptions for lack of data. This scenario assumes the validity of extrapolating from studies on animals with short lifespans to life-time human exposures. Furthermore, it assumes the appropriateness of dose-level extrapolation from experimental studies to real human exposures and that all individuals in a population experience the same risk independent of susceptibility factors. If we take lamps with the highest measured UV output (still well within Risk Group 0), such exposure adds the equivalent of 3 to 5 days of vacation in a sunny location to the average annual UV dose. Although this would lead to an increase in the personal risk of squamous cell carcinoma, such an increase would remain small (a few % over a lifetime in Denmark). Population-wide exposure to such lamps could, however, add approximately 100 cases of squamous cell carcinomas a year to a base line of 900 cases/year in Denmark. It should be stressed that the UV output of most of the fluorescent lamps tested fall well below this level, and are not expected to affect squamous cell carcinoma incidences. Improper use of lamps belonging to Risk Groups 1-3 (due to missing or disregarded user information, non-professional installation) could cause retinal damage. While no such cases are known, appropriate measures could be considered to ensure that these lamps are not misused. The current standardization of lighting lamps and luminaires in four risk categories appears sufficient to limit the personal short-term risk. However, RG0, as it is based on acute effects, should not be taken to imply adequate protection of the general population as a whole from effects after long-term exposure to UV radiation. Nevertheless, it would be useful to communicate information on risk categories to the consumer.

The previous SCENIHR opinion (SCENIHR 2008) stated that a number of patients are exceptionally sensitive to UV/blue light exposure. The number of EU citizens with light-associated skin disorders that would be affected by exposures from CFLs was estimated in the report to be around 250,000. Clearly, the risk for this group of patients is not limited to CFL, but includes all light sources with significant UV/blue light emissions. The lack of proper data precludes any improvement of the estimate of the size of the affected group.

Also photo-sensitive patients undergoing photodynamic therapy might be expected to react to CFL and LED sources to a greater extent than to incandescent lighting. This is due to a combination of greater sensitivity of porphyrins to blue light (soret band), coupled with an enhanced blue light emission of these sources. However, such patients are aware of their extreme photosensitivity which needs careful management.

For patients with light-associated skin disorders, the previous SCENIHR opinion recommended that, when using CFLs, a double envelope type is preferable. The current opinion supports that position. Double envelope CFLs generally emit much less UV radiation than single envelope CFLs and are much less likely to induce a reaction in patients with light-associated skin disorders. While a second envelope undoubtedly reduces the UV component of any particular lamp, the currently available data, however, documents the high variability of UV and blue light emissions due to different internal design parameters, even for the same externally visible architecture (i.e. also when a second envelope is present). While some compact fluorescent lamps are in the same category, retrofit LED lighting, which does not emit UVR on the physical grounds of the light generation therein, would potentially provide an even better option for such patients. However, for patients whose sensitivity extends into the visible part of the spectrum, it may be necessary to exclude LEDs which have a significant blue component. The UV/blue light irradiation from halogen lamps is also highly dependent on the lamp type. With lamps other than incandescent retrofit halogen bulbs, attention needs to be given to the proper installation, as they are at times sold by the manufacturer to be installed at larger distance or in conjunction with special luminaires or filters against e.g. UV or IR irradiation or to prevent other hazards like fires. While it is unlikely that there would be a significant UV risk from halogen lamps for the general public, provided that protective measures are complied with, the UV content can rise to levels which are of concern for patients with light-associated skin disorders at close operating distances and long exposure times, which is not a very common use pattern for this lamp type.

For individuals with photosensitive skin diseases a list of lamp models (not only types) that are specifically suitable for their situation is needed. The non-representative sample spanning across a wide range of lighting technologies which is provided by Schulmeister et al. (2011) provides a first try. However, important issues like the modification of the emitted spectrum with time after switching on, with progressive aging, and from one to the other manufactured batch are not currently assessed. In view of the large number of patients affected by photosensitive diseases it may be advisable to make sufficient information on the emitted spectrum for individual lamp models available to the healthcare professionals and their patients to allow them to choose their lighting solutions optimally.

D: *To identify potential research needs related to the areas where the lack or scarcity of scientific evidence prevents SCENIHR from coming to firm conclusions.*

The scientific rationale has identified a number of areas where relevant data are lacking regarding the effects of specific lighting technologies on medical conditions. The most important areas where knowledge gaps have to be filled in order to be able to draw firm conclusions related to this opinion include:

- Emission data (ranging from UVC up to 800 nm) characterizing the different lighting technologies – a challenge due to the variation of manufacturing parameters, and a database of these characteristics of specific lamps on the European market.
- Exposure database on indoor visible light radiance to the eye and personal UV exposures from various lamp types compared to ambient outdoor exposure. The database should be established in view of the potential conditioning of the eye due to the largely different voluntary exposure to sunlight from one individual to another, and for the also very different use patterns for UV/ light protective eyewear between individuals and populations.
- Attention should be paid to develop a risk group categorisation that takes into account potential chronic effects like SCC.
- Eye conditions:
    a) epidemiologic studies of artificial light exposure and ocular pathologies (including AMD); and
    b) retinal effects of chronic exposure to artificial light for visibility purposes (animal studies).
- The role of various types of artificial lighting sources in photosensitive skin diseases (provocation studies).

- Mechanisms and consequences of exposure to artificial light in the late evening, at night and in the early morning, including circadian disruptions in both shift-workers and in the general population.
- Flicker induced health effects from the residual high frequency (100-120 Hz) intensity modulations.
- The particular role of UVC components in artificial lighting for skin diseases taking into account especially sensitive populations and the role of prior exposure to sunlight.
- The effects of non-incandescent light sources, in particular those with very inhomogeneous or biased spectral distribution on colour rendition, fatigue, and other components of the human visual perception.

ANNEX E: REFERENCES CHECKED FOR UPDATES ON HEALTH ISSUES

Institutes checked on updates, new publications and running research projects:

- Health Protection Agency (HPA), UK
- World health organization – international agency for research on cancer
- Bundesamt für Energie, Switzerland
- Institute of Electrical and Electronics Engineers
- National Institute of Environmental Health Sciences, USA
- Health Protection Agency, Chilton, UK
- UNEP
- US Food and drugs administration
- National Research Council, Canada
- The National Academies, division on engineering and physical sciences, Washington DC, USA
- US Department of Energy (DOE), Washington DC, USA
- National Institute for Occupational Safety and Health, Pittsburgh, PA, USA
- Scientific Committee on Health and Environmental Risks
- Scientific Committee on Emerging and Newly Identified Health Risks
- Australian Radiation Protection and Nuclear Safety Agency
- French Agency for Food, Environmental and Occupational Health & Safety
- Alliance for Solid-State Illumination Systems and Technologies (ASSIST).
- The Association of Electrical Equipment and Medical Imaging Manufacturers
- University of Essex, UK
- Trent University, Canada
- McGill University, department of psychology, Montreal
- Erasmus medical centre, Rotterdam, Holland
- Leiden University, Medical Centre, Department of dermatology, Holland
- The Photobiology Unit, University of Dundee, Ninewells Hospital and Medical School, Dundee, UK (Dermatology unit Specialized in Chronic actinic dermatitis)
- Migraine Action

Checked references:

Dawson, et al, *Local fundus response to blue (LED and laser) and infrared (LED and laser) sources*, Exp. Eye Res., 73(1):137-47 2001

A Review of the Literature on Light Flicker: Ergonomics, Biological Attributes, Potential Health Effects, and Methods in Which Some LED Lighting May Introduce Flicker, IEEE Standard P1789 (2010)

Yadong Li and Li Jin. Environmental Release of Mercury from Broken Compact Fluorescent Lamps, published in Environmental Engineering science, volume 28, number 10, 2011

Mary Norval, Gary M. Halliday, The Consequences of UV-Induced Immunosuppression for Human Health, Photochemistry and photobiology volume 87, issue 5, 2011

Assessment of Advanced Solid State Lighting, National Research Council 2013

Fenton et al, Impact Assessment of Energy Saving Lamps on Photosensitive Skin, published in Journal of Investigative Dermatology volume 132, sept 2012.

A neural mechanism for exacerbation of headache by light, Rodrigo Noseda et al 2010, published in Nature Neuroscience.

Ultraviolet Radiation Emissions from Compact Fluorescent Lamps, Fact sheet 30, Australian Radiation Protection and Nuclear Safety Agency, 2011

Alliance for Solid-State Illumination Systems and Technologies (ASSIST). Flicker Parameters for Reducing Stroboscopic Effects from Solid-state Lighting Systems. Vol. 11, Iss. 1., 2012

JStåhl-Hallengren C, Jönsen A, Nived O, Sturfelt G., Incidence studies of systemic lupus erythematosus in Southern Sweden: increasing age, decreasing frequency of renal manifestations and good prognosis. J Rheumatol. 2000 Mar;27(3):685-91.

Ball, James C. 1995. A comparison of the UV-B irradiance of low-intensity, full-spectrum lamps with natural sunlight. Bulletin of the Chicago Herpetological Society. 30 (4):69-72. Ultraviolet light; UV-B; Lighting

List of searched disseases related to light sensitivity and flicker:

- Meniere’s dissease
- Chronic actinic dermatitis (photosensitive eczema)
- (Prevalence in Scotland 16.5 per 100,000)
- Lupus (auto immune disease)
- Actinic prurigo
- Solar urticaria
- Photodermatitis
- Atopic eczema
- patients taking photosensitising drugs or undergoning photodynamic therapy
- Atopic eczema
- Cateract
- Photophobia
- Influence of blue light on childrens eyes, due to transparency of their crystalline lenses
- Photosensitive epilepsy
- Rosacea

websites with personal stories:

21-2-2013 http://www.lupus-support.org.uk/Sandy.htm

ANNEX F: RELATIONSHIP BETWEEN LAMP EFFICACY VERSUS LIFE TIME, LAMP VOLTAGE, WATTAGE AND COLOUR TEMPERATURE FOR FILAMENT LAMPS

According to the literature[52]. the following equations can be applied (capital letters represent normal or reference values):

$life/LIFE = (VOLTS/volts)^d$

$lumens/LUMENS = (VOLTS/volts)^k$

$LPW/lpw = (VOLTS/volts)^g$

$watts/WATTS = (volts/VOLTS)^n$

$colour\ temperature/COLOUR\ TEMPERATURE = (volts/VOLTS)^m$

Wherein,

LPW is efficacy in lumen per watt

For approximate calculations, the following exponents are referred: d =13, g =1.9n k = 3.4, n 1.6 and m = 0.42. For more accuracy those exponents must be determined per lamp type and manufacturer. Hereafter those exponents are used to check some assumptions but therefore need to be confirmed.

From those relations and catalogue data it is clear that:

- Shortening life time can increase efficacy
- Lower voltage lamps have higher efficacy, e.g. 12 V or 130 V compared to 230 V

The direct relationship between efficacy and life time can be calculated from above equations:

$(life/LIFE)^{1/d} = (VOLTS/volts)$

$(LPW/lpw)^{1/g} = (VOLTS/volts)$

Therefore,

$(LPW/lpw) = (life/LIFE)^{g/d}$

A similar relationship will show that more efficient lamps have a higher colour temperature. This relations also demonstrate that higher wattage filament lamps have higher efficacy.

[52] Lighting Handbook, 8th Edition, Illumination Engineering Society of North America (p. 186), ISBN 0-87995-102-8.

ANNEX G: INDICATIVE REFERENCE LAMP DATA

ref.	lamp designation	cap	Voltage	life time	Power	Lumen	price	Efficacy	244/2009	874/2012		244/2009	
						Φ			E-savings	label	EEI	Pmax	Mpfactor
			[V]	[h]	[W]	[lm]	Euro	lm/W	%			[W]	
1	Halogen saver (Xenon)	E27	230	2000	42,0	630	1,89	15,0	-24%	C	0,79	42,37	0,79
2	Standard GLS	E27	230	1000	60,0	705		11,8	0%	E	1,04	46,33	1,04
3	Standard GLS US voltage	E26	130	2000	60,0	790		13,2	-9%	E	0,95	50,76	0,95
4	Standard GLS US voltage	E26	130	1000	60,0	880		14,7	-17%	D	0,87	55,38	0,87
5	Halogen saver (Xenon) US voltage	E26	130	1000	50,0	860		17,2	-29%	C	0,74	54,36	0,74
6	Halogen saver (Xenon) US voltage	E26	130	3500	52,0	770		14,8	-20%	D	0,84	49,72	0,84
7	Halogen saver (Xenon) US voltage	E26	120	7000	46,0	600		13,0	-13%	D	0,90	40,76	0,90
8	Base case GLS-C	E27	230	1000	54,0	594	0,6	11,0	3%	E	1,07	40,44	1,07
9	Base case HL-MV-G9	E27	230	1500	40,0	480	5,5	12,0	-11%	E	0,93	34,24	0,93
10	Base case GLS-C Halogen saver lumen eq.	E27	230	2000	39,2	588	1,89	15,0	-25%	C	0,78	40,12	0,78
11	*Base case GLS-C Halogen saver lumen eq. Short life caclulated*	E27	230	1000	35,4	*588*	*1,89*	*16,6*	-32%	C	0,71	40,12	0,71
12	Base case GLS-C HL-MV (electronic) equivalent	E27	230	3000	30,0	588	9,95	19,6	-43%	B	0,60	40,12	0,60
13	Base case GLS-C LEDi eq.	E27	230	15000	11,2	674	14,99	60,2	-79%	A	0,20	44,72	0,20
14	Base case GLS-C minimum class B lamp	E27	230	1000	30,0	588	1,89	19,6	-43%	B	0,60	40,12	0,60
15	60W GLS-C retrofit minimum class B lamp	E27	230	1000	34,0	695	1,89	20,4	-43%	B	0,59	45,80	0,59
16	HalA 40W E14 type BS/CG shape	E14	60	2000	60,0	840	7,74	14,0	-14%	D	0,90	53,33	0,90
17	R7s no IR	R7s	230	1000	200,0	4000	2,91	20,0	-18%	C	0,68	201,32	0,79
18	R7s HIR	R7s	230	2000	225,0	5000	15,03	22,2	-25%	C	0,61	245,78	0,73
19	*R7s HIR short life calculated*	R7s	230	1000	225,0	*5530*	*15,03*	*24,6*	-31%	B	0,55	269,13	0,67
20	R7s	R7s	230	2000	48,0	750	5	15,6	-24%	C	0,79	48,68	0,79
21	*R7s-1000 h calculated*	R7s	230	1000	48,0	*830*	*5*	*17,3*	-30%	C	0,73	52,79	0,73
22	*R7s-1000 h & IR bonus calculated*	R7s	230	1000	48,0	*1019*	*8?*	*21,2*	-41%	C	0,62	62,44	0,62
23	*R7s-1000 h & IR bonus & -15% instead of -10% tolerance calculated*	R7s	230	1000	48,0	*1070*	*8?*	*22,3*	-44%	B	0,59	64,99	0,59
24	X2 IR transformerless halogen saver	E26	120	1500	50,0	1600	2,73	32,0	-59%	B	0,43	90,88	0,44
25	*X2 IR transformerless halogen saver*	*E26*	*230*	*0,31*	*141,0*	*15597*	*2,73*	*110,6*	*-87%*	*A+*	*0,12*	699,32	0,16
26	*X2 IR transformerless halogen saver*	*E26*	*230*	*1500*	*141,0*	*4531*	*2,73*	*32,1*	*-56%*	*B*	*0,42*	225,00	0,50
27	*X2 IR transformerless halogen saver*	*E26*	*230*	*2000*	*50,0*	*1600*	*2,73*	*32,0*	*-59%*	*B*	*0,43*	90,88	0,44
28	G9	G9	230	2000	48,0	740	3,69	15,4	-23%	C	0,80	48,16	0,80
29	35 W IR coating	GY6.35	12	4000	35,0	860	4,63	23,2	-48%	B	0,55	54,36	0,55
30	35 W standaard	GY6.35	12	2000	35,0	600	1,49	16,2	-30%	C	0,73	40,76	0,73
31	Base case GLS-C G9 adapter to Xenon (assumed LOR=1)	GY6.35	12	4000	35,0	860	*12?*	23,2	-48%	B	0,55	54,36	0,55
32	Base case GLS-C G9 adapter to Xenon (assumed LOR=1)	G9	230	2000	48,0	740	5,45	15,4	-23%	C	0,80	48,16	0,80
33	average test result of 3 different eco-halogen(test.de 2009)	E27	230	1555,7	42,1	563	1,89	13,4	-17%	D	0,87	38,79	0,87
34	average declared data of tested lamps (test.de 2009)	E27	230	2000	42,0	620	1,89	14,8	-23%	D	0,80	41,83	0,80
35	2X light US	E26	120	1500	50,0	1600	2,8	32,0	-59%	B	0,43	90,88	0,44
36	*Base case-1000 h & IR bonus & -15% tolerance calculated*	E27	230	1000	29,9	*588*	*8?*	*19,7*	-43%	B	0,60	40,12	0,60
37	R7s Base Case	R7s	230	1500	300,0	5177	2,91	17,3	-3%	C	0,79	253,59	0,95
38	R7s option 1 Xenon	R7s	230	2000	230,0	5000	3,8	21,7	-23%	C	0,63	245,78	0,75
39	R7s	R7s	230	2000	300,0	5600	3,8	18,7	-10%	C	0,73	272,20	0,88
40	R7s	R7s	230	2000	240,0	4900	3,8	20,4	-18%	C	0,67	241,36	0,80
41	R7s	R7s	230	2000	120,0	2250	3,8	18,8	-20%	C	0,73	121,59	0,79
42	R7s 2 x 2X	R7s	240	1500	100,0	3200	5,6	32,0	-50%	B	0,43	165,26	0,48
43	R7s LED	R7s	240	25000	9,0	600	26	66,7	-85%	A	0,18	40,76	0,18
44	R7s CFL	R7s	240	15000	24,0	1519	26	63,3	-78%	A	0,22	86,98	0,22
45	R7s HIR	R7s	230	2000	375,0	9400	15,03	25,1	-30%	B	0,54	436,74	0,69
46	G9 Base Case	G9	230	1500	40,0	480	5,5	12,0	-25%	E	0,93	34,24	0,93
47	G9 Energy Saver	G9	230	2000	48,0	740	3,8	15,4	-29%	C	0,80	48,16	0,80
48	G9 Energy Saver	G9	230	2000	20,0	235	3,8	11,8	-50%	C	0,80	20,00	0,80
49	G9 Energy Saver	G9	230	2000	33,0	460	3,8	13,9	-37%	C	0,80	33,13	0,80
50	GU9 LED (diam 28mm, lenght 68 mm, dimmable)	GU9	230	25000	4,0	220	3,8	55,0	-90%	A+	0,17	19,07	0,17

Notes:

Lamps with designations in italic are based on assumptions that need further confirmation. Other lamp data is based on catalogue data apart from reference '29' which is average data of a test report. Updated prices were obtained from retailer websites.

The information contained herein is for information purposes only and should be further confirmed by industry.

Life time of lamps 11, 19, 21, 22, 23 and 31 was calculated with formula of Annex F ($2^{1,6/13}$-1).

The assumed impact of IR coating lamps 22, 23 and 31 efficacy was proportional to the efficacy ratio of lamp 19 vs lamp 17 (1,23).

In lamp 49 it was assumed that a 240 VAC lamp is equivalent to two 120 VAC lamps in series similar to lamp 35

The ‘MPfactor’ in this table means ‘$P_{max}/(0.88\sqrt{\Phi}+0.049\Phi)$’ and should be 0,6 in Regulation 244/2009 to match stage 6 requirements for normal clear lamps and 0,8 for G9/R7s.

For G9 market survey showed that the best available lamp ‘MPfactor’ was 0,8. The GU9 LEDi had ‘MPfactor’ 0,17 but had larger dimensions, higher weight and limited maximum luminous flux.

For R7s market survey showed that the best available lamp ‘MPfactor’ was 0,69 in MV HL technology and expected to be available in a large lumen output range. The assumed feasible R7s lamp 49 had even an ‘MPfactor’ of 0,4. The R7s- alternatives in LED- or CFL-technology have the same inconveniences (dimensions, weight, luminous flux).

ANNEX H: COMPARISON 120V (US) AND 230V (EU) IRC LAMPS

Contribution LightingEurope[53]:

"Why we cannot extrapolate the efficacy of 120V IRC lamps from United States to main voltage"

The reasons for the efficacy decrease for MV IRC lamps:

- the filament is much thinner than a 120V wire and less dense (more reflected IR rays go through the filament without being absorbed by the tungsten);
- due to the small wire thickness (30-40 micro) the filament tends to sag much more than a 120V wire and the efficacy gain by the coating is gone after a couple of hours;
- the burner shape will be much more complex than a 120V burner due to the fact that the wounded filament length is 1,5 to 2 times longer;
- the core diameter of the filament is also much thinner, the filament alignment becomes much more critical than a 120V version (complicated process and expensive equipment) and the limited efficacy gain achieved by the coating will disappear over lifetime;
- efficacy gain will be different between a low wattage and high wattage MV lamp (dependent on core thickness of the filament).

The efficacy gain of the coating on a mains voltage IRC is only a small fraction of the efficacy gain of a 120V IRC capsule, but the coating price will be even higher due to the fact that, as explained before, European Mains volt filaments are longer than the same wattage 120V filaments and therefore the halogen burner that is being coated needs to be larger. This increases the price of coating per lamp and the ratio efficacy gain/price decreases also with this fraction. In addition the volume of the burner shape will be much bigger. This leads to a high Xe demand per lamp and so also to high costs for filling gas.

Technical explanation on why our IRC HAL example costs 10 EUR and the US version costs 3,5 USD (more detailed preferably quantitative discussion on how the American "2XL" lamp technology (50 W, 1650 lm, 1500h, $ 3.50/unit) translates into European conditions):

Option A

Adapt IRC technology to 230V

Due to the higher mains voltage the coil of a 230V burner is made of a thinner wire than the coil of a 120V burner which makes a very big difference. The arguments are already well described in annex H of the Review study by VHK and VITO.

The reasons for the efficacy decrease for MV IRC lamps:

- the filament is much thinner than a 120V wire and less dense (more reflected IR rays go through the filament without being absorbed by the tungsten);

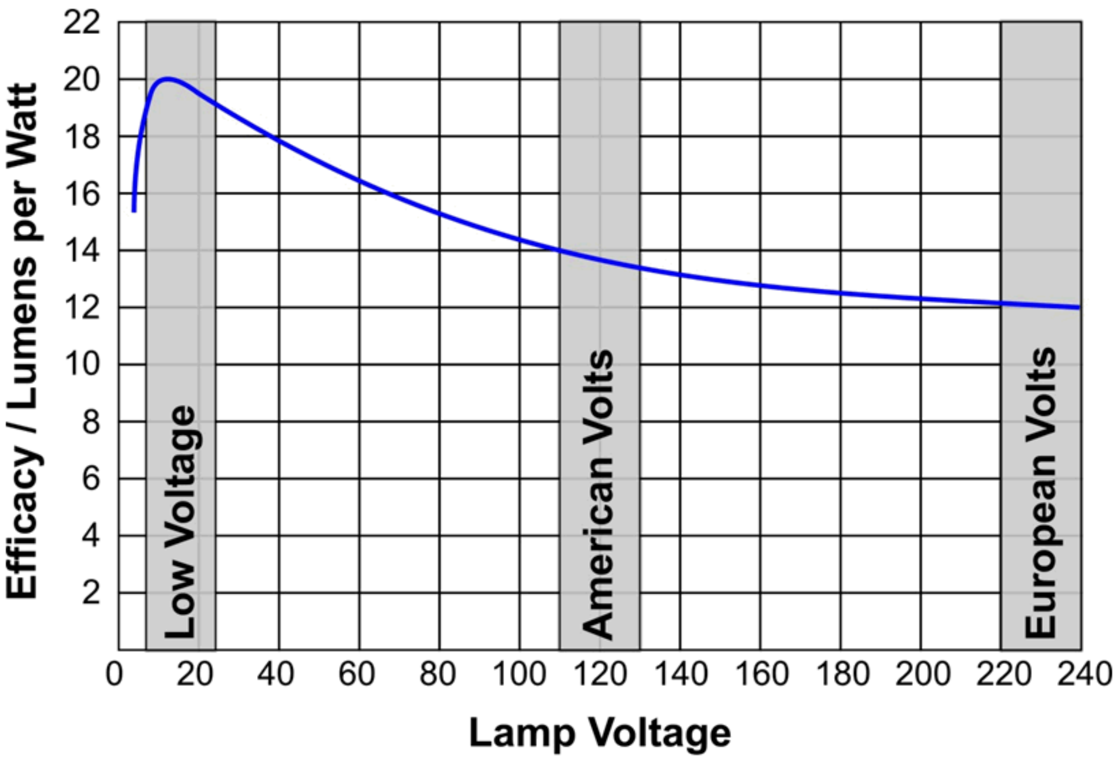
[53] Pers. comm. LightingEurope 20.3.2013

- due to the small wire thickness (30-40 micro) the filament tends to sag much more than a 120V wire and the efficacy gain by the coating is gone after a couple of hours;
- the burner shape will be much more complex than a 120V burner due to the fact that the wounded filament length is 1,5 to 2 times longer;
- the core diameter of the filament is also much thinner, the filament alignment becomes much more critical than a 120V version (complicated process and expensive equipment) and the limited efficacy gain achieved by the coating will disappear over lifetime;
- efficacy gain will be different between a low wattage and high wattage MV lamp (dependent on core thickness of the filament).

The efficacy gain of the coating on a mains voltage IRC is only a small fraction of the efficacy gain of a 120V IRC capsule, but the coating price will be the same; therefore the ratio efficacy gain/price decreases also with this fraction. In addition the volume of the burner shape will be much bigger. This leads to a high Xe demand per lamp and so also to high costs for filling gas.

In any case, the efficacy of 120V lamps is always greater than 230V, with or without IR Coating.

The chart illustrates the relationship between voltage and efficacy, for one particular lamp type having constant flux and lifetime at all points on the curve. It shows that the optimum voltage for lamp design is about 12V, and that the Americans have an efficacy advantage over the Europeans due to our difference in mains voltage.



Option B:

Two 120V burners in series in one bulb

The 2X product has an input power of 50W and a technically comparable product from Philips is on the market as 40W, 50W and 70W type. A lower wattage is not offered by 2XLightDirect nor by Philips. If we would put two of these burners in series the power would be at least 80W, resulting in a lumen level that would be comparable to a GLS of at least around 140W. This option is therefor only possible for high lumen packages which are only a minor part of the market. An alternative product for the most popular types 40W and 60W GLS-equivalent cannot be realized as a low wattage (15W – 30W) 120V burner is not feasible with the IRC coated technology.

The cost of the product is dominated by the cost of the burner. To place 2 burners in one bulb would require additional mounting costs. The price of a lamp with 2 burners will come close to double the price of a lamp with only one burner.

ANNEX I: MINUTES & SLIDES TECHNICAL EXPERT MEETING

Minutes of the Technical Stakeholder meeting on the review of Stage 6 Requirements of Commission Regulation (EC) No. 244/2009

Date and time: Friday 26 April 2013, 14.30-17.30h
Place: Berlaymont building, Room S7, Brussels
The list of attendants is attached as a table at the end of the document.

The meeting starts at 14.30. René Kemna (VHK, Chair) welcomes everybody to this technical stakeholder meeting on behalf of the VHK/VITO study team. After a tour de table with short introductions Ruben Kubiak (EC) welcomes all at the Commission's premises and explains practical arrangements. The meeting will only be on stage 6 on NDLS. The political Stakeholder Consultation will probably take place in June but the exact dates will follow. The draft agenda is approved.

Main purpose of the meeting is fact-finding on issues addressed in the report. Political comments and opinions will be noted in the minutes, but will not be subject to discussion.

Peter Bennich (Swedish Energy Agency) asks if this is the normal procedure for a revision. Normally there is a preparatory study, multiple stakeholder meetings, consultation forum meeting etc.

Ruben Kubiak (EC) answers that this is the normal procedure for a review, which is different to the initial preparatory phase for new Regulations. A Consultation Forum meeting will take place after the written report has been analysed, probably end June.

Peter Bennich (Swedish Energy Agency) states that he has some problems with vague definitions in the regulation and that the time to give comments is really short.

Ruben Kubiak (EC) replies that this meeting is just about Stage 6 of the 244/2009 regulation. The definitions will be discussed more elaborately in meetings following later this year.

René Kemna starts the presentation on the review of the stage 6 report. Scenarios to be investigated include a) continuation or b) abolishing Stage 6. Written comments after this stakeholder meeting can be send in till 10th of May.

After the presentation (sent by e-mail to participants) the chair proposes to structure the discussion by keeping the chapter structure of the presentation and report. Topics which cause big discussions can be handled at the end of the meeting.

Chapter 1 "intro":
No comments are raised.

Chapter 2 "technical analysis":

2XL LAMP (US) and other Stage 6 conform MV-HL lamps

Michael Scholand (MS, CLASP) takes the floor and mentions a new product launched on the US market called: 2XL. It is an infrared (IR) coated halogen capsule operating at 115V-120V. Main voltage in the USA is 115V and in Europe 230V: This is the difficulty (also addressed in the presentation) to introduce this lamp in Europe. One of the product ideas MS would like to see included in this section of the report, is to take two of these US capsules (115V) and wire them in series so you have a voltage of 110-115V on each of the filaments. This would result in a European 220-230 V version (simultaneous running capsules) and this would prevent the electronics problem that was mentioned in the technical section. The fact that those capsules are online available and can be put in an E19 envelope will be included in our (CLASP) comments to VHK.

James Hooker (Lighting Europe) states that two capsules in one lamp can be achieved relatively easy, but there are two obstacles from his point of view. The first is that with two capsules you double the costs of the product compared to what is available on the North American market. This is mostly because the primary cost of a lamp is in the IR coating of the capsule. The second drawback is that when you put two lamps in one capsule you double the luminance flux. One 2XL lamp in the US replaces an 170-180W incandescent lamp, but also in the US there is no solution for the 60W lamps. When we combine the two lamps it might be a solution to replace a >300W incandescent lamp on the European market but there is still not a good solution to replace the 40-60 W lamps.

Michael Scholand agrees, but he sees it as a solution in the high end flux packages which could be a B-class. At this moment LED technology is commercially available in the lower flux packages let’s say 800 lumens and we are going to see 1000 lm packages which will be coming out soon. It is interesting to see that we have a low flux solution at A, A+ class in the lower flux output but could have a B-class solution in the high flux products in 2016, so in 3,5 years from now.

Extra: EPRI independent assessment is 1650 lumen for 50 W with efficacy of around 32-33 lm/W. this would place the lamp in the B-class category. Two of them together would not work as good together in Europe because there will be some internal absorption of light output between 2 capsules.

Paul van Tichelen (VITO) states that one lamp in US is 50 W and two lamps in series in the EU would, with the help of extrapolation formula’s, means 100W but would have 2 times 1650 lumens and this is way above the reference luminance output we have. It is interesting though to see that these lamps can be manufactured for a low price. $ 3.50 is really low for an IR coated lamp, which is very promising. It is really difficult to extrapolate US data to European data so we have to be careful with these data and double check calculations.

Michael Scholand will do some more research on it and will come back with written comments.

The chair says that the study team knew about the lamp and the EPRI research, but we didn’t know about the price till yesterday and thus it is not in the report. Does this have consequences for the report? As stated in the report US data is not easily transferred to EU data. But the report also says when we would do something similar in Europe we would end up with a lamp costing of around 10 euro and here we have a lamp that costs $3.50. How is it possible that this lamp costs just $3.50? Is it because of a shorter filament? Is geometry is less critical? Is it a matter of the batch quality (20 lamps or more?) that is less critical? The report needs to explain this price difference.

Kees van Meerten (Philips lighting) replies that for its old B-class lamp Philips needed an internal transformer to realize a higher efficiency lamp and this lamps doesn't need that. This explains something. The lamp needs also IR coating but the price should be higher than what the US lamp indicates. He is curious how this is possible.

Michael Scholand (Clasp) states that analysts should look at the price difference between EU products with and without IR coating (e.g. Directional Lamp). Philips lamps with IRC can be bought for around 3.50 Euros in the UK.

Casper Kofod (Danish Energy Agency) states that concerning the last point raised by MS there are at least 4 webpages (when googling) on B-Class halogens. It is not certain if this is the Philips lamp or another, he hasn't investigated that, but it shows that they are available and can be found online quite easily.

Paul van Tichelen replies that when he looks on-line he finds also some old webpages of the Philips lamps, but they are not produced anymore.

Kees van Meerten (Philips) can confirm that the lamp is already three years not in production anymore.

Paul van Tichelen continues that the latest available price mentioned in the report for the Philips lamp with transformer is a reference price at this moment, even when the lamp is not produced anymore.

The chair asks to send around data at least for this specific subject data: Does a B-class with transformer still exist? The report says that there is not a B-class lamp available at the European market but if that is wrong please correct.

Christoph Mordziol (Environmental Agency Germany) wants to know if Philips can start producing these lamps again when stage 6 is maintained. And did he understand correct that this 50 W lamp has 1600 lumen and would be a B-class lamp with an efficacy of 32 lm/W.

Paul van Tichelen states that Christoph is right that this US lamp is better than the Philips lamp on the American line voltage. But we have no data on how this lamp would perform on the European market.

Paul van Tichelen mentions his results from extrapolation formulas in the report when applied to the 2XL lamp, but the outcomes (up to 110 lm/W) do not work. Tungsten has a melting point of 52 lm/W so it is not possible to get 110 lm/W (the filament would just melt).

James Hooker replies that the IR capsule which is used in this American lamp is similar to the capsules, Lighting Europe member companies, used in the saving lamps on the US market. The lowest wattage they have been able to produce for these lamps is 45W. When going below 45 W the filament is getting thinner and the same problems as when producing a 230V lamp for the European market. There is potential for a 50-45 W lamp in the US and a 90W lamp for the European market but we think this is not a suitable replacement for the European market.

The chair summarizes that the discussion did not yield a clear conclusion on the performance of the 2XL lamp for the European market so he asks for written comments.

Michael Scholand replies that he appreciates what James Hooker is saying and that he will get back in written comments to the study team on this issue.

Chair asks if there are more remarks on the technical analysis.

LEDs

Casper Kofod states to have found lamps on the market that have more than 800 lumen. There are two examples of lamps: one of 1055 lumen from Samsung 12W, 88 lm/W with good colour and colour rendering, priced at €18. Motiva, Finland has been informed on a new Philips LED also providing 1055 lumen which will be available from July 2013 and provides 81 lm/ W.
Looking ahead towards 2016 he sees a speedy development comparable towards 75W or 100W replacement up to 1700 lumen (available in shops in Japan).

Paul van Tichelen replies that we have to make distinction between clear and frosted equivalent. A clear lamp is always in the lower lumen output. The lamps we found with above 800 lumen output were for frosted lamps (higher lumen output than clear lamps). We have to agree what we are talking about. We have to make clear what we mean by a C and F lamp in legislation and the report so the discussion has to be clear.

The chair states that the question here is not only if it is technically possible to make high flux LED but also what happens with the price, i.e. that the price goes up with the capacity. At the moment commercially that is a problem for LEDs. Price information would be relevant. Can they be made at a reasonable price with these lumen outputs (1200 lumen)?

Michael Scholand states that in the report perhaps there should be more discussion on projections for LED. One should be talking about Stage 6 conform instead of class B halogen. LED is already stage 6 conform. There are independent projections made by European manufacturers and projections available on the website of the US Department of Energy. On the DoE website projections on efficacy and price forecast have been made; he encourages participants to look at those. LED is operating under American voltage, but the LED operating in the lamp is most often under direct current after controls. And this can be alternated to 115V or 230V by engineers. For instance the Philips L Prize lamp works at 115V in the US and at 220-230V in the UK. The lamp and its component are exactly the same, only the driver is adjusted to different voltage.
MS is showing a 60W – 9.5V LED retrofit lamp by CREE lamp which costs 11 euro in US with a payback period of 0.93 year in Europe (should you run it here). Commercially available today.
For 2016 price reductions can be seen. Stage 6 confirming lamps can be seen then.

James Hooker states that it is important for Europe to build a profitable and solid business. They purchased the lamp, took it apart and found that the lamps has more than 13 USD of parts in it, so the 13 USD sales price is less than the costs put in the lamp to make it, so they have to make losses with each sales. In the EU market it is not likely to sell below cost price.

Kees van Meerten states that the L Prize lamp in the EU is 20% less efficient due to the voltage difference.

Michael Scholand agrees with James that the costs per lamp might be higher than the price if you buy every component separately from suppliers, but CREE makes LEDs themselves and this gives a different angle to what the cost price is. He will ask if CREE wants to give a comment.

The chair asks the industry and Michael Scholand to come back with written comments and data on this discussion.

Stamatis Sivitos (ECOS) thanks for the possibility to give comments. Expectations for 2016 are that there will be more LEDs on the market and would like to see this included in the report, in line with what Michael Scholand addressed before. He is happy that the chair addressed the possible loophole with the G9 adapter lamps and this should be treated properly.

DIMMING ETC.

Wim De Kesel (CECAPI) mentions that the report stated that there were certain replacement criteria. On some of the lamps it was indicated what was the dimmability and this is only one part of the problem. In his view it is extremely important that halogens are a last resort for installations where these lamps need to be replaced. LED replacements do not fit and are not compatible with all the existing installations. The fact that halogens are on the market gives us a last resort as an alternative for existing installations and replacements.
We are talking about active components and not passive resistors. Passive resistor gives no problems with existing installations but when you put in active components, you might get problems with controllers and not only dimming. (see Annex M)

Otmar Franz (Lighting Europe) underlines what Wim De Kesel said. When you take a lamp out of working point when you dim a light, you lose CRI and efficacy. When you work against those two properties it will cost you immediately a lot of money. Dimming is not so easy even when done on LED technology, same is for CFL.

The chair asks if it is possible to give some data on this. How much do you lose on CRI and efficacy when using dimming? Preferable something that is representative for the whole market and not one model.

Paul van Tichelen reminds that temperature plays a role as it has a negative effect on LEDs efficacy.

James Hooker states that every LED lamp has an electronic driver build into the lamp and the efficacy of the LED electronic driver is roughly the same as the lamp wattage, maybe 80-90%. When dimming the lamp the power going through the lamps is reducing but the power in the electronic driver is staying proportionally almost the same. A second difficulty is that the wattage of these lamps is quite low and that with dimming the lamp is not working properly when going below a certain level. Many LEDs even have a resistor inside the lamp and simply when shifting the dimmer the power to the LED is decreasing and the reduced power is burned up as heat inside the lamp. So there can be certain LED types where you dim them and the wattage stays almost the same even though the light output is decreasing. Lighting Europe will try to find some concrete examples of this and provide them after.

Paul van Tichelen mentions that it depends on the way you dim the lamp.

René Kemna asks to provide data for a typical EU dimming situation, so we know on average what to expect.

Wim De Kesel states that for the consumer there might not be an alternative. Dimming is one of the problems but there are similar technologies as in dimmers used in switches (infrared detectors). That technology is used in many different applications and some of these applications are necessary in other European legislation types (e.g. accessibility). You cut halogens out and give no possibilities to the new electronic light sources. We might hinder legislation in other domains, so we have to consider all other legislations also.

To clarify the chair asks if this statement by WdK only applies to existing installations. WdK doesn’t mean that if there were no halogens we could not use sensors etc. ?

Wim De Kesel replies that we would find solutions in the new installations, but we would need to know what to do in that case. If there is no alternative for the existing installations than we have economically seen a big problem. Millions of households with existing installations and they are important.

MARKET/ECONOMIC DATA

Casper Kofod addresses the Premium Light projects in which 2/3 of the European manufacturers are participating. Premium light is concerned with the lifting of LED quality sold on the market. Detailed audits show that the 500 hours operation time is similar to what is found (Premium Light found 600 hours of usage for halogen lamps).

RK ask if this is for all lamps or specific for halogen lamps?

Casper Kofod replies the MV halogen have in average 600 hours operating time (audit where analysing usage of all types of lamps in the house divided on rooms too). Kofod mention that elsewhere in the report is supposed a 200-300 hours operation which is far from 500-600 hours.

The chair answers that we would like to receive those data. According to our sources we know that some places in the house lamps are used 200-300 hours. Not every light source is 600 hours, otherwise we would have 3 times the energy consumption we have today.

Casper Kofod has after the meeting provided the survey data that shows installed MV HL bulbs are distributed with:

- 16 % of the MV-HL being among the lamps burning most (assumed 1200 h/year)
- 36 % of the MV-HL being among the lamps burning second most (assumed 900 h/year)
- 35 % of the MV-HL being among the lamps often switched on but burning short time each time (assumed to be 350 h/year)

- 14 % of the MV-HL being among the lamps not used very much (assumed 100 h/year)

The main message is that the assumption in the scenarios of an operating time of 500 hours is OK.

Torsten Sundmacher (Sustain Consult GmbH) has a concern about the 500-200-300 hour operating times. Take for instance two different scenario's 200 and 300 hours on one side and 500 on the other and use SPP calculation. Different result can be useful in different cases.

René Kemna mentions that in the economic study we can't come to a clear-cut conclusion. As is stated in the economics section:" It is impossible to make calculations right now". We don't have enough data (e.g. energy price in 2020). There are many unknown data so if we use 450 or 550 hours is not bad it doesn't need to be exact. The data needs to be a good estimation of the correct order of magnitude. With current calculations we already show that we are in the right direction.

EMPLOYMENT

Torsten Sundmacher has another comment concerning this. The potential savings of the private households has been calculated coming from electricity on one hand and on the other hand from lower investments costs regarding this lifespan. There is another effect coming from this, i.e. the employment effect:
You have to calculate losses from employment: Losses in income taxes, company taxes, public unemployment expenses etc.

The chair looks forward to the calculations from TS on this subject.
All objective information and facts are welcome (Slide 24)
Social costs we could take into account in the calculation. Can estimates be delivered that are correct?

Torsten Sundmacher replies that they don't have the exact numbers or the complete picture at this moment, but could include them in the written comments. There are some remarks on the methodology dealing with these numbers. It might be a good idea to distinguish suppliers and manufacturers of the end-products direct and indirect effect. He thinks a part of suppliers of halogens are not a focus. In Germany there are some special suppliers dealing with fittings, glass production in Aachen, and Augsburg. Normally the indirect employment effect is in the same order as the direct effect. Other studies (lime industry) employment effects are a factor 1 to 3 higher. Look at purchasing volumes, glass production, wire production etc. Purchasing volumes on the different sides are important.

Harald Schönfelder (Philips Aachen) mentions that for instance 270-300 people in the burners manufacturing business stand to lose their jobs in 2016.

The chair replies that we took into account the supply chain/ filament/ burners etc. and could make, from independent sources, an estimate of the direct and indirect employment effects.

LightingEurope confirms that these were also taken into account in their estimates for the report.

Chair continues: The problem is that there is a third dimension that we could not take into account, namely the effect on the employment at a factory or site if half of the turnover goes away. Will this plant still be economical to run as a whole? What will happen with the people working on other products at this plant? For this third effect we can only rely on the input of the industry. Anyway, any additional input from outside is very welcome, because it is a complex calculation: It is not enough to know how many people will lose their job, but also how many will go into early retirement, how long will the others stay unemployed, etc..

Another issue is what will happen if the Stage 6 is abolished and the halogen production continues? How long can it actually continue in competition with ever cheaper and more efficient LEDs? In the report’s analysis, the continuation of the halogen production will buy the industry extra time to come up with alternatives. In that context the chair mentions that Havell’s Silvania brings production ‘back’ to Europe from Asia. This creates new jobs for highly qualified staff in production automatisation, design etc.. The actual manual labour costs after automatisation is low enough to be competitive for Europe. This is a very interesting strategy, but might require the extra time that abolishing Stage 6 might give. How can you do something about the employment or can’t we do something about it? These are very complex questions especially for a 3 month study.

Peter Bennich (Swedish Energy Agency) raises the option whether to abolish stage 6 completely or only partly. Japan will produce in 2020 only LEDs in all segments and they skip all other filament technology. (see also Annex O) Maybe explaining long term strategy plans when sending in comments is important for policy making.

MORE ON PROJECTIONS

Marie Baton (CLASP) states that the market scenarios are an important part of the report. We support Mr. Bennich’s request for more long term data. We try ourselves also to give own information.
Employment questions are too one sided when just looking at losses in main voltage halogens and imports from Asia. Furthermore we don’t see the urge to review stage 6 at this moment already. We still have 3.5 years to go and review could be done next year.

Michael Scholand continues that halogen C-class increasing rapidly and when Stage 6 is abolished you are postponing the decision, but it is not likely they go away in the future. Osram/ Philips don’t do assembly/ production in Europe this is just Havell’s Sylvania. So maybe the commission should create employment incentives (e.g. tax breaks) so that employment possibilities in the future in Europe can be maintained.

The chair answers that it is noted as an opinion. To Marie Baton he answers that the reasons for the speedy review are mentioned in the report: To provide both industry and consumers with planning security.

Ruben Kubiak answers to Marie Baton that the Stage 6 requirements were based on a technology (MV halogen with integrated transformer) that had been just recently introduced on the EU market in 2008. In 2012 it became obvious that the technology disappeared from the market as it was not viable, while no alternative was introduced that could fulfil Stage 6. This is was one of the reasons to launch the review apart from providing planning certainty to industry.

The chair asks Sylvania how long it took to set the Directional LED factory up in Tienen. Could this be done in 3.5 years?

James Hooker replies that a manufacturing facility will logically be put in the lowest cost situation possible, so when the labour costs can be lowered, the transportation costs will play an important role and being situated in Europe is then a huge advantage. So if you can make a costs saving as a company you do it as soon as possible.

The chair adds that one of the important questions is if we wait 7 years instead of a forced action to phase out after 3.5 could we have some employment left in Europe.

Michael Scholand states that next generation lamps most likely will not be manufactured in Europe by manufacturers present with us today. This is important for the Commission to consider for the employment of these employees.

Otmar Franz replies that this is not true and MS has no evidence on what we are going to do in the future in Europe on halogen or other technology.

The chair asks if anybody has a better alternative than the market figures that are mentioned in the report?

Casper Kofod comes back to efficacy, i.e. what can be bought from catalogues. He sees at this moment for non-directional lighting an **average** of 66 lm/W with the best lamps providing 88-95 lm/W so the estimate 2017-2020 figure 80 lm/Ws are too much on the low side.

The chair replies that the figures are based on today’s mainstream lamps with an average of 50 lm/W, we are not talking about best on the market**.** In our projections we consider 80 lm/W in 2017-2020 to be the average, not the best.

Otmar Franz underlines what the chair said. And we have to be careful not to mix up the efficacy of the chip and the LED lamp.

Casper Kofod states that they have the latest version of the products from IKEA. Lamps with 53, 57 and 60 lm/W with colour rendering 93 are mentioned in the latest IKEA catalogues. So 80 lm/W in 3.5-6 years (2017-2020) is all too low as projection.

The chair would like to have market data, distribution of LED sales in Europe, etc. as much as possible. The chair asks for inputs on lm/W projections for the scenarios.

Michael Scholand replies that as an analyst he would take the 50 lm/W of 2012 as an anchor point and then follow the DoE projections proportionally up to 2020.

James Hooker makes a point that efficacy over time is not always important but variance of LED lamp lifetime in the future is important.
Low costs LED lamps might have lower lifetime, less than the average 20 000 hours. The 40 years in the report is very optimistic.

The chair replies that 40000-50000 hours are claims and we assume 20000 hours, support us with data if you think this is still too high.

Ruben Kubiak replies that the study should not go below functionality requirements for LED lamps and modules stipulated in European Union Regulations.

OPINIONS

The chair starts the last point of the meeting, i.e. the voicing of opinions for the sake of the minutes. There will be no discussion on opinions. The question is to keep or abolish stage 6.

Ruben Kubiak states that recommendations at this point of time should be concerning stage 6 only.

Torsten Sundmacher states it is clear to them that something needs to be done. Do not abolish stage 6, i.e. MV halogens should be kept on the market after 2016.

Peter Bennich states that there is a strong drive towards environmental issues. We need strong data/ arguments why abolish stage 6. He does not like to change current recommendations/ regulations and come back on issues.

Casper Kofod would like to see more time spend on looking at LED market development. The position of the Danish Energy Agency is that abolishment of stage 6 for MV-HL lamps is not needed as very energy efficient LED lamps of good quality are available and they will provide substantial beneficial economical savings for the consumers.

Kees van Meerten statement of Lighting Europe is that consumer choice is important also after 2016. Abolish stage 6 for mains voltage halogen. Maintaining Stage 6 for low voltage halogen is no problem.

Marie Baton states that it is premature to take decision now. Better evidence would be there in one year. More information on LED evolution and investments is necessary.

Stamatis Sivitos replies that it is good to start already early in 2013. But a review now is premature, further time needs to be taken, no rush decisions. We heard in this meeting that LED technology is improving, so more data and time is necessary. Stage 6 requirements are step towards ‘Minimum Class A reuirement’ for lamps that ECOS is striving for and should not be reviewed too early. Market transformation can slow down when Stage 6 is abolished. Do we want Europe to fall behind Asia and the US when making now decisions quickly?
When stage 6 would be postponed when can a ‘Minimum class A’ label be expected? More time can help set the tone in the EU for years.

Wim De Kesel replies that he would like to keep halogens.

Christoph Mordziol is not able to express a statement for Germany since discussion still is going on there.

Ruben Kubiak wants to point out that a review and possible revision take some time, hence an early start has been deemed necessary to provide industry and citizens with planning security well in time. Furthermore, the European Commission is waiting for the technical review report before formulating any recommendations about a possible revision.

Fabio Pagano (Lighting Europe) states that this topic has also a big impact on luminaire producers. There are 1000 companies producing luminaires who are closely related to this subject. It is also important that manufacturers have time to invest in resources and change in products. It is crucial to have due time in advance before the market transformation.

Simonetta Fumagalli (ENEA) states that from their research they found that there is an important trade- off between light quality and efficacy. They have taken E27 socket LED lamps were taken and a questionnaire under around 100 people was held. We concentrated on 2 models:
One Extra EU LED model with efficacy of 90 lm/W and a colour rendering index of 82, the other one was an EU LED models with efficacy of 43 lm/W and the colour rendering was excellent.

The chair states that this is a real important point. It may be that with cool light and a bad CRI your lm/W goes up, but many consumers will not be happy.

ANY OTHER BUSINESS

Tobias Schleicher (ANEC/BUEC) comes back to the introduction where it was stated that the R7 lamp was excluded from the scope of this review. From the consumer point of view he sees that they are energy consuming and therefore have a very high life cycle costs. Is there any discussion on this?

The chair answers that this comment is noted. We can't answer because we don't know what is on the agenda.

Ruben Kubiak states that this review is just on stage 6 of Regulation 244/2009. The rest of the Regulation will be reviewed starting in the second half of this year.

Christoph Mordziol states that the Commission should also look at the review of other requirements not only these in stage 6. Second comment is that the Commission should look at loopholes for special purpose lamps. The third and last comment is towards the regulations, ecodesign directive and energy labelling directive, these only refer to anorganic LED, OLED are excluded. The commission should look at this OLED loophole, it is not a problem at this moment but might be in the future.

The chair is interested if the stakeholders have information on R7s, heavy duty incandescent lamps, OLEDs that can help the review studies, if not the present one than the ones announced by the Commission for later.

Ruben Kubiak states that the evolution of sales of special purpose lamps will be part of the general review starting in the second half of 2013. This review might further look into OLEDs but a more detailed answer can only be given once the review process has started. Further, reviews are always an open process without a pre-determined conclusion.

Otmar Franz states that there are shockproof lamps and there are fakes but market surveillance missing.

The chair concludes the meeting and thanks those present. The PowerPoint presentation will be send as soon as possible to the stakeholders. The study team will keep the stakeholders informed about the progress but the EC will take over after the final report is handed in.

RvdB/ VHK. 3.5.2013 (draft), 16.5.2013 (final)

Participants

SURNAME	**Affiliation**
BATON, Marie	CLASP
BENNICH, Peter	Swedish Energy Agency
BLASO, Laura	ENEA
BOORN, Roy van den (Minutes)	VHK
BRIATORE, Chiara	LightingEurope
DE KESEL, Wim	CECAPI/Legrand Group Belgium nv-s.a.
FRANZ, Otmar	LightingEurope, OSRAM
FUMAGALLI, Simonetta	ENEA
HOOKER, James Dalton	Havells-Sylvania NV
KEMNA, René (Chair)	VHK
KOFOD, Casper	Danish Energy Agency consultant
MALIZOU, Angeliki	ANEC/BEUC
MEERTEN, Kees van	PHILIPS Lighting
MORDZIOL, Christoph	Umweltbundesamt (Federal Environment Agency, Germany)
PAGANO, Fabio	LightingEurope (Associazione Nazionale Produttori Illuminazone)
COUET, Claire	Dow Corning
HAENTJES, Rony	NV NIKO
ROSSKOPF, Hubert	Betriebsrat OSRAM GmbH Eichstätt
SATTLER, Willi	Gesamtbetriebsrat OSRAM GmbH
SCHLEICHER, Tobias	ANEC/BEUC (Ökoinstitut)
SCHOLAND, Michael Joseph	N14 Energy, representing CLASP
SIVITOS Stamatis	ECOS Asbl
SUNDMACHER, Torsten	Sustain Consult GmbH
TICHELEN, Paul van	VITO
TIMMER, Holger	IG Metall
TIRONI, Fabrizio	LightingEurope, Assoluce, Flos S.p.A.
VANHOOYDONCK, Lieven	Kreios
SCHÖNFELDER, Harald	Philips, Betriebsrat (Aachen)

Commission:

KUBIAK, Ruben	European Commission

Ecodesign Review NDLS Stage 6

VHK - VITO
René Kemna (VHK)

Technical stakeholder meeting
Brussels, 26.04.2013

Draft Agenda

Technical Stakeholder Meeting,

Review Ecodesign NDLS Stage 6
26 April, 14.30-17.30h, Berlaymont, S7

- Welcome and introduction
- Presentation of the draft intermediate review report
- Specific comments and corrections regarding the report (including possible written comments received beforehand)
- Discussion
- Any Other Business (AOB)
- Closing of the meeting

Notice

Ecodesign Review of Commission Regulation.No. (EC) 244/2009 on Non-Directional Light Sources, Stage 6

Contract No. ENER/C3/2012-418 LOT 2/01/SI2.645913
Service Contract to European Commission, DG Energy

Authors: VHK (NL, p.l.), VITO (BE)

Intermediate Report d.d. 2.4.2013

Content

1. Introduction (incl. Annexes A, C)
2. Technical Analysis (incl. Annexes F, G, H)
3. Market and Economics
4. Environment
5. Employment
6. Health (incl. Annexes D, E)

Introduction: Assignment

Objective EC

- Provide planning security for industry & consumers buying luminaires designed for halogens.

Motivation EC

- At the time of conception Regulation (EC) 244/2009 the legislator did not intend to phase out mains voltage (MV), halogen (HL) non-directional light sources (NDLS) in Stage 6
- Yet, there are currently no MV-HL NDLS that would meet Stage 6 requirements;

General Tasks for Study

- Restricted impact analysis on priority aspects: Technology, Market & Economics, Employment, Environment, Health.
- At least two scenarios: Keeping Stage 6 or abolishing Stage 6

Introduction: Planning

February

- Draft intermediate report

March

- Finalised intermediate report *(distributed, CIRCA)*

April

- Technical stakeholder consultation 26.4.’13

  (written comments till 5.5.’13)

May

- Final Report to the Commission 16.5.’13

Follows: Political consultation by the Commission

Introduction: Stage 6

Commission Regulation (EC) 244/2009 on NDLS

Stage	Date	Scope	P_{max} (W) at Φ (lm)	Function (e.g. life L)
1	01/09/2009	Clear >950 lm	0,8 * (0,88√Φ+0,049Φ)	√
		Non-clear: all	0,24√Φ+0,0103Φ	(e.g. L≥1000h)
2	01/09/2010	Clear >725 lm	0,8 * (0,88√Φ+0,049Φ)	
3	01/09/2011	Clear >450 lm	0,8 * (0,88√Φ+0,049Φ)	
4	01/09/2012	Clear >60 lm	0,8 * (0,88√Φ+0,049Φ)	
5	01/09/2013	All, excl. CFL/LED		√ (e.g. L≥2000h)
Review, at the latest 13/4/2014				
6	01/09/2016	All Clear, except R7 and G9	0,6 * (0,88√Φ+0,049Φ)	

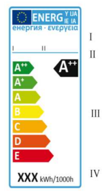
Introduction: Stage 6 & Energy Label

Minimum luminous efficacy (in lm/W) per label class for selected power inputs Pcor

	mains-voltage halogen							low voltage halogen (corr=1.06)					
	18	**28**	**42**	**53**	**70**	**105**	**W**	**20**	**25**	**35**	**50**	**75**	**EEI**
A++	124	124	124	124	124	124		131	131	131	131	131	**0.11**
A+	49	80	80	80	80	80		54	85	85	85	85	**0.17**
A	34	41	57	57	57	57		38	42	60	60	60	**0.24**
B	**14**	**16**	**19**	**20**	23	23		15	17	19	21	24	**0.6**
C	**10**	**12**	**14**	**15**	**16**	17		11	12	14	16	17	**0.8**
D	9	10	12	13	13	14		10	10	12	13	14	***0.95***
E	*8*	*9*	*10*	*11*	*12*	*12*		*8*	*9*	*10*	*11*	*12*	***1.1***

**red font* = lamps >1300 lm have different metrics in labelling delegated regulation; **grey font* = phased out*

Com. Del. Reg.(EU) 874/2012



Stage 6 limit (according to current Reg. (EU) 874/2012)

Technical: Product Scope

NDLS Low Voltage HL

G4 GY6.35

6-75 W; 6-48V (12-24V)
2000-4000h
C € 1.1 (street)- € 3.5 (top)
B € 4.5 (top, IR coating)

NDLS Mains Voltage HL

E27 E14

18-105 W; 6-48V (230V)
2000h (after 1/9/'15)
C € 1.5 (street)- € 4 (top)
~~B~~ not available

Technical: 'Lock-in' effect & replacement

'Lock-in': Lamps need a fitting to match the cap (or an adapter)

Replacement: Consumer wants a lamp with similar characteristic

Crystal luminaire with G9 lamps and lock-in effect
Swarovski- VERVE luminaire

Technical: The CFL alternative

Available for retrofit with various NDLS lamp caps

Characteristics PRO (vs. HL):

- 3 times longer product life (up to 6-10 000 h)
- 3-4 times energy efficacy (40-55 lm/W)
- Most economical (shortest payback, low maintenance)

Characteristics ± EQUAL (vs. HL):

- Comparable price (from € 1.5)
- Available in high power range

Characteristics CONTRA (vs. HL):

- Different characteristics: Diffuse light, no sparkling, lower CRI, dimmability optional
- Delayed ignition
- Mercury balance positive, but mercury requires special handling in disposal
- Not suited for all fittings (too big, not for low voltage, etc.)

Technical: The LED alternative

Available for retrofit with various NDLS lamp caps

Characteristics PRO (vs. HL):

- 25 times longer product life (up to 50 000 h)
- 4-6 times energy efficacy (65-75 lm/W and rising)

Characteristics ±EQUAL (vs. HL):

- Similar light characteristics (bright sparkling, colour render >80-95 Ra, wide colour temperature range, immediate ignition)
- No mercury, no UV

Characteristics CONTRA (vs. HL):

- 5 times higher price (€ 9 – 11)
- Not available in high power range (and price goes up linearly with lumen output)
- Some are dimmable, but at a price; problems with dimmer-compatibility; problems with oversized transformers'; possible space restrictions (temperature sensitive technology); batch colour differences possible

Technical: The G9 + adapter alternative

G9 is exempted from stage 6; can be used with adapter to fit E14/E27

Characteristics PRO (vs. HL):

- Would be available after Stage 6 (loophole)

Characteristics ±EQUAL (vs. HL):

- Same light characteristics (halogen), product life, efficacy

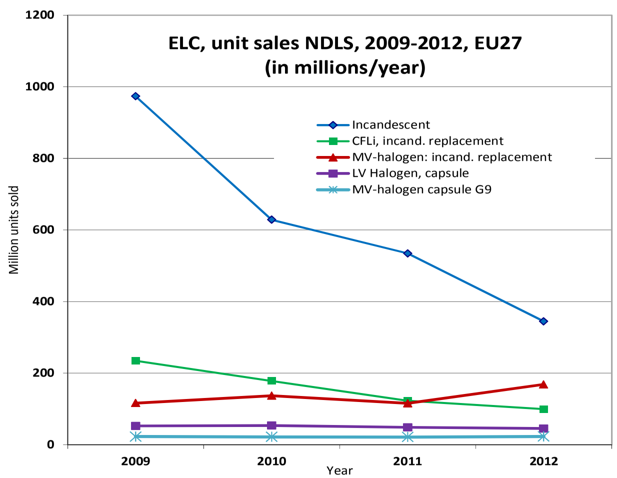
Characteristics CONTRA (vs. HL):

- higher price (adapter € 6.25 + G9 lamp)

Technical: Stage 6 MV-HL, could it be done?

- Yes:
  With an integrated transformer (fig.→)
- Maybe:
  Without a transformer, but in an ideal production environment and top technology (IRC, quartz, perfect envelope, ultrathin and strong filament)
- Not:
  At a competitive price, i.e. consumer price would be comparable to LEDs, and at a reasonable investment level.

Market: Industry sales *LightingEurope* Members



Market: LED projections industry

LightingEurope, projections LED market value share and prices

GLS 25-40-60-100W	**2012**	**2016**	**2017**	**2018**	**2019**	**2020**
Price (end user)	18 €	10 €	9 €	8.50 €	8 €	7.50 €
Market share LED	6%	15%	20%	30%	45%	60%

Note: Market share in value
Price LED 3-6 times higher than MV-HL--> smaller market volume %

Market: Sales and stock MV-HL retro (mln. units)

Year	ex-GLS free for MV-HL retrofit	MV-HL sales (66% EU industry)	MV-HL stock	MV-HL discarded (after 4 years)
2009	163	163	163	-
2010	191	191	354	-
2011	162	162	516	-
2012	234	234	**750**	-
2013	380	543	1130	163
2014	220	411	1350	191
2015		162	1350	162
2016		234	**1350**	234

Market: Keep Stage 6 (sales & stock in mln. units)

Year	sockets free for retrofit (ex MV-HL / ex Other)	LED retro sales (60%)	Other retro* sales (40%)	LED retro stock	Other retro* stock	Other retro discarded (after 2, 4, 12 yr)
2017	543	326	217	326	217	-
2018	411	247	164	573	382	-
2019	162	97	119	670	446	54
2020	234	140	135	810	540	41
2021	90	90	105	900	450	195
2022	90	90	72	990	360	162
2023	90	90	43	1080	270	133
2024	90	90	28	1170	180	118
2025	90	90	11	1260	90	101

*=CFL (20%), G9+adapter (10%), special purpose GLS (10%)

Market: Abolish Stage 6 (sales & stock in mln. units)

Year	sockets free for retrofit* ex MV-HL	MV-HL sales	LED retro sales	MV-HL stock	LED retro stock	MV-HL discarded after 4 years
2017	337	287	50	1300	50	337
2018	337	267	70	1230	120	337
2019	337	232	105	1125	225	337
2020	337	197	140	985	365	337
2021	287	117	170	815	535	287
2022	267	67	200	615	735	267
2023	232	14	218	397	953	232
2024	197	7	190	207	1143	197
2025	117	-	117	90	1260	117

*=longer term average, starting from 1350/4 = 337 mln. units replacement sale/year

Economics: Scenarios, assumptions

Impossible to make projections with certainty, because of long product life of LED (20 000 h → 40 years) and pace of efficacy improvement

Example:
Scenario **1**: *Keep Stage 6 (replace MV-HL over 2017-2020)*;
Scenario **2**: *Abolish Stage 6 (replace MV-HL over 2017-2025)*

Period 2017-ca. 2060. Start stock: 1350 mln. units MV-HL
MV-HL: 32W (400 lm), € 1.5/unit, 4 year stock life (2000h life, 500h/yr 'on')
LED average 2017-2020: 5 W (**80 lm/W**), € 8.5/unit, 40 year stock life
LED average 2017-2025: 4 W (**100 lm/W**), € 7/unit, 40 year stock life
Electricity rate: € 0.22 (start 2016, discount rate 4%, escalation rate 4%)

Economics: Scenarios (example 1)

1350 million LEDs

€ 8.50 — 5W (80 lm/W)

KEEP STAGE 6

Buy: 1.35 x 8.50 = € 11.47 bn

Use (over 2017-ca. 2060):
LED: 5 W x 500 h/yr x 40 yr = 100 kWh
--> x 0.22 € x 1.35 bn = € 29.7 bn
HL: 32W x 500 h/yr x 4 yr = 64 kWh
→ x 0.22 € x 0.675 bn = € 9.5 bn
Total electricity € 39.2 bn
Total Life Cycle Costs: **€ 50.8 bn**

1350 million LEDs

€ 7.00 — **4 W** (100 lm/W)

900 million MV-HLs Replacement sales

€ 1.50 — **32 W** (12.5 lm/W)

ABOLISH STAGE 6

Buy: 1.35 x 7 + 0.9 x 1.5 = € 10.8 bn

Use (over 2017-ca. 2060):
LED: 4 W x 500 h/yr x 40 yrs = 80 kWh
--> x 0.22 € x 1.35 bn = € 23.7 bn
HL: 32W x 500 h/yr x 9 yr = 144 kWh
→ x 0.22 € x 0.675 bn = € 21.4 bn
Total electricity € 45.1 bn
Total Life Cycle Costs: **€ 52.9 bn**

Economics: US DoE projections LEDs

LED metrics roadmap, US DoE 2012 MYPP[1]

Metric	Unit	2011	2012	2013	2015	2020
LED Package Efficacy (warm white)	lm/W	97	113	129	162	224
LED Package Price (warm white)	$/klm	12.5	7.9	5.1	2.3	0.7
LED Package Efficacy (cool white)	lm/W	135	150	164	190	235
LED Package Price (cool white)	$/klm	9	6	4	2	0.7
OEM Lamp Price	$/klm	33	23	16.5	10	5

Notes:
1. Projections for cool white packages assume CCT=4746, 7040K and CRI=70-80, while projections for warm white packages assume CCT=2580, 3710K and CRI=80-90
2. All efficacy projections assume measurements at 25°C with a drive current density of 35 A/cm2
3. Note that MYPP projections are based on price, not cost

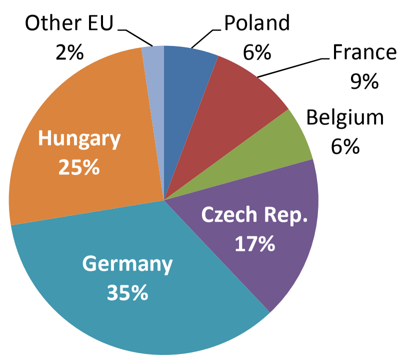
[1] US Department of Energy (DoE), EERE, Solid-State Lighting Research and Development: Multi-Year Program Plan, April 2012.

Environment: Scenarios

- Preparatory study (VITO 2009), roughly difference scenarios 2b and 2c: **5.5 TWh/yr** difference in 2020.
- Simple steady state scenario: Current MV-HL lamps (1350 million units) use 26.6 TWh/yr. A switch to 'Energy Class B' would save 25% → **6.65 TWh/yr.**
- Plausible scenario: Keeping Stage 6 will initially lead to a 60/20/10/10% mix of LED/CFL/G9+/Special GLS (see market scenario), which means an average of 16 W that will replace the 39.4 W MV-HL lamps over the 2016-2020 period → 10.8 TWh/year in 2020.

  Abolishing Stage 6 will lead to a more moderate LED introduction. At 50/50 LED/MV-HL in 2020 the electricity consumption will be 16 TWh/year in 2020. Overall this gives a difference of **5.2 TWh/yr** in 2020.
- Over a longer period till 2060 (see economics section), the LED 'lock in' effect (long product life prohibits application of more efficient LEDs or OLEDs), the difference becomes **less/negligible** and it may even be in favour of the abolishing Stage 6 from the environmental point of view.

Employment: MV-HL jobs EU



Negative effects Stage 6
- EU Production Jobs MV-HL : 3000
- EU Jobs jeopardized: 4350*

Positive effects Stage 6
- EU Jobs gained in alternatives to MV-HL (mainly trade): 500

Net employment effect Stage 6
- EU net job loss: 2500 - 3850 jobs
- Geographic distribution see fig.

**=industry indication, LightingEurope 2013*

Health: Alleged health concerns NDLS

Effect of:

- Ultraviolet (UV) radiation on skin and retina of healthy people
- Blue light and UV radiation on photosensitive patients
- Flicker of lamps on epilectics and people suffering from migraine
- Lighting on certain light-sensitive symptoms in some patients with e.g. chronic actinic dermatitis and solar urticarial
- Artificial (blue) light on the day-night rhytm
- Health effects related to the different light spectrum from artificial light

Health: Status quo scientific insight

SCENHIR (Scientific Committee on Emerging and Newly Identified Health Risk), Opinion of March 2012:

SCENHIR found no evidence of considerable risks for lamps (HL, CFL, LED) in normal situations

For patients exceptionally sensitive to UV and/or blue light exposure, there might be a risk from all light sources. For this group LEDs and double-envelope CFL and HL lamps are a solution.

On health risks of mercury exposure through breaking CFLs: SCER (Scientific Committee on Health and environmental risk) opinion 2010: Unlikely.

An update by the VHK-VITO study team found no new evidence that would contradict or modify the above conclusions.

Thank you!

Discussion..

ANNEX J: EMPLOYMENT IMPACTS (TRADE UNIONS, IMG)

From: Torsten Sundmacher, Sustain Consult for IGM (received 2nd version 17/5/2013)

Supplementing the study "Review study on the stage 6 requirements of Commission Regulation (EC) No 244/2009" – the view of employees and trade unions

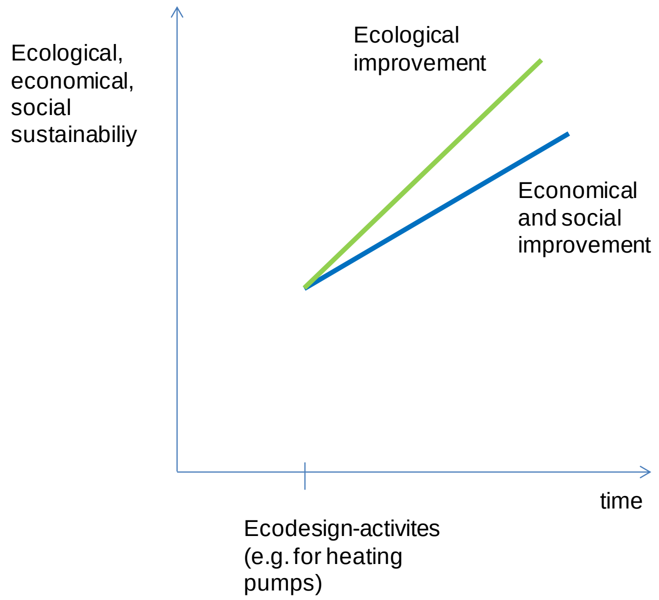
1 Preliminary Remarks

Works Councils and Labour Unions of the lamps and light industry seize the opportunity to accompany the debate on changes to the prohibition of halogen with their expertise. We consider this participation as an opportunity to lift and wave the banner and emphasize the fact that a good number of innovative jobs can be sustained in Europe without endangering the important objectives of the European Community, to save energy in the process. Accordingly, our proposals on supplementing the study also relates largely to the effect of employment and its impacts on the citizens and environment of the EU.

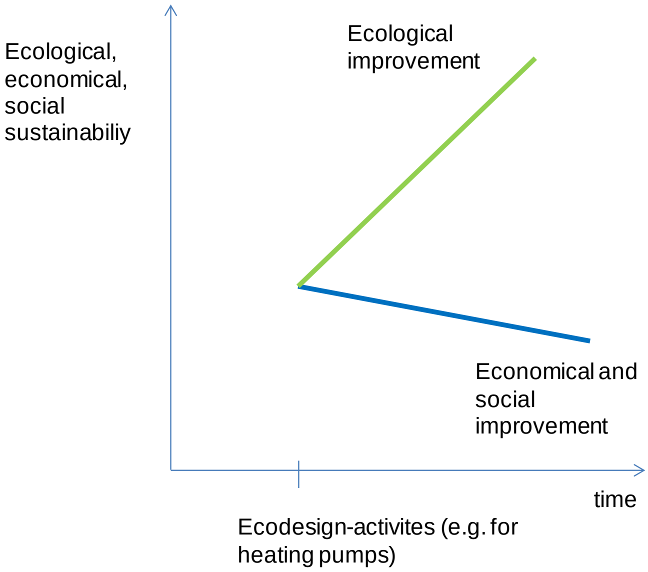
From our point of view, there are good reasons to reconsider the prohibition of halogen as from 2016. First, because this regulation with its intention to improve energy efficiency, will lead to the non-attainment of this objective because of a change to a premature LED technology that is yet undergoing fast development. This will cost private households money and at the same time, damage the environment. Secondly, the prohibition of halogen will lead to a huge loss of employment in spite of the related promotion of innovative technology because the new LED technology is largely manufactured outside Europe.

A double wrong impression may insofar emerge with a view to the prohibition of halogen:

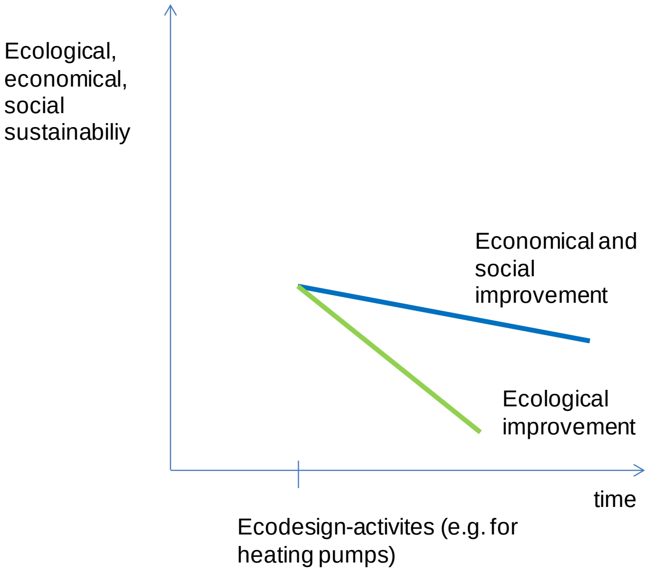
1. The promotion of ecological innovations often goes hand-in-hand with a strengthening of the European competitiveness because energy-saving products are highly ambitious and require European R&D and production know-how. There are numerous examples of this in the eco-design process of the EU. The following illustration shows the aligned improvement of sustainability of such a case.



2. A view of the impacts of halogen prohibition on employment illustrates that all-in-all, negative employment impacts and reduced economic prosperity should be expected in Europe – halogen prohibition can insofar, become one rare example in the eco-design process, of a trade-off between the pillars of sustainability.



3. A precise view of the negative impacts of a change to a less efficient (and more expensive) premature LED technology may uncover the fact that the ecological benefits of the halogen prohibition may turn to the reverse. The halogen lamp can be an environmentally-friendly transitional technology such that its prohibition may lead to a too early lock-in in an LED technology that is undergoing rapid improvements. There is insofar, no conflict in this case, between the pillars of sustainability – halogen prohibition may generally be a disadvantage.



Reconsidering the prohibition of halogen may help prevent the occurrence of such a result.

While the lock-in effect can be reduced by a wait-and-see approach instead of prohibition, the improvement of economic and social sustainability will require more than that: Even if the halogen lamp is not prohibited, market development will reduce production and employment within a foreseeable period. At the moment, there is no indication in major parts of the European lamp industry that losses of employment suffered by the decline of conventional lamp production can even come close to being compensated through LED production in the EU.

For this reason, we suggest taking advantage of the debate on halogen prohibition to promote expanding all LED-related production competences in the EU – trying to compensate the employment losses suffered in conventional lamp production. If this path is toed, it is possible that the impending prohibition of halogen may still be reasonably exploited to ensure that an upward development can be achieved for all pillars of sustainability.

2 Employment impact

2.1 Losses of employment through the prohibition of halogen

To determine losses of employment through the prohibition of halogen, the study assumes that European factories will shut down or reduce the number of employees. This will lead to permanent losses in employment.

The study contains two different approaches with different results from the point of view of employment impact:

The **estimation made by the project team of the study** is based largely on the known production facilities of halogen lamps. Some suppliers such as Bruntál and Turnhout[1] are mentioned but the number of employees of the suppliers is not ascertained. Rather, it is assumed for employees of the production locations that there are employees in the same amount at the supplier sites. The question if the loss of (high-voltage) halogen production leads to the abandonment of a site and to the shedding (or outsourcing) of the present activities is not discussed in respect of every location.

The data mentioned by **LightingEurope** takes internal but no further external suppliers into consideration. It is not clear, which locations were taken into consideration. How the shut-down of sites and the shedding of further activities are handled upon the prohibition of halogen is also not comprehensible.

We proceed with some methodical clarifications as follows to complement the present *modus operandi*.

[1] The location Turnhout in Belgium no longer supplies wire to Philips or other European halogen lamp production facilities.

In the first step, the number of employees was determined for all known locations that are directly linked with halogen (factories for lamps, burners, wires, and sockets). In this process, up to date figures were used as far as they were available.[2]

Estimation was made for every location to ascertain if the end of high-voltage halogen lamp production would lead to the shut-down of the site with further activities affected. This was assumed to be the case only for the location Eichstätt because an external purchase could be a cheaper alternative for the other products of the location than the sustenance of a small site or the outsourcing of products that are being phased out. The same applies to the location Molsheim – there is virtually no other production here in addition to the production of halogen. The shutdown of the (less significant) low-voltage halogen production can therefore also be expected when the production of high-voltage halogen is banned. The loss of the complete supply for halogen was therefore assumed for the supplying sites of OSRAM. In other sites, only the proportion of employment for high-voltage halogen lamps was taken into consideration as far as possible.

Attention was also paid to other special supplies beyond lamp manufacturers – this affects particularly sockets or socket parts. Here too, the proportion of employees manufacturing high-voltage halogen products was determined. Precise analysis of these supply structures was however possible only in Germany and parts of Italy – these data were not available for other European countries (particularly not for the production of halogen lamps in Hungary).

The precise listing of the number of employees and comments on methodical and data shows the following overview:

[2] Given the planning made by the two big halogen lamp producers OSRAM and Philips (which fits into the market scenarios used in the study), it can be assumed that the production of halogen lamps will rise clearly within the next two years through the new construction/putting into operation of further lines and a boost in employment by approximately 5% can be expected. A similar situation can also be expected for supply. Such a boot was not taken into account here.

Country	Company	Location	Job Description	Employees: Halogen production	Employees: Direct delivery	Remarks
Germany	Philips	Aachen	Production of halogen burners, coating	270		Only part of location is affected and taken into consideration here
	Glas Frings	Baesweiler	Quartz glass production, glass bulbs		100	Philips is by and large the only customer, complete location to be taken into consideration
	Osram	Eichstätt	Production of halogen burners, coating	700		Complete location affected: Location likely to be given up, because it is too small without halogen (approx. 300 MA) and other products such as HQI are running down, external procurement likely in this case
		Schwabmünchen	Production of wire		80	Only part of location is affected; complete production for halogen (High and low voltage) taken into consideration (see explanation for Eichstätt)
		Augsburg	Quartz glass production, glass bulbs, production of bases		120	Only part of location affected; complete production for halogen (high and low voltage) taken into consideration (see explanation for Eichstätt); Can't be ruled out that the entire glass works (250 employees) will be affected through merger with the glass works of Berlin
	BJB	Ansberg	Production of halogen sockets		25	Only part of location affected; only high voltage halogen taken into consideration
	VosslohSchwabe	Lüdenscheidt	Production of halogen sockets		50	Only part of location affected; only high voltage halogen taken into consideration
Poland	Philips	Pabianice, Pila	Production of halogen lamps with burners from Aachen	280		Only part of location affected; only high voltage halogen taken into consideration
France	Osram	Mohlsheim	Production of halogen lamps with burners from Eichstädt	320		Complete location affected (basically, no further production)
	Dr. Fischer	Pont à Mousson	Production of halogen lamps	60		Only part of location affected; only high voltage halogen taken into consideration
Belgium	Havells Sylvania	Tienen	Production of halogen lamps	200		Only part of location affected; only high voltage halogen taken into consideration
Czech Republic	Osram	Bruntál	Production of coils		70	Only part of location affected; Production for halogen (high and low voltage) taken into consideration (see explanation for Eichstätt); only a share of the production that is sold in the EU is taken into consideration
	???	???	???		680	According to the list Lighting Europe (a total of 750 for the Czech Republic)
Hungary	GE	Budapest, Gyöngyös, Nagykanizsa oder Vác	Burners and lamps	1.100		According to the list Lighting Europe

Table 1: The direct impact on employment, of halogen production and direct supply

According to this estimation, about 4,200 employees will be affected in production and direct supply if high-voltage halogen production is lost (direct impact on employees).

It is known from different investigations in other sectors that this direct impact on employment is often clearly smaller than the indirect impact on employment. First, this indirect employment impact of high-voltage halogen production results from the loss of purchase volume of the sites mentioned above. For example, the purchase of repair and maintenance services, catering services or machineries falls accordingly. This leads to a drop in employment figures in these sectors and their purchase volume is reduced with the respective second round effects, etc. Secondly, the income of those that are no longer employed drops. The drop in income leads to a fall in the purchasing volume of those that were previously employed. This reduced purchasing volume leading to a second negative employment impact.

These two general forms of indirect employment effect are methodically shaped in various studies and applied in detail in a different manner. The following overview of studies that are known to us shows a specific range in the determination of such indirect employment impact. The decisive factors in the process however are not the methodical differences: the studies of “Sustain Consult” and “Pestel Institute” were always conducted with widely identical methods respectively. Also, the line of business does not have to be a decisive criterion – thus a cement plant (study No. 5), a theme park (study No. 10) and a municipal utility all have a factor of indirect employment around 2. On the contrary, the precise situation of the respective company is decisive – locations with a very high depth of own value-adding and very low level of outsourcing (study No. 6 in the overview is an example in this respect) show low factors for indirect employees. Accordingly, locations with very low own value-adding (study No. 12 is an example of this) achieve a high ratio.

No.	Consultant	Sector, Characterization	Year	Method
1	Forecast	Mining	2007	including impact of purchasing power
2	Forecast	Lignite-based power production	2011	including impact of purchasing power
3	RWI	Exploitation of lignite	2000	including impact of purchasing power
4	Sustain Consult	Cement works	2001	excluding the impact of purchasing power
5	Sustain Consult	Lime works big	2002	excluding the impact of purchasing power
6	Sustain Consult	Lime works medium-sized	2005	excluding the impact of purchasing power, including investments
7	Sustain Consult	Limeworks small	2003/2005	excluding the impact of purchasing power
8	Sustain Consult	Lime works very small	2001	excluding the impact of purchasing power
9	Sustain Consult	Factory for firebricks	2005	excluding the impact of purchasing power, including investments
10	RWI	Theme park	2003	including impact of purchasing power
11	RWI	Industrial park	2003	including impact of purchasing power
12	Pestel Institut	Small Public Utilities, other services	2013	including impact of purchasing power and furtehr induced impacts
13	Pestel Institut	Medium-sized Public Utilities, a few own generations	2012	including impact of purchasing power and furtehr induced impacts
14	Pestel Institut	Big Public Utilities, own generation	2012	including impact of purchasing power and furtehr induced impacts
	Average			

Table 2: Overview of studies on in indirect employment impacts

In the meantime, it can be assumed that the level of outsourcing is relatively high for halogen lamp production with the exception of intra-group supply. Larger parts of employment-intensive services (repair and maintenance, canteens, cleaning and partly logistics) are thus outsourced. It can insofar be assumed that the factors of indirect employment impact is clearly higher than 2. Since, for reasons of time and competition, the investigation of a higher number of major locations that would have been necessary in the face of the scattering of the factors also for companies with very similar activities (compare No. 4-8 or No. 12-14) is not possible, the usage of the simple average of the studies presented above offers an initial evidence.

This factor amounting to 2.4 can however not be applied on the overall employment impact because the employees of some suppliers (glass, wire, sockets) have already been taken into consideration for halogen lamp production. For this reason, as the following overview indicates, the factor will be first used on employees at supplier sites (1,175 direct employees, see table 1). Secondly, it will be used to determine the indirect employees at production sites by a downward correction of the figure determined, by the number of direct suppliers (2851 employees, see table 2) that have already been taken into consideration. At the Molsheim site, the direct employees of the Eichstätt “supplier” were subtracted from the determined indirect employees in the high-voltage halogen production (approx. 200 employees), because an essential part of the production in Molshein uses burners from Eichstätt, and otherwise it would result in a double-count.

Indirect negative employment impact	
Factor	2,4
Indirect employment impact on delivery	2.851
Indirect employment impact on production gross	7.254
Indirect employment impact on production net (excluding delivery that has already been taken into consideration)	4.403
Total sum of indirect negative employment impact	**7.254**
Total sum of direct negative employment impact	**4.165**
Total sum of overall negative employment impact	**11.419**

Table 3: Calculation of direct and indirect negative employment impacts

According to this estimation, adding direct and indirect employment impacts together results in an overall employment impact of about 11,200 employees as a result of a prohibition of halogen.

2.2 Employment gains through LED?

The employment losses described above resulting from the prohibition of halogen can be compared with employment gains particularly through production associated with LED. Four sites are mentioned and discussed in the study in this respect.

Given the scope of employment in **OSRAM Regensburg,** it is argued that the prohibition of halogen will lead to employment gains through the stronger sale of LED. It is assumed that one-third of about 1,000 currently employed workforces in the LED production will be additionally created at the Regensburg site. Indeed, LED wafer production in Regensburg is used almost exclusively for special applications and not for application in the area of general lighting. These special applications include e.g. laser, medical technology applications, visual sensors and IR applications. The high quality level (and the respectively high prices) of the products in Regensburg render it highly improbable that this location will profit from the expansion of LED sale in the face of halogen prohibition. This example should insofar, be deleted from the list of possible employment gains.

At the end of 2012, **Optagon** in Landshut had approximately 40 employees. Since December 2012, the company has been undergoing insolvency because the Russian proprietor has withdrawn production and will purchase LED chips in Asia in the future. Even the production model Optagon with its high-quality chips that were supposed to be produced here (with state subvention) does not seem to be sustainable – it should be more so even impossible for standard chips meant for general lighting. This case is insofar, a counter-example of employment gain due to the production of LED for general lighting and should also be deleted accordingly.

A third example mentioned in the study relates to employment impacts of **manufacturing systems engineering for LED production**. Aixtron is mentioned as an example of a European company specialised in the MOVPE technology (producing III-V-compound semiconductor like GaN used in LED). Positive employment impacts of LED systems engineering is definitely possible even if numerous usable competences for machinery building particularly in the area of semiconductor handling and assembly/mounting are already available. Competent providers of these facilities can be found particularly at the centre of gravity of the semiconductor industry – Japan and Taiwan are for instance, centres of the semiconductor systems engineering. It can therefore be assumed that Europe will not necessarily be the focal point of LED systems engineering.

This employment gain of LED manufacturing systems engineering in Europe (especially concerning the MOVPE technology) have however to be compared to a loss of employees in halogen systems engineering. As opposed to LED systems engineering, the machinery required for LED production are very specific. For that reason there are hardly standard solutions available in the market. Therefore, manufacturing systems engineering for conventional lamps belongs to core competences particularly for OSRAM – there is an own highly specialized manufacturing systems engineering within the group. The employment gains that may be realized only in parts in Europe with the less product-specific LED systems engineering will stand out against the employment losses in Europe, of highly specialized halogen systems engineering. These were not factored into the losses of employees in Chapter 2.1. A negative net employment impact can be expected – however, it cannot be quantified in the face of the uncertain share of European LED machines. This example of a positive employment impact shall thus be discussed in more details in the study or shall be deleted.

Altogether, the production facility of Havells Sylvania in Tienen with a production gain of 150 employees will be left on the list of examples with positive employment impacts. It has generally, not been ruled out that other lamp manufacturers will equally establish such an LED production facility in Europe. However, there have already been such productions in Europe with some manufacturers, in which LED was produced with a low level of automation before they were transferred to Asia with the start of mass production. The existence of the production of LED in Tienen at the moment must insofar, not necessarily mean a permanent employment gain.

If the 150 employees are rated as employment gain, the factor of indirect employment impact shall also be applied in this case. **Added together, employment losses and gains will thus result in a net employment loss of about 10,700 employees (see table 4).**

Factor	2,4
Indirect employment impact on delivery	2.851
Indirect employment impact on production gross	7.254
Indirect employment impact on production net (excluding delivery that has already been taken into c	4.203
Total sum of indirect negative employment impact	**7.054**
Total sum of direct negative employment impact	**4.165**
Total sum of overall negative employment impact	**11.219**

Table 4: Calculation of net employee effects

2.3 Recommendation

The part of the study that deals with the possible employment impacts of LED production should be adjusted by deleting the non-applicable examples accordingly.

The figures on negative direct and indirect employment impacts may be complemented in the study at the respective positions (at the end of Chapter 5.2) and the precise calculation attached as Annex. The above text may serve as basis.

3 Prohibition of halogen and savings by private households?

3.1 Alternative scenario on the estimation of savings by private households as a result of the prohibition of halogen coming from electricity consumption and ‘costs of investment’

3.1.1 Explanation

Savings potential by private households as a result of the prohibition of halogen is estimated in the study. In the estimation, the savings derive from reduced electricity consumption[3] as well as reduced ‘costs of investment’ of the lamps given the long service life of the LED (40 years at assumed 20,000 hours and annual usage of 500 hours). Another part of the study draws attention to the fact that halogen lamps are preferably used in sockets with low operating hours (200-300 h). An estimation of the saving potential can insofar, also use this lower value. Moreover, the service life assumption of 40 years for LED is rather unlikely. At least, operating hours particularly at low annual switch-on times cannot translate into service life without much ado. Opposing facts (that are admittedly not easy to measure) are impacts such as premature scrapping e.g. for reasons of fashion (particularly in the case of LED fixend in luminaires), diminishing brightness, colour changes in light, more efficient successor products or the combination of the LED with other technical features (such as wireless control options integrated in the base). The aging of structural components without operation (particularly organic compounds such as adhesives or parts of electronic systems) also speaks against a service life of 40 years. Also, the standard plastic bulbs typically used display some marked decolouration (e.g. yellowing) after a few years in practical use, which can lead to premature replacement, too.

Tables 5 and 6 show two alternative scenarios of calculating the cost effects of private households from electricity savings and investment that are calculated on the basis of a service life of 10 years respectively as well as 200 hours or 300 hours annual usage duration.[4] It can be seen that the high-voltage halogen in the present construction form (without adapter) is the cheapest solution at assumed annual usage duration of 200 hours. At 300 hours, this is not the case if the respective lower prices are applied and vice versa if the upper prices are applied. Normally used light bulbs made from standard plastic, under conditions of use after a few years, also exhibit distinct changes in colour (e.g., yellowing) – and this, too, can lead to premature exchanging.

---

[3] As far as we see, the calculation of the electricity consumption of LED doesn’t take the expected power corrected for control gear losses of LED drivers into consideration. Particularly if “no name” brands are imported, it should be expected that performance factors >0.9 are operated and lead to system load and additional electricity consumption through the occurrence of idle power. The actual electricity consumption of LED can insofar end up being higher than anticipated.

[4] All other assumptions of the study (compare p. 20 there) remain the same.

Duration of burning 200 h / year Service life 10 years Electricity costs 0,18 € / kWh						Lower price limit			Upper price limit		
	Watt	Operating hours	Lower price limit	Upper price limit	Extra	Costs Investm	Costs Operation	Total	Costs Investm	Costs Operation	Total
LED	8	20.000	13	18		1,30	0,43	**1,73**	1,80	0,43	**2,23**
HAL	32	2.000	1,5	2,95		0,23	1,73	**1,95**	0,44	1,73	**2,17**
HAL Adapter	32	2.000	1,5	2,95	6	0,83	1,73	**2,55**	1,04	1,73	**2,77**

Table 5: Cost effect for private households through electricity consumption and 'costs of investment'; annual operating time 200 hours

Duration of burning 300 h / year Service life 10 years Electricity costs 0,18 € / kWh						Lower price limit			Upper price limit		
	Watt	Operating hours	Lower price limit	Upper price limit	Extra	Costs Investm	Costs Operation	Total	Costs Investm	Costs Operation	Total
LED	8	20.000	13	18		1,30	0,29	**1,59**	1,80	0,29	**2,09**
HAL	32	2.000	1,5	2,95		0,15	1,15	**1,30**	0,30	1,15	**1,45**
HAL Adapter	32	2.000	1,5	2,95	6	0,75	1,15	**1,90**	0,90	1,15	**2,05**

Table 6: Cost effect for private households through electricity consumption and 'costs of investment'; annual operating time 300 hours

It can insofar not be assumed in both scenarios that the prohibition of halogen will be a relief to private households – on the contrary, it is quite possible that halogen prohibition may result in additional burdens on private households through electricity consumption and costs of investment, particularly in the typical areas of application of halogen lamps (e.g. in sockets with low annual operating time and in decorative applications with relatively fast, fashionable wearing of the lamps).

3.1.2 Recommendation

The authors of the study highlight the fact that the estimation made by them has the character of a mere orientation and the calculation made is therefore meant to underscore the dimension of the impact. Since however only the result of saving is documented in the study – and this result could form the basis of the arguments advanced in next discussions – attention should, at least, be drawn to a plausible alternative scenario in an Annex.

3.2 *Complementation of the estimation of impacts on private households through halogen prohibition: Loss of tax earnings and additional payments on social security*

3.2.1 Explanation

Should (negative) employment impacts occur through halogen prohibition, they will create further impacts on private households in addition to changes in the cost of electricity and investment. If there is a net loss of jobs, they will no longer be available in the EU. At an unemployment ratio greater than zero at the initial situation, unemployment figures will rise accordingly in a sustained manner, through the prohibition of halogen. If additional jobs are created in the EU in the aftermath of the prohibition of halogen, the rate of unemployment would drop – it would however drop to a lower value if the prohibition of halogen had not previously risen the rate. It is possible (and in fact, even probable) at the level of the individually affected employees that the well-trained employees of halogen production will find a new job within a relatively short period. They will either displace an employee in their new job, who will then end up being unemployed in their stead, or they take up a job for which an unemployed person would have been employed. In both cases, finding a new job at the level of individuals will not change a thing in the fact that the loss of employment through the prohibition of halogen will lead to a situation of sustained higher unemployment than a situation without prohibition would have led to – in the process, the individual situation of the employees of halogen production is irrelevant to this consideration. Correspondingly, a halogen prohibition, as opposed to the situation without a halogen prohibition, leads to a long-term shedding of approx. 10,000 jobs (see Figure 1) – independently of how the number of jobs otherwise develops. At the same time, with existing unemployment, the number of unemployed will increase by the same amount.[5]

[5] A conceivable exception thereto could arise if the accruing unemployed should reduce the matching-problem of the labour market. In all European labour markets, it is to be observed that unemployment and open positions arise simultaneously, because, e.g., the qualifications of those seeking work do not fit the open positions. Now, if the additional (accruing) unemployed were, in part, to occupy the unfilled open positions (which cannot be filled by the unemployed), it would not result in an increase in unemployment. However, in opposition to this unemployment-reducing effect is the fact that with a displacement of a person previously employed by an accruing unemployed person from the lamp industry, the opposite effect can occur. The displaced employed person has, presumably, a lower level of qualification as the one who has displaced him (otherwise, the displacement would have not taken place in the presence of price equality of the work factor, due to wage agreements). This newly unemployed person, with his lower qualification, is difficult to place in the labour market and probably makes a poor fit to the demand for labour/to open positions. In this respect, this process of displacement can lead to an increase of the mismatch in the labour market. Both effects can occur, without both effects being able to be quantified. Alongside the qualification level, the situation in the (local) labour market is an essential factor for the direction of the mismatch effect. But as it is impossible to weight this factor for the affected locations, the mismatch effect was generally not considered here.

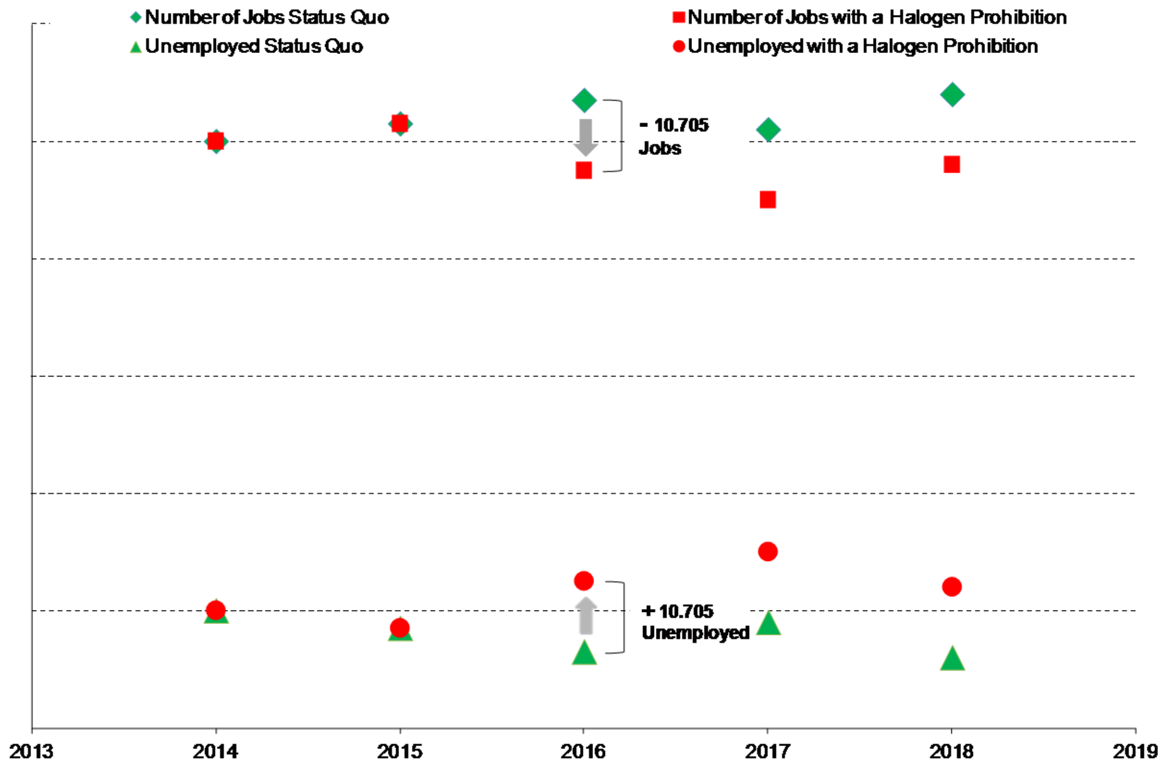


Fig. 1: Example of Development of Jobs and Unemployed with and without a Halogen Prohibition

The sustained high unemployment figures (as opposed to what it would have been without halogen prohibition) will be noticed in two ways: first, tax earnings will drop and secondly public expenditure on unemployment insurance or for a guaranteed minimum income for livelihood will increase. Moreover, reduced corporate income tax can be considered on the revenue side. The sale of LED is presently a subsidy business for many lamp producers while the production of halogen lamps is very profitable such that it may lead to reduced income from the taxation of capital. Furthermore, severance payments lead to a reduction in profits in the lamp industry.

The effect of purchasing power can also be considered: The reduced income of additional unemployed persons will lead to reduced spending, which in turn, also leads to reduced employment (e.g. with a food dealer). This also leads to the effect of taxes and expenditures as described above. The estimation of such effect of purchasing power is not quite easy because reduced income usually goes hand-in-hand with a growing rate of consumption, which partially compensates the effect of falling income. Since European data regarding this effect are not available without much ado, an estimation of this effect was waived. The cost effect on private households as estimated here by the loss of employment is insofar lesser than what is to be expected ‘in real life’.

Reduced tax incomes and rising expenditures for the additional unemployed lead to tax increases – at constant performance level of the state and social security systems – which in turn, means additional burden on private households!

3.2.2 Income losses

As far as possible, the estimation of income tax losses through additional unemployment uses specific values of EU countries affected by the prohibition of halogen. Average wages that are subject to tax and social security charges were ascertained for such countries and multiplied by the country-specific rate of tax and social security charges (compare table 8).[6]

These incomes are multiplied by the number of employees affected by halogen prohibition. In the process, the supplier structure – if known – is apportioned to the country that makes the focal point of supply activities.[7]

	Gross earning of the year 2007 (PL, CZ: 2006)	Growth rate Net earning 2007-2011	Projected gross earning of the year 2011	Ratio of tax and social security payments 2011 in %
BE	38.659	11,8%	43.212	44,0
CZ	8.284	42,3%	11.787	35,3
DE	40.200	8,6%	43.646	37,1
FR	32.413	12,2%	36.379	44,2
IT	37.091	12,5%	41.727	42,9
HU	8.952	3,7%	9.284	26,8
PL	8.178	22,4%	10.010	22,5
SK	8.400	35,4%	11.374	22,9

Table 7: Base data for the estimation of the income losses through additional unemployed (source: OECD, EUROSTAT)

Table 8 shows that a total of €99,5 million is to be expected in reduced annual state income following the additional number of unemployed.

---

[6] Since gross salaries were available only until the year 2006 or 2007, the values for 2011 were derived with the aid of net salary escalation. No figures were available on gross salaries for Italy. The average of the countries France, Belgium and Germany was assumed in this case.

[7] All German suppliers are assumed to deliver exclusively to German production and additionally to the location Bruntál. In this case, this reduces the number of further indirect employees taken into consideration. The other suppliers of the Czech Republic and Italy are taken into consideration in halogen production in Hungary because it is not known that these factories make deliveries to the two German halogen production sites.

	Net employment impact including indirect employees	Loss of earning: taxes and social security payments in million € yearly
BE	171	3,3
CZ	2.570	10,7
DE	3.528	57,1
FR	1.102	17,7
IT	171	3,1
HU	1.998	5,0
PL	959	2,2
SK	206	0,5
Summe	**10.705**	**99,5**

Table 8: Estimation of income losses through additional unemployed

Reduced capital taxation through reduced corporate profit is estimated as follows. EU-wide effective tax obligation on capital (including land taxes etc.) is approximately 25% (compare www.jarass.com/jarass.de/dat/pub/0904/KapitalbesteuerungDeutschlandEuropa.pdf).
Corporate profit in halogen production is derived from the turnover of €200 million in the EU as estimated in the study.[8] Turnover profit of 8% was assumed for halogen production and this should be presumably higher in reality rather than lesser. Turnover profit of 0% is assumed for the sale of LED – current turnover profit should be lesser in this case. The cautious estimation made in both directions uncover a **loss of corporate earning tax amounting to a minimum of €4 million per annum** – compared with income tax losses, this is a comparably small state income loss.

In all European countries, regulations exist pertaining to compensation settlements for employees affected by lay-offs. These severance payments represent additional costs for the company. Due to the market situation, with shrinking quantities in the traditional lamp business and with great competitive pressure from the LED, it is not to be expected that these increases in costs can be passed along to consumers. Rather, these costs are likely to depress profits and thereby revenues from taxes on profits as well.

In Table 9, the costs to be expected due to severance payments are estimated. In so doing, the statutory minimum rates are presumed. The actual severance payments can be proportionately greater. Also not considered are additional restructuring costs (e.g., due to

8 Actually, the revenue is likely to be higher by incorporation of suppliers; due to lack of relevant data we are using the value from the study as the lowest estimate.

relocation or selling of facilities), because no reliable information is at hand for this for the relevant locations.

	Net employment effects incl. indirect employees	Extrapolated gross annual earnings 2011	Severance Rates (Months)	Severances (€)	Calculated Severance Payments	Assumptions
BE	171	43.212	18,4	11.325.636	Clay Formula: (Years of employment with the company x 0.88) + (age x 0.06) + (gross annual compensation incl. all extra performance/1000 x 0.03) - 1	Employment with the company (average DE, FR): 17.8 years, Age: 40 years
CZ	2.570	11.787	3	7.571.433	3 months' wages	
DE	3.528	43.646	8,5	109.085.187	Minimum of 0.5 months' wage per year of employment with the company	Average employment with the company in Eichstätt/Aachen: 17 years
FR	1.102	36.379	4,4	14.586.885	1/10 months' wages per year + 1/15 months' wages for more than 10 years; doubling for lay-off due to economic reasons	Employment with the company at Molsheim: 18.5 years
IT	171	41.727	17,8	10.602.701	1 month's wages per year of employment with the company	Employment with the company (average Germany, France): 17.8 years
HU	1.998	9.284	1	1.545.478	1 month's wages after three years of employment with the company	
PL	959	10.010	2	1.600.477	Mean Value: 1 month's wages for employment with the company < 2 years; 2 months' wages for employment with the company of 2-8 years; 3 months' wages for employment with the company > 8 years	
SK	206	11.374	2,5	487.084	Average: 2 months' wages; for more than 5 years of employment with the company, 3 months' wages	
Sum				**156.804.881**		
Per Year (14-year period)				**11.200.349**		
Of which: taxes on capital				**2.800.087**		

Table 9: Estimate of Drop in Revenue Due to Profit-reducing Severance Agreements

The gross earnings (converted to monthly earnings) are multiplied with the net number ***of*** employees and with the severance rates in months. The entire severance sum thereby resulting is – because it concerns a one-time cost position – divided by 14 into the period under consideration. This period emerges, correspondingly, through the study's assumption that after this time, from the point in time of the halogen prohibition, all halogen lamps will have been replaced and also the LED substitute – with the lifespan of 10 years imputed here – will have arrived at the end of its lifespan.

The average annual burden, in accordance with the assumptions, reduces the annual profit of the lamp industry, so that for an average taxation on capital in the European Union, an **annual drop in taxes of approximately €2.8 million results**.

3.2.3 Increases in spending

Support payments for additional unemployed should be considered on the side of additional expenses. Initially, unemployment benefit is paid by the European countries affected by loss of employment. The duration of receipt and amount received vary from country to country and often also within the same country. For instance, the amount of benefit received often drops the longer it is received. Relevant cases were ascertained for the countries affected by halogen prohibition respectively and averages determined for the cases to facilitate the estimation of the actual costs; Table 10 shows the breakdown of the data.

Country	Individual regulations / Cases				Average values applied
CZ	Duration of support	5	8	11	8 months
	Share of net income	65 %		2 months	
		50 %		2 months	
		45 %		4 months	51 %
PL	Share of basic suppoı	80%	100%	120%	
	Duration of support	6	12		9 months
	Support	717 Zloti		2 months	
		563 Zloti		7 months	1720 € / Year
HU	Duration of support	1	3		2 months
	Share of net income	60 %			60 %
IT	Duration of support	8	12		10 months
	Share of net income	60 %		6 months	
		50 %		2 months	
		40 %		2 months	54 %
BE	Duration of support	unlimited, Assumed: 10 years			120 months
	Share of net income	60 %		12 months	
		44 %		3 months	
		35 %		105 months	38 %
FR	Duration of support	24	36		30 months
	Share of net income				57 %
SK	Duration of support	6			6 months
	Share of net income	50 %			50 %
DE	Duration of support	6	12		9 months
	Share of net income	60 %		67 %	64 %

Table 10: Basic data of the annual costs of unemployment insurance through halogen prohibition; Source: EU

(http://ec.europa.eu/eures/main.jsp?catId=8991&acro=living&lang=de&parentId=7839&countryId=CZ&living)

With the exception of Poland, the payment of unemployment insurance depends on the amount of income prior to unemployment. The approved rates are multiplied accordingly, by the gross salaries and the duration of receipt.

Following the expiration of support from unemployment insurances, a system of guaranteed minimum income sets-in in all European countries affected.

It is assumed in this case that the additional unemployed will remain unemployed throughout the entire period. Should a heretofore unemployed person be replaced with a heretofore employed person, the overall expenses will be higher because the periods for which unemployment insurance (usually pays a higher amount) will be extended while the lower payments of the guaranteed minimum income system will be reduced. This is accordingly, a cautious estimation.

The systems of guaranteed minimum income are not uniformed in the EU and partly within the countries – in Italy, there are regional differences and in the Czech Republic, the guaranteed minimum income is determined on individual basis. The average value of comparable countries is used in these two cases. The system of guaranteed minimum income is based on the need of the affected party in such a way that different amounts are paid particularly in accordance with the family situation. To estimate the costs of the system of guaranteed minimum income, the average of three typical cases (single, couples without children, and couples with 2 children) was determined (compare table 11).

	BE	DE	FR	IT	PL	SK	CZ	HU
Single	1.036	624	475	712		60,5		
Married couple	1.347	1.024	771	1.047		105,2		
Couple 2 children	1.804	1.612	997	1.471		157,6		
Average	**1.396**	**1.087**	**748**	**1.077**	**102**	**108**	**105**	**106**
Remarks	Including rent	Including rent		Different regional regulations, family and povertry payment (poverta), minimum rent system; Average of BE, DE, FR used			Determined individually; Average of Pl, HU, SK used	

Table 11: Basic data on the monthly costs of guaranteed minimum income through halogen prohibition, Source: EU *(http://www.missoc.org/MISSOC/INFORMATIONBASE/COMPARATIVETABLES/MISSOCDATABASE/comparativeTableSearch_de.jsp)*

Table 12 shows expenses through unemployment insurance and subsequent guaranteed minimum income. Again, a review period of 14 years was assumed. According to the assumption of the study, this was derived from the fact that after this period, beginning from the point in time of halogen prohibition, all halogen lamps have been replaced and the LED substitute – based on the service life of 10 years assumed in this case – has reached the end of its service life. The costs were thus calculated through the unemployment insurance in accordance with the respective duration of the receipt of benefit and subsequently, the costs of guaranteed minimum income for the remaining period.

	Costs of unemployment insurance in million €	Costs of minimum insurance for 14 years minus the duration of receipt of unemployment benefit in million €	Annual average costs (related to a period of 14 years)
BE	38,3	0	2,7
CZ	7,3	43,3	3,6
DE	73,3	609,6	48,8
FR	57,5	113,7	12,2
IT	3,2	29,1	2,3
HU	1,9	16,9	1,3
PL	1,2	15,6	1,2
SK	0,5	3,6	0,3
Summe	**186**	**850**	**74,0**

Table 12: Costs of unemployment insurance and guaranteed minimum income through halogen prohibition

Table 12 shows that in relation to the 14-year period of review, the annual costs incurred through unemployment insurance and guaranteed minimum income amount to about €74 million.

3.2.3.1 Conclusions

Put together, the effects taken into consideration here will result in the picture presented in table 13: the effects through loss of tax earnings and expenditures on the additional unemployed makes up a total of about €180 Mio. per annum. This is the magnitude of additional burden exerted on private households in the EU by higher taxes or reduction of benefits by the state. In comparison, the savings calculated in the study (figures from the presentation of the stakeholder meeting) make up just €48 million per annum through reduced costs of electricity and investment. If (as shown in Chapter 3.1.1) a lesser burning duration of the lamps and a reduced service life of the LED in calendar years is assumed, only the burden on private households resulting from halogen prohibition will be left.

	Milion € / Year
Income tax lost	100
Capital tax lost	7
Costs of unemployment insurance and guaranteed minimum income	74
Total	**180**
For comparison: savings calculated in the study (presentation) through Electricity and Investment	48

Table 13: Estimation of effects through the rise of unemployment in the aftermath of halogen prohibition

Even if saving effects through the reduced costs of electricity and investments as calculated in the study endure, the annual effects of burden exerted by the additional unemployed are almost four times as much.

It is however also possible that the burden exerted by the additional unemployed occur purely through a market decision against halogen lamps without the prohibition of halogen. Should, as for instance, assumed in the study, the sale of halogen lamps in the EU tend towards zero in the year 2024 (i.e. 7 years after the potential prohibition of halogen) in the aftermath of poor demand, burden will in any case, be exerted at this point in time, through the additional unemployed. At best, savings of €180 million per annum * 7 years = €1.3 billion would be expected accordingly if the prohibition of halogen does not take hold.

On the other hand, it can be argued that the savings will accrue for the entire service life of the LED through electricity and investments in such a way that savings of €48 million * 44 years = €2.1 billion would be realized.

However, the subsequent diffusion of LED at a later period – in the face of the rising efficiency of LED, its plummeting price and its long durability – would lead to stronger savings for private households than a change that would be effected now. Accordingly, the loss of saving through a late change must be set-off against the savings impact of electricity and investments in the aftermath of the change to LED as triggered by the prohibition of halogen. This effect of lost savings (resulting from the doubling of efficiency and the cutting of the price of LED by half until 2020) may be clearly higher than the savings that the prohibition of halogen would trigger. It is insofar not reasonable to exclusively consider (gross) savings realized through the change from LED to halogen through a period of 44 years given this lock-in effect of a (too) premature change to LED. On the contrary, (net) savings including lost savings must be considered through the lock-in effect, which can also be clearly negative depending on the assumed LED development.

Burden exerted by the rise of unemployment that can be temporally limited through the market development of halogen lamps have to be seen against further burden from the costs of electricity consumption and investments that have been triggered by a too premature change to the expensive and far less efficient LED.

The halogen lamp can insofar, be seen as a transitional technology that offers the LED more time for further development and helps prevent a too premature change. In any case, unemployment can be reduced without prohibiting halogen. An annual burden of €180 million on private households can thus be prevented – at least for as long as there is demand for halogen lamps in the market. Accordingly, the retention of every job will help save about €16,500 each year for the affected states.

3.2.4 Recommendation

The estimation of the economic consequences of additional unemployment in the form of additional yearly burden on private households (through tax increases or reduction of benefits by the state) should be included in the study as annex.

The summarized results of this estimation should be complemented on the basis of Chapter 3.2.1.3 of this report where the economic effects are discussed in the study (Chapter 3.2).

4 Appendix: Plausibility Check of the Number of Indirect Employees

A possibility for making the estimated factor for the employment effect (including the factor for the indirect employees) plausible consists of converting the determined total employment effects into wage costs. In this manner, the entire input (e.g. materials) is actually converted into wage costs. The sum resulting ought not to be larger than the revenue, because there are also profits and interest costs in addition to these “total wage costs” (direct (real) wage costs and converted input costs).

If this calculation is carried out, “total wage costs” result in the amount of approximately €270 million. This amount is higher than the study’s imputed halogen turnover in the EU in the amount of €200 million. However, in the €270 million “total wage costs” approximately €60 million of “total wage costs” are contained which do not originate in the halogen production. Rather, it was argued that at the Eichstätt site, with a halogen prohibition the production of additional lamps will be given up, and the location will close. The employment effects from the lamp production beyond the halogen lamp and the “total wage costs” tied to it must, therefore, be deducted from the calculated €270 million total wage costs. **Consequently, approximately 210 million in total wages costs for the halogen production result.**

This amount conforms quite well to the assumed 200 million of turnover with halogen lamps in the EU, especially since (small) parts of the workforce taken into consideration work for the export business, which is not taken into consideration in the EU turnover.

	Extrapolated Gross Annual Earnings 2011	Net Effect on Employment Including Indirectly Employed	Wage Costs (€)	Note
BE	43.212	171	7.402.234	
CZ	11.787	2.570	30.285.731	
DE	43.646	3.528	154.002.617	Approx.€60 million result from additional affected areas beyond halogen with closure of Eichstätt location
FR	36.379	1.102	40.086.096	
IT	41.727	171	7.147.888	
HU	9.284	1.998	18.545.740	
PL	10.010	959	9.602.860	
SK	11.374	206	2.338.004	
Summe			269.411.171	

Table 14: Plausibility check of the estimated employment Effect

4 Contact persons and preparation

Contact persons:

Works Councils Network Lamps and Lights, German:

- Werner Leyer
- Mobile phone: +49 170 78 72 231
- Email: w.leyer@osram.de

Executive Board of IG Metall;

- Holger Timmer
- Mobile phone: +49 171 97 66 182
- Email: holger.timmer@igmetall.de

IndustrieAll:

- Andrea Husen-Bradley
- Mobile phone +32 473 302 564
- Email: Andrea.Husen@industriall-europe.eu

Prepared by:

SUSTAIN | CONSULT Beratungsgesellschaft für nachhaltige Wirtschaftsentwicklung mbH

- Dr. Torsten Sundmacher
- Mobile phone: +49 171 74 52 787
- Email: sundmacher@sustain-consult.de

ANNEX K: EXPERT COMMENTS, DANISH ENERGY AGENCY (DENMARK)

Below please find comments from the Danish Energy Agency on the Commission's draft Intermediate VHK/VITO report dated 2.4.2013 and discussions at the technical stakeholder meeting 26 April on Review of Stage 6 in Ecodesign Regulation 244/2009 on non-directional lamps.

Summary

The Danish Energy Agency (DEA) welcomes that the Commission has started the revision process of the EU eco-design regulation for domestic lighting where regulation 244/2009 is implemented in Denmark without major problems.

DEA find that the premises for the analysis for the revision should follow the purpose of the revision as described in the explanatory note (20) to 244/2009. The note specifies that the revision particularly should take note of the feasibility of establishing **stricter** energy efficiency requirements at the A-class level and should look into the use of special purpose light sources. The draft intermediate report raises the question if stage 6 should abolished for MV-HL lamps due to no availability of class B MV-HL lamps.

However, we don't understand this concern as high efficacy LED lamps are available.

During the last year, we have seen a worldwide 50 % price cut for LED lamps. Consequently, it is economically beneficial to shift directly from halogen mains voltage (MV HL) energy class C to LED energy class A or A+. This will provide larger energy savings than projected as a most welcomed environmental impact and impact on the consumers' energy bills.

Concerning the foreseen employment impact, we encourage the European lighting industry to enforce development and production of smart lighting applications by use of LED, OLED and intelligent control technology. It is important to be in the front and the potential seems large.

Concerning the halogen lamp exceptions G9 respectively R7s, we suggest the intermediate report do further analysis on how these two types of lamps could be replaced by LED retrofit solutions in a new Stage 7 - especially it is urgent to replace the G9 lamps due to the G9 adapters giving a major loophole in the regulation as described in the intermediate report.

In conclusion, abolishment of stage 6 for MV-HL lamps is not needed as very energy efficient LED lamps of good quality are available and they will provide substantial beneficial economical savings for the consumers.

Finally, we are providing some important suggestions for revision of regulation 244/2009 and 1194/2012.

Timing

Stage 6 appear 1/9 2016. For regulation 244/2009, the review has to be done by 13/4 2014 (five years after the entry). At the time when the industry established MV-HL production for replacement of GLS lamps, they did know of Stage 6 and phased out of MV-HL lamps.

The actual development of LED products is faster than expected in the eco-design pre-study including faster decrease in prices than expected. We recommend no rush in evaluation of Stage 6 – it is worth to include the fast LED development during the rest of year 2013.

Low voltage halogen and LED lamps meet Stage 6 requirements

Halogen low voltage non-directional halogen lamps are broadly available in class B (see Figure 2b in the intermediate report including typical prices). These lamps benefit from the low voltage and are able to fully exploit the benefits of infrared coating. Thus stage 6 is appropriate for this type of lamps.

The draft report state there are LED lamps (Figure 4a in the intermediate report) with G4 and GY6.35 caps and suitable for 12 V that could be used as replacements at roughly 25 times the rated product life of the mini-halogens, 4-6 times the energy efficacy and 5 times the price (€ 9-11 versus € 1.5-2 per unit) but the price is decreasing. It is recommended to consider adding new stages with increased requirements equal to energy class A and eventually A+.

LED lamps can be used as retrofit for MV-HL in Stage 6

The efficacy for MV halogen lamps is very poor nearly at the level of the phased-out GLS lamps. The draft report states there are currently (3/2012) no MV-HL lamps on the market that meet Stage 6 requirements and "it is highly uncertain whether halogen lamps meeting the qualification will be on the market when Stage 6 will apply".

The latest insight shows there are LED lamps available that can replace all types of GLS shaped MV-HL lamps. The LED lamps have a much higher efficiency (energy class A or A+) and actually the prices have decreased remarkable. The draft report states GLS shaped LED lamps are suitable replacements for MV-HL lamps with immediate ignition, clear bright light, no UV, no mercury and good colour rendering up to 95 Ra (higher quality than for the CFL lamps).

The report states new types of LED lamps can provide a glitter effect in crystal luminaires or reflection on glossy surfaces such as silver cutlery (the lamp is shown in Figure 4b in the intermediate report).

The report claims the highest light output available at the time for market investigation was 800 lumen. Now only two months later, several lamps with higher lumen output are found in the EU market: Samsung 1055lm (E27, 12W, 88 lm/W, 2700 K, 18€), Philips 1055 lm (E27, 13W, 81 lm/W, 2700 K, 23€) and Perfect Light 1550 lm (E27, 15W, 103lm/W, 6000 K (at present only cold white), 31€) [54]. In Japan and USA (with lower voltage) is already many products providing higher luminance e.g. 1500 lumen. Within more than three years to 1/9 2016 and the actual fast LED development, it is most unlikely there will be any lack of high lumen output LED lamps in EU. With a small postpone of the stage 6 review until the beginning of 2014, all high lumen LED lamps might already be available.

The draft report assumes a partly retrofit by G9 adapters. It is recommended to investigate the consequences of a phase out of G9 lamps and to obtain a closing of this major loophole.

[54] http://virtualleds.com/index.php?route=product/product&product_id=285, Information provided by Philips in Finland to Motiva, http://www.loja-perfectlight.com.pt/loja/produto.asp?item=SL196

Market

The draft report find it "plausible that MV-HL replacement lamps particularly find their way to sockets with low operating hours (e.g. 200-300 h/a) and many switches (short start time) or to lamp sockets for fixtures where the light characteristics are considered essential".

The EU IEE project PremiumLight has in 2012 executed a large survey including 500 audits for each country. The participating countries covered 76 % of the households in EU. This survey shows that the installed MV HL bulbs are distributed with:

- 16 % of the MV-HL being among the lamps burning most (assumed 1200 h/year)
- 36 % of the MV-HL being among the lamps burning second most (assumed 900 h/year)
- 35 % of the MV-HL being among the lamps often switched on but burning short time each time (assumed to be 350 h/year)
- 14 % of the MV-HL being among the lamps not used very much (assumed 100 h/year)

Based on the above data, it is calculated an EU operational average around 600 hours/year for MV halogen lamps which is more than the double than guessed value in the draft report. However, the scenarios in the preliminary report and mentioned below use the value 500 hours/year which is of the same size as the above found operational time.

For the remaining GLS lamps in the homes in 2012 which are to be replaced, the PremiumLight survey found a bulb distribution not far from the MV-HL lamps and an EU operational average of 573 hours/year.

In the PremiumLight IEE project is actually collected LED market data which shows an average efficiency of new LED lamps of more than 60 lm/W for NDLS as well as for DLS. Based on these actual market data, the **predicted average efficacies** 80 lm/W for 2017-20 (5 years from now) and 100 lm/W for 2017-25 (8 years from now) are **all too low**.

Table 5 in the draft report provides LightingEurope projection of LED market share and end-user price.

Table 5 LightingEurope projections LED marked value share and prices (pers. comm. 20.03.2013)						
	2012	2016	2017	2018	2019	2020
End-user price	18€	10€	9€	8.5€	8€	7.5€
Market share LED	6%	15%	20%	30%	45%	60%

During the last half year, there has been a 50 % price cut in the LED market for lamps of high quality:

- IKEA LED, E14, 200 lm, 57 lm/W, 2700 K, CRI 93, 25,000 h, € 7 (DK)
- IKEA LED, E27, 400 lm, 53 lm/W, 2700 K, CRI 93, 25,000 h, € 10 (DK)
- IKEA LED, E27, 600 lm, 60 lm/W, 2700 K, CRI 93, 25,000 h, € 12 (DK)

- CREE A19, 450 lm, 84 lm/W, 2700 K, CRI 80, 25,000h, dimmable, 10 years warranty, $ 10 (USA, price equal to € 7.6)
- CREE A19, 800 lm, 84 lm/W, 2700 K, CRI 80, 25,000h, dimmable, 10 years warranty, $ 13 (USA; price equal to € 9.9)
- Philips A19, 800 lm, 76 lm/W, 3000 K, CRI 85, 20,000h, 6 years warranty, $15 (USA, price equal to € 11.4, Philips has announced they will later 2013 launch a new lamp version for only $10 equal to € 7.6)

Thus some actual prices already are at the level predicted for 2016 **and it seems reasonable to assume that we will experience a bigger price decrease than predicted for 2017-20**. However, the draft report states that consumer investments in LED retrofits will be economically beneficial with a payback period less than 3 year for the period 2016-2020. With lower prices and longer operational hours at 614 hours/year, the payback period will less than 2 years.

The draft report compares two scenarios:

Maintaining Stage 6 where the 1350 million GLS-retrofit sockets in 2020 is filled with LED lamps of an average a power of 5W (80 lm/W, as predicted average in 2018) and an average unit purchase price of € 8.50/unit (expected average in 2018). For the period 2016-2020 it is predicted that the consumer will spend around 5-7 euros more per lamp compared to buying the MV-HL lamps. Based on actual market data we find it is appropriate to calculate with higher efficacy and lower purchase price for the period 2016-20.

Abolishment of stage 6 for MV-HL where around 40-50 % of the 1350 million GLS-retrofit sockets in 2020 is filled by LED lamps and the other half by MV-HL lamps generating replacement sales of 200 million per year which is expected to diminish by 20-30 % annually due to competition with LED lamps, and expected to be close to zero around 2024-2025.

Shifting from MV-HL to LED lamps is beneficial for the consumer where the draft report estimate the payback period to be less than 3 years. With the actual price cut and higher operational time than presumed, the payback period seems to be less than 2 years.

Environmental impact

The draft report finds that maintaining Stage 6 for MV-HL lamps provides an energy saving of 5-7 TWh/year in 2020. Calculations with appropriate higher efficacy increase the savings.

Employment

The report estimates that production of MV-HL lamps gains 3000-4350 jobs in EU (in De, Cz and Hu mainly). It is estimated that the phase-out of MV-HL lamps could have a positive EU employment effect of around 500 new jobs and a net EU job loss of 2500-3850 jobs.

It is mention abolishment of Stage 6 MV-HL requirements might be perceived as EU doesn’t support energy efficient lighting and deviation from the EU roadmap. This could have long-term negative effect on the worldwide LED market investments/employment for manufacturing of both LED lamps and luminaires.

DEA comment: The European manufactures have since they invested in the MV HL production known of Stage 6. We encourage the industry to develop and produce smart lighting applications using LED, OLED an intelligent control technology and being in front on the world-wide level and having a net positive impact on jobs creation in the long term.

Health

With Stage 6 phase-out of MV-HL replacement lamps, the people with lighting-sensitive diseases can use LED replacement lamps. With medical prescription, economical support could be provided to shift to LED lamps. The draft report states actually no LED bulbs provide more than 800 lm but as far as we know lighting-sensitive people don't demand lamps with high lighting output. Anyhow, LED lamps with higher lumen output are already available in Japan and USA and will appear in Europa.

The draft report state, that LED lamps have the benefit that they don't produce or emits UV while halogen lamps and CFL lamps produce a small amount of UV.

Suggestions for revision of the regulations 244/2009 and 1194/2012.

The DEA welcomes integration of the two regulations to one regulation as some functional requirements are spread on the two regulations due the historical development.

- Concerning the halogen lamp exceptions G9 respectively R7s, we suggest the intermediate report to further analyze how these two types of lamps could be replaced by LED retrofit solutions in a new Stage 7 - especially it is urgent to replace the G9 lamps as a there exist G9 adapters giving a major loophole in the regulation.
- We suggest revision of the definition of a clear lighting source in order to avoid appearance of stripes or patterns in the light distribution e.g. from small halogen lamps with G9 cap.
- The DLS-regulations definition of special purpose light sources should be applied to the NDLS' as well.
- Near future ecodesign requirements could be minimum A+ for LED lamps.
- Add new stages including energy class A and eventually A+ requirements. Ongoing market investigation in the IEE PremiumLight project indicates around 50 % of the non-directional LED lamps at the market have class A+ efficacy.
- Both CFL and LED lamp functionality is sensitive to the heat conditions in the fixture. It is recommended to change lifetime test conditions from 25^{o}C to 40^{o}C (have to be specified in accordance with the condition in the respective standards)
- For all directional lighting sources, the manufacturers or sales companies should at their web sites provide the light distribution as a photometric file or a table. All manufactures have to measure these data as the regulation concerns the useful flux.
- The definition of special purpose lamps from 1194/2012 also should apply to NDLS.
- Information about colour rendering should be required to be shown at the packing. This is an important light quality parameter for the consumer.

ANNEX L: EXPERT COMMENTS, BAM AND UBA (GERMANY)

Ecodesign Directive (2009/125/EC)
Comments on the review study on the stage 6 requirements of Commission Regulation (EC) No 244/2009

1. General remarks

We welcome the review study and acknowledge the provided data and information, which give a sound picture of the relevant aspects with regard to stage 6 of regulation 244/2009. However we wonder, why the commission asked only for an assessment of stage 6 and not of the other requirements. We see especially a need to review the exemption of special purpose lamps, as this is used as a loophole of the regulation.
Following we provide some comments on the study and further aspects which need to be addressed in a revision.

2. Comments on the review study

2.1 Technical analysis

The description of the product scope is appreciated, as it illustrates the available techniques very well and comprehensible. We propose to add also recent developments of (almost) mercury free fluorescent lamps, e.g. in 2012 an electrode-free fluorescent lamp ("3rdPPBulb") has been presented, which was developed by the Light Technology Institute (LTI) of Karlsruhe Institute of Technology (KIT) in cooperation with University of Applied Sciences in Aachen.[55] The first types contained about 10 µg mercury per lamp. The products presented at the Hannover Faire in 2013 contained mercury below the detection limit only.

2.2 Mains voltage halogen lamp with transformer

The study assumes that the retail price for a mains voltage halogen lamp with transformer would be at least € 9.95, i.e. the price of the lamp which Phillips had on the market in 2008. We wonder if the assumption would be right taking into effect scaling effects and having in mind that more complex LED-lamps (equivalent to 60 W incandescent lamp) are already available for about € 15,- and further price decrease is announced.

2.3 Market data (chapter 3)

The dynamic development of the lamp market has certainly been further effected by the phase out of non-directional incandescent lamps by regulation 244/2009. We assume that especially the development of LED-lamps has been further inspired. We therefore wonder why the market volume of LED-lamps (at least for 2012) is not indicated.
It is stated on page 20, that there is an unknown percentage of special purpose lamps. We understand the problems to identify market data, however in order to assess the relevance of the provided exemptions there is a need to identify the respective market data.

2.4 Health issues

We appreciate that the impacts of UV and blue light have been assessed in more detail by

[55] See for example http://www.kit.edu/visit/pi_2012_9933.php, http://www.research-ingermany.de/service/newsletter/newsletter-issue-17-june-2012/science-research-news/101204/news-4.html

SCENIHR. In the opinion of 19 March 2012 (p. 9) it is stated, that there "*is no evidence that artificial light from lamps belonging to RG0 or RG1 would cause any acute damage to the human eye. Studies dedicated to investigating whether retinal lesions can be induced by artificial light during normal lighting conditions are not available. Lamp types belonging to RG2 and higher are usually meant to be used by professionals in locations where they do not pose a risk.*"
Nevertheless SCENIHR identified research needs including the investigation of retinal effects of chronic exposure to artificial light for visibility purposes. We therefore wonder with which security the photobiological risk indeed can be determined.
The review report should describe, how industry secures, that lamps with Risk Group 2 and higher are indeed not offered for household lighting and analyse if for example an information requirement regarding the risk classes would be advisable.

3. Issues, which should be addressed in the revision

The necessary exemption of special purpose lamps in regulation 244/2009 provides a loophole to the phase out of incandescent lamps, which is legally used also by major lamp producers still to offer incandescent lamps in do-it-yourself stores or via internet sales. Commission regulation (EU) No 1194/2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment provides already a more technical definition of exemptions. As one exemption refers to lighting products which have to withstand extreme physical conditions (such as vibrations), it seems, that the loophole would still exist, as some of the offered incandescent lamps are sold as vibration resistant industrial or mine lamps.
There is no doubt, that certain exemptions are necessary. However in order to assess the effect of the exemptions market data would be needed, how many incandescent lamps are sold as special purpose lamps. Furthermore it should be assessed in more detail, if the available lamp technologies indeed can't offer the functionalities, e.g. vibration resistant halogen lamps.
Regarding the scope it needs to be investigated in how far organic LEDs should be included in the scope, at least for the information requirements.
While the scope of the regulation 244/2009 addresses all non-directional household lamps, the definitions provided in article 2 do not cover all available lamp technologies. Especially concerning the definition of fluorescent lamps we see some need for clarification. Fluorescent lamps are defined as discharge lamp of the low pressure mercury type and are therefore linked to a mercury content. Such a definition does not include other fluorescent lamps like mercury free induction lamps (including the new developed "3rdPPbulb"). N.B. concerning regulation 245/2009 it is the same.

Contact:
Federal Institute for Materials Research and Testing (BAM), Floris Akkerman, Department S, Ecodesign

Federal Environment Agency (UBA):
Christoph Mordziol, Section I 2.4 Energy Efficiency,
Ines Oehme, Section III 1.3 Eco-design, Environmental Labelling, Environmentally Friendly Procurement.

ANNEX M: EXPERT COMMENTS, CLASP

From: Pernille Schiellerup, Director of European Programs, CLASP (received 10/5/2013)

pdf, see attached

clasp

To: René Kemna, VHK/VITO study team

From: Pernille Schiellerup, Director of European Programs, CLASP

Cc: Ruben Kubiak, Policy Officer, DG Energy
Ismo Grönroos-Saikkala, DG Energy
Marie Baton, Senior Technical Advisor, CLASP
Michael Scholand, Technical Consultant, CLASP

Date: 10 May 2013

Subject: **Comments on Draft Report on Stage 6 of 244/2009 Non-Directional Household Lamps**

Thank you for the opportunity to comment on the draft report on the Review of Stage 6 of 244/2009. CLASP is concerned about several aspects of the draft report. We understand however that the report has had to be produced within a very tight timetable, and therefore it is understandable that the contractor has not been able to mobilise sufficient evidence or analysis that would support a decision whether to retain, delay or abandon Stage 6. There is ample time to improve this analysis, with the review deadline in 244/2009 set for April 2014. A revised version could also be included in discussions in the context of a September 2013 omnibus review of all lighting regulations now being considered. With more time, and possibly more budget, we know VHK would be able to deliver a more robust analysis.

Regulation EC No. 244/2009 is the result of four years of investment by the European Commission and stakeholders. We find that the draft report as it stands underestimates the loss of energy and financial savings and overestimates risks to employment of abandoning Stage 6.

On loss of savings, our analysis suggests that instead of eliminating 5-7 TWh/annum of energy savings in 2020, the savings lost would be more likely to be in the region of 14 TWh/annum in 2020. For comparison this is more than the combined savings of the implementing measures on domestic refrigerators and freezers (4 TWh/annum), domestic dishwashers (2 TWh/annum), domestic washing machines (1.5 TWh/annum), and simple set-top-boxes (6 TWh/annum). The importance of *prioritizing* is emphasised by the European Commission and by stakeholders. This should include a consideration of what new implementing measures and what reviews of existing implementing measures to undertake, *and* not lightly throwing to the wind existing achievements such as Stage 6 of 244/2009 which represents significant sunk costs by the Commission and stakeholders.

On loss of employment, we would welcome a more systematic assessment of what proportion of the jobs cited as at risk are likely to disappear even without Stage 6 of 244/2009. We would also welcome a consideration of the risk to employment by abandoning Stage 6, as its retention can help secure a domestic European market for more efficient lighting technology.

Below we list areas for improvement which, if addressed, would allow the draft report to serve as a more adequate basis on how to proceed with Stage 6 of 244/2009:

1. **The review of LED technology needs further development.** The report focuses on B-class halogen technology but does not look at clear-LED lamps that could exceed B-class requirements. The

research presented only superficially explores the potential for LED technology. In-depth research and discussion is lacking, including as regards the critical parameter of price (where significant reductions are on-going) and performance (where rapid improvement in efficacy are continuing). The report refers to the DOE 2012 solid state lighting research and development multi-year programme plan, but only in an illustrative way. This does not appear to have been used in any systematic product analysis or forecast for LEDs. DOE issued its 2013 multi-year programme plan in early May.[1]

The draft review report should therefore also include:

1. A discussion of AC-LEDs, which have been demonstrated in Japan in 2013 as a mains-voltage driverless-replacement for low-wattage incandescent lamps;
2. A product overview or discussion of types of LED-based clear lamps currently available on the market in Europe and abroad;
3. Test results of commercially available clear-lamps, such as those sold in Europe by IKEA;
4. Results of primary research, such as interviews with experts on important trends in LED technology that will impact what is commercially available in 2016 – including, for example, DC and AC LED efficacy, LED drivers, manufacturing costs and retail price trends;
5. A discussion on phosphor-based LEDs vs. colour-mixing LEDs and the efficacy potential associated with each; and
6. A discussion of the Commission's LED Green Paper and of the on-going work on LED performance forecasts of the Commission with respect to solid-state lighting.

In the meeting held at the Commission on 26 April, LightingEurope suggested that CREE is losing money on the sale of their LED replacement lamps for halogen and CFLs in North America. CLASP has spoken with a senior manager at CREE and confirmed this is not the case. CREE suggested that interested stakeholders should study the publicly available financial data on CREE's website (CREE is a publicly traded company, so they have public filings on their financials). We provide the web address with CREE's financial data here:

- Financial website: http://investor.cree.com/financials.cfm
- A press release about CREE's LED lamp can be found here: http://investor.cree.com/releasedetail.cfm?ReleaseID=744999

2. **The employment analysis needs further development.** The VHK employment analysis looks at direct and indirect employment of people working on halogen lamp manufacturing in Europe (and even more specifically on MV-HL), but does not address important trends that are already observable in today's market:

[1] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2013_web.pdf

C-class halogen lamps produced in Europe are already being supplanted by lower-cost C-class halogen imports. This suggests that the jobs which are identified as at risk by Stage 6 of 244/2009 could be gone by 2020 in any case.

Halogen lamps have roughly double the life of incandescent, so we should expect to see an increase of approximately 300 million halogen lamps in response to an incandescent shipment decrease of 600 million between 2009 and 2012 – however, those sales are not evident in the LightingEurope member data, which show only a small increase of about 50 million units in 2012. This suggests that LightingEurope member companies are losing market share in halogen C-Class sales in Europe today, and that the number of jobs at risks due to Stage 6 is likely to be an overestimate because these jobs are already at risk.

Conversely, the report does not consider the business risk to European companies of losing out in the intense global competition in the LED lighting market by abandoning Stage 6. Companies such as CREE, LG, Samsung, Toshiba and Panasonic represent a significant threat to Osram, Philips and other European lamp manufacturers. Such American and East Asian companies benefit from strong domestic market support for LED lighting from regulations and other supporting policy measures that European manufacturers will not have if Stage 6 is dropped. CLASP would like to see a closer examination of the case for retaining Stage 6 on the grounds that this will help build domestic demand for European-produced LED lighting. This could help European companies leverage European sales to compete in overseas markets.[2]

3. **The aggregate (EU-wide) economic scenarios need further development.** The section on economic scenarios is limited to “a very simple analysis” and concludes with the statement that “it is now not possible to predict whether on the long-run maintaining or abolishing Stage 6 for MV-HL lamps is economically more advantageous.” This is an important gap in the evidence base and a good reason not to rush into a decision. The Commission should provide VHK with more time, and if necessary budget, to address this. CLASP has prepared an initial European market spreadsheet model that starts to address this analytical gap in the report, which we are submitting with these comments. We hope that VHK will be able to build on this.

In our initial assessment, we have found that the discounted net present value of keeping Stage 6 is worth over 30 billion Euro to European consumers. Furthermore, using new data from LightingEurope and our own estimates, we find that the lost energy savings to be approximately 14 TWh/year in 2020, rather than 5-7 TWh as estimated by the draft report review study on the Stage 6 requirements and by the 2009 Impact Assessment report. This magnitude of energy

[2] An interesting example in this context is Grundfos in Denmark, a circulator pump manufacturer who became a world leader thanks to the “push effect” of ecodesign (the principle of “innovation through ecodesign”). Grundfos recently participated in an eceee seminar supported by STEM and CLASP on innovation and ecodesign. The presentation can be downloaded from eceee’s website.

savings, 14 TWh/annum by 2020, is more than the combined annual savings in 2020 of the implementing measures on domestic refrigerators and freezers (4 TWh), domestic dish-washers (2 TWh), domestic washing machines (1.5 TWh), and simple set-top-boxes (6 TWh). The difference between the two estimates is primarily due to differences in assumptions made about e.g. the evolution of the number of lamps in use and the average wattages. We suggest that with more time, VHK would have been able to develop a more robust set of assumptions. We hope our attached spreadsheet will be helpful in this respect.

4. **The draft report does not have a consumer-level life-cycle cost analysis**. Through the ecodesign process, the levels of ambition that were adopted in Regulation 244/2009 were based, in part, on a detailed assessment of what would be cost-effective for consumers. Regrettably, the draft report omits any such analysis. CLASP prepared a simple payback period analysis of the CREE lamp based on the product that is commercially available today in the United States. This was discussed at the stakeholder meeting, and we provide a table showing the results below. When discussing these results in the meeting, a Philips representative indicated that the performance of the LED lamp would be 20% lower when operated in Europe due to the higher mains voltage (230V), so we also provide that analysis in our payback table("LED-EU20%"). We discussed the 20% Philips estimate with CREE, and according to their expert 20% was too high and the actual difference due to the higher mains voltage would be more like 10%. We created that scenario too, calling it "LED-EU10%".

Table 1. Payback Period Calculations for CFL and LED Lamps, Compared with Halogen C-Class

Lamp Type	Rated Wattage *(Watts)*	Daily Use *(hours/day)*	Efficacy *(lumens/Watt)*	Light Output *(lumens)*	Cost per Lamp *(€)*	Energy Use *(kWh/yr)*	Electricity Price *(€/kWh)*	Simple Payback *(years)*
Halogen	52	3	15	780	1.5	56.9	0.22	
CFL	15	3	55	825	3	16.4	0.22	0.17
LED-USA	9.5	3	83	789	11	10.4	0.22	0.93
LED-EU10%	10.6	3	75	789	11	11.6	0.22	0.95
LED-EU20%	11.9	3	66	789	11	13.0	0.22	0.98

We note from this simple payback period analysis that LED technology available on the market from March 2013 has a payback of less than one year compared to halogen C-Class, and it is widely understood that LED technology will continue to progress in performance and reduce its cost. Therefore, we believe it to be critical that the review report include both a current and forward-looking (to September 2016 when Stage 6 takes effect) consumer-based life-cycle cost and payback-period assessment be prepared and included in this technical review in order that Member States and other experts who will review this study in the Consultation Forum have the opportunity to discuss this critical aspect based on real and projected cost and performance data.

5. **Additional data is available to support a more in-depth consideration of environmental resource efficiency beyond energy.** The draft report only considers environmental impacts through a reference to the preparatory study for lot 19, acknowledging its limits in terms of reflecting the current situation. The draft report does not discuss the environmental aspect issues associated with the options being presented and discussed in the report. There is a growing body of literature of life-cycle assessments on various lighting products, including a 2012 publication

from the US Department of Energy that looked at impacts of a Philips NDLS LED lamp compared with an incandescent and CFL lamp in 2012 and 2017.[3] This study found there to be considerable gains to be had across fifteen environmental indicators from the LED technology. We would encourage the contractor to review this report, consult with DG Environment as well as the JRC, and researchers who are active in the lighting-related life-cycle assessment field.

6. **The draft report does not discuss other policy options that might be considered as potential alternatives** to the keep / drop consideration, thereby limiting the potential of an evidence-based discussion at the Consultation Forum. Thus in addition to the case for and against keeping or dropping Stage 6, the case for and against delaying Stage 6 could be considered. Whatever the options, it should be supported by an adequate evidence base.

7. **CRI of 100 is not "ideal"**. We regret the use of the word "ideal" in the report when discussing the value of 100 for the colour rendering index. We would instead suggest that a CRI value of 100 reflects an accurate reproduction of an incandescent lamp's ability to render colour. A CRI of 100 means that 8 specified colours look exactly the same as they would under a blackbody radiator at 2700K. Incandescent lamps being blackbody radiators, they just behave as the reference for this index, which is why they have a CRI of 100. Halogen achieves a score of 100 due to the fact that it is also an incandescent lamp, with halogenated gases in the capsule. CRI is accepted by many experts to be a poor measure of light colour, and new light colour metrics including, for example, Colour Quality Scale (CQS) are under development that would provide a technology-neutral basis for a comparison of colours rendered by a light source.

8. **We agree with VHK that there are no patent issues associated with infrared reflective coatings**. IRC coatings are technologically feasible for all LV halogen lamps in Europe – both non-directional and directional lamps. In addition to the Philips EcoClassic50 product that was withdrawn[4] from the market, ADLT demonstrated a 24V IRC capsule that achieved B-Class at the 2011 Light + Build conference in Frankfurt (see Attachment A to this memo). Adopting IRC coating for these lamps would not reduce jobs, but sustain this market and bring consumers savings. The reasons we do not see Halogen B-Class products in the market today is not because of any technical or patent barrier, but is because the regulation is still allowing lower-first cost, higher life-cycle cost C-class halogens in the European Market. Technology progression is the point of ecodesign, and we believe that the combination of B-Class halogen already demonstrated with the new A/A+ - class LED products entering the market ensures consumes will have choice and lower-lifecycle products with Stage 6.

---

[3] Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products; Part 2: LED Manufacturing and Performance, June 2012. US Department of Energy Solid-State Lighting Program. See: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_led_lca-pt2.pdf

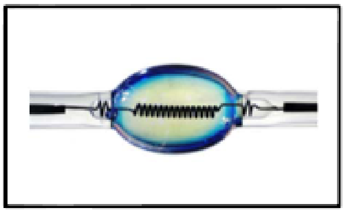
[4] During the meeting on April 26, the representative from Philips confirmed that this product had been discontinued in 2010 or 2011. There are still a few websites which list the product for sale, however their inventories are not being replenished as Philips has stopped manufacturing. As an example, here is an on-line retailer in the UK: http://www.energybulbs.co.uk/philips+20w+ecoclassic50+dimmable+clear+gls+-+warm+white+(es%2fe27)/2808673015

Attachment A. Literature from ADLT's Demonstration of B-Class Halogen

26W IR Halogen Capsule

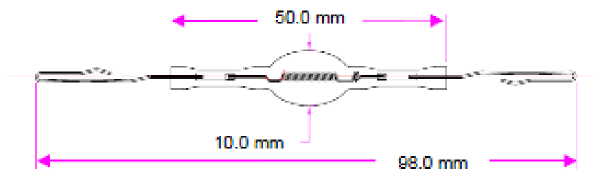
2X Incandescent
Draft Specifications

ADVANCED LIGHTING TECHNOLOGIES, INC.

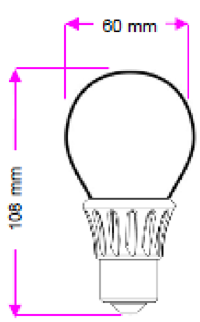


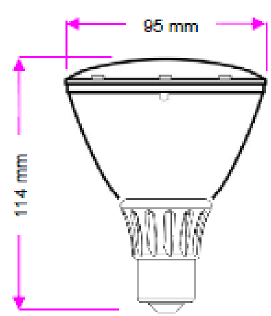
- Bright, crisp light
- 100 CRI
- 50% energy savings vs. C Class halogen (Europe)
- 50% savings vs. 60W incandescent (N. America)
- Long life: 3,500 hour
- Excellent point source for directional lamps
- Global design capability

Capsule:	Double end
Overall Length:	50.0 mm
Operating Position:	Universal
Watts:	26W
Lumens	840
Voltage:	24V
Dimmable:	Yes
CRI:	100
Color Temperature (K):	2950
Life (hours):	3,500



Lamp Concepts:	A-Line Configuration	PAR Configuration
Lamp configuration:	A19	PAR30L
Overall length:	108 mm	114 mm
Input voltage:	120V / 230V / Other	120V / 230V / Other
Watts:	26W	26W
Lumens	815 (1)	630 (2)
CRI	100	100
Color temperature	2950	2950
Base type	E26 or E27	E26 or E27





(1) 97% optical efficiency
(2) 75% optical efficiency

REV130430A

ANNEX N: EXPERT COMMENTS, CECAPI

CECAPI: Comité Européen des Constructeurs d'Appareillage Electrique d'Installation, European Committee of Electrical Installation Equipment Manufactures

CECAPI comments on Stage 6 of 244/2009 Ecodesign Regulation:

CECAPI would like to express comments regarding stage 6 requirements in Commission Regulation N° 244/2009 that are under review.

Halogen lamps are very well adapted to existing electrical installations in building and residential premises in Europe. They are also adapted to new installations in several European countries where the neutral is not available at the control device which commands or controls the light. It is estimated that both these new and existing installations represent around 200 million installations in the European Union.

Halogen lamps together with control devices such as movement or presence detectors or dimmers can generate energy savings up to 50% compared with traditional incandescent lamps controlled by a mechanical switch.

Halogen lamps are the “easy to implement” and “no worries” solution for:

- Around 200 million existing electrical installations (residential and tertiary)

- Countries such as Germany and France where regulations to ease access for disabled people require that switches controlling lights are provided with an integrated indicator light unit.

- Installations where energy saving control devices are installed such as presence or movement detectors, dimmers, timers, etc....

Today we can find CFLs and LEDs in the market that are able to work satisfactorily in existing installations and with control devices. Unfortunately, they are not readily available and are still 5 to 10 times more expensive than halogen lamps.

Moreover, as standards do not exist yet, the customers have no “objective” guidance that the CFL or LED they buy will work well in their installation. They have to rely on manufacturer’s or importer’s claims and cannot be fully reassured with their choice.

As an example, regulation 244/2009 requires that the customer is informed whether the lamp is dimmable or not:

> *Annex III, 3.1. Information to be visibly displayed prior to purchase to end-users on the packaging and on free access websites*
>
> *(f) A warning if the lamp cannot be dimmed or can be dimmed only on specific dimmers;*

Today, no standard is defining what “dimmable” means nor how this claim can be tested by market surveillance authorities and manufacturers.

Standardisation bodies dealing with Control devices and Lamps have started to work on these topics and results are expected by September 2014 so as to meet the deadline from Commission Regulation 1194/2012.

However, after this date, and after 2016, if halogen lamps are banned, the consumer’s choice will be:

- To buy more expensive than average CFLs or LEDs together with new control devices complying with these standards so as to be sure they will work with their existing installation.
- To modify their existing installations and install new cables into their premises which will result in additional expense and significant inconvenience within their homes.

Considering this, CECAPI is not in favour of banning halogen lamps and requests that any such decision is postponed for 4 years.

.

This will allow control device and lamp industries to invest in new, compatible products and to disseminate them widely in the market so as to ensure customer availability and affordability.

Additional product solutions will also be proposed which will be adapted to the electrical installation requirements of the customer and to the customer's available budget while still generating significant energy savings.

ANNEX O: EXPERT COMMENTS, ITALY/SWEDEN/NGOS

ENEA, ITALY

From: Simonetta Fumagalli and Laura Blaso, ENEA, Italy (received 9/5/2013)

Comments on the document and our opinion on stage 6 requirements:

1) the alternatives described and presented are not totally true alternatives. The report already states pro and contra of the different possibilities but:
1a) The "adapter" can NOT be considered as an alternative. It exists, but is only produced by a single manufacturer (monopoly problems?).
Furthermore, and most important, we want to have efficient "products", not temporary - altough maybe efficient "assemblies"
1b) CFL-i are, by definition, nonclear lamps, so their use as a substitution for clear lamps is in principle wrong, because it leads at least to different lighting performances. Diversification of the market offer is very important.
1c) LED lamps are really not available in a full range of sizes, powers... There are the already well known (stated also in the VHK-VITO
study) problems with temperature, easy dimmability, costs...

2) comfort with artificial lighting implies the possibility to perform our activities under certain conditions, and color rendering is an essential element for this comfort. Apart from the scientific activities today running in order to find better colour related indexes, there is in any case a lot of evidence that also the CRI<<100 (note that CRI<<100 means in any case CRI>=80) maybe very poor for many everyday activities and this will lead to discomfort, also because CRI itself is not able to distinguish which of the colours will be penalized and this is another trouble for the users. Very good CRI in general means less efficacy, more costs and in some cases there are no avialble products.

3) if something has to be decided for 2016, there is not much time to wait. Industry needs time to adapt their production strategies.

For at least these reason we are strongly in favour to abolish stage 6.

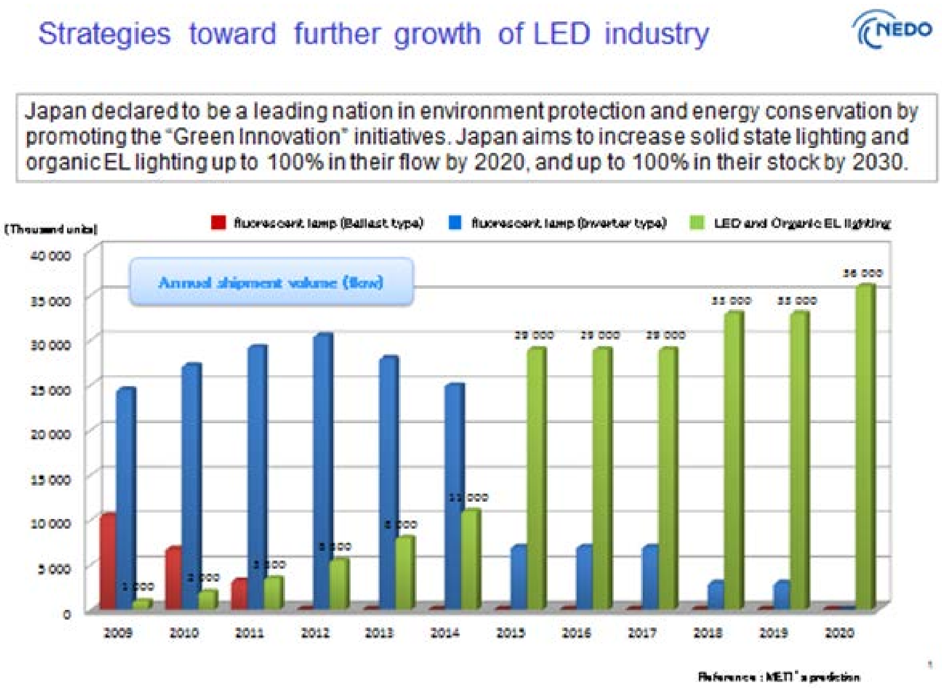
SWEDISH ENERGY AGENCY, SWEDEN

From: Peter Bennich, Efficiency Dept., Swedish Energy Agency (received 13/5/2013)

We refrain from specific comments at this stage, but hope that the detailed comments provided by the Danish energy agency and CLASP will be considered, since they provide important feedback of use for the final report.

However, SE have many comments and concerns of principal nature, and we will come back separately with these in time for the CF in June. One of the major concerns we anyway have to bring up already now, is that we find the stage 6 revision premature and with a large risk for sub-optimisation, it is also a risk in terms of loss of credibility of ecodesign as a policy tool (if we start to abolish stages already decided on). On the contrary, we find that the omnibus revisions (of all lighting regulations) in the fall is much more important and where the focus should be, with an opportunity were flaws in the current regulations can be corrected and where a stronger link to the EU research agendas (such as Photonic 21) and deployment strategies (such as Lighting the Cities - Accelerating the Deployment of Innovative Lighting in European Cities) could be established more clearly.

Finally, an addition to the minutes from the TF: I'm partly erroneous quoted when referring to the Japanese strategy for developing and deployment of LED-based lighting. As seen below, the graph shows that Japan plan to phase out *all* technologies but LED in both production/sales (to 2020) and into the stock (2030)!



Y Kudo, NEDO, at the Symposium on standardisation of LED, Tokyo, march 2012

ECOS

From: Stavatis Sivitos, ECOS (received 13/5/2013)

Environmental NGOs fully support the below comments and detailed analysis put forward by CLASP on the on-going review of the Stage 6 requirements of 644/2009. We hope that these are addressed/ integrated in the final report, with a view to providing a solid basis for a later discussion in the consultation forum.

[cit. CLASP]:

we fully understand the need for prioritisation and careful use of resources to deal with a heavy workload, leading to tight timelines and a lighter analysis concerning the elaboration of the aforementioned report; for products groups with less significant impacts (including lower savings), such as external power supplies discussed a few weeks ago in the consultation forum, this could be justified. For the review of the stage 6 requirements however, taking into account the potential repercussions a possible revision of these may have for the EU in terms of energy savings, employment in the long term as well as maintaining leadership regarding innovative technologies - among others-, it has to be ensured that the basis upon which any future decisions are made is robust. Moreover, the 2014 deadline for the review of these requirements allows for the timely completion of such a review study, consequently providing an opportunity for a deeper investigation of the points raised in CLASP's input .

To this effect, we call upon the Commission to provide more time (and resources, if needed) for the completion of this report to the consultants.

ANEC/BEUC

From: Angeliki Malizou, ANEC/BEUC Ecodesign Project Coordinator (received 10/5/2013)

ANEC/BEUC attribute great importance to this product group under the Ecodesign framework as we are confident that it can deliver considerable energy savings. At the same time we consider crucial to ensure that if any measures are taken they do not affect adversely consumers' trust to this product group, especially taken into account that previous Ecodesign measures on lighting have raised complaints and distrust to a part of consumers.

As far as it concerns Stage 6 and the associated technical discussions we would like to draw your attention to the following key points:

· From a consumer perspective it is desirable that, given that Stage 6 requirements come into force in 2016, the market provides lamps that have the same light quality characteristics as the halogen lamps to be out-phased then. As most research and development activities within the lighting industry concentrate on LED research, we believe among the main benchmarks should be whether LEDs are likely to reach light quality properties comparable to halogen lamps by then. Therefore, we consider important to include in this discussion an overview of the progress of LED light quality throughout the recent years as well as the performance of light sources under other measurements scales. A lot of discussion has been dedicated on whether CRI is the appropriate reference for light sources other than incandescent and halogen lamps such as LEDs. We have observed increasing confidence to the Color Quality Scale (CQS) as a more appropriate measurement method and we consider useful to have an assessment of this method.

· We believe that for the success of any measure it is crucial to take into account information on consumer behaviour and consumer acceptance of LEDs or any other alternatives. For example, “PremiumLight” project has delivered a report on consumer attitudes and experiences regarding lamp technologies and luminaires as well as on the phase out of certain lamps (see http://www.premiumlight.eu/uploads/images/system/default/content/project/D2_1_D2_2_D2_4_PreparatoryTasks.pdf). The report was published in early 2011 and since then a lot of market developments have taken place. However, we would like to use this as an example of the information we consider necessary to underpin any decision to implement or to abolish Stage 6.

· Finally, consumers have a great interest on R7 lamps as they are commonly used in floor lamps and are very energy demanding, resulting to high life costs. Although R7 has been excluded from the scope, we believe that it is necessary to assess what kind of headway has been made regarding this lamp type- if any- as well as the current technological feasibility for more energy efficient R7 lamps.

ANNEX P: EXPERT COMMENTS, AUSTRALIA

NDLS Draft Intermediate Report on Review Stage 6 of Ecodesign Regulation 644/2009 on non-directional lamps – Comments from the Australian Government, Department of Resources, Energy and Tourism.

Topic	Comments
General – 1.1 Assignment	There is some very interesting analysis in this report, but as yet no conclusions. It hints basically that the stage 6 requirement (class B "super-halogens") is not achievable - "There are currently no mains-voltage (‘MV’) halogen lamps on the market that would meet the Stage 6 requirements and it is highly uncertain whether halogen lamps meeting the qualification will be on the market when Stage 6 will apply, i.e. by 1 Sept. 2016." In Australia we have also had feedback from industry regarding limits to further improvements in the efficacy of mains voltage halogen lighting.
General – requirements	Based on Australia’s experience with the phase-out of inefficient lighting, some lessons have been learned that may be of interest for discussion and consideration: 1. Describing the requirements in terms of rated values has caused much confusion. There is also an EU regulation clause that allows the lamps to be 10% under the requirement. Adding all these together means that the lamps can be much less efficient than they claim. 2. We have had a minor problem with MEPS-compliant halogen lamps extracting the increased efficacy as increased light output, i.e. the 60W incandescent becomes a 60W halogen which emits more light. "Lumen binning" requirements would address this issue (as the Chinese have proposed for LEDs). 3. We have also had minor problems with exempted lamps being sold, such as "rough service lamps". However, this is really a matter of tightening compliance activities.
General – halogen phase-out	Given the difficulty in halogens meeting the Stage 6 requirements, consideration might be given to setting a date at which time halogens could be phased out in favour of CFLs and/or LEDs.
General – clear decorative lamps	On considering the impact on fixtures which rely on clear lamps as opposed to pearl lamps, our understanding is that there is only

	a limited range of applications where clear lamps are required. One area where this may be a possible issue in the future is low wattage (~ 5-10W) decorative lamps for chandelier-type fixtures. Currently LED lamps are not yet able to meet these needs, but may be suitable by 2016. It is suggested that consideration be given to exempting lamps below about 120 lumens (currently regulation applied to lamps over 60 lumens) until either halogens achieve the Stage 6 limit or LED lamps provide a satisfactory visual equivalence to clear decorative (candle)-type lamps.
Section 2.2, lock-in effect pp.10-11	There is no reference in the text to Figure 3c. G9 cap lamps (mains voltage) are exempt and will continue to be for sale. Is the figure meant to be a photo of a LV lamp fixture?
Section 2.3 Technical feasibility of mains voltage Stage 6-conform halogen lamps, pg.15	There appears to be an editorial error in the explanation of on the physics of the lamp filament (7th paragraph): *The relationship between voltage V and resistance R at power P is quadratic (formula P= V2/R). For instance, the resistance at 115V (e.g. US) is 4 times* ***lower*** ~~*higher*~~ *than at 230V (e.g. EU)* for the same power input; likewise the resistance at 12 V ('low' or 'extra-low' voltage) is 378 times **lower** ~~higher~~ than at 230V ('medium' or 'high' voltage). Hence, it is much easier for a US *main voltage halogen lamp or a European low voltage halogen to be a 'B' class efficacy lamp than for a 230V halogen (without integrated transformer).*
Section 3.1 Market Scenarios	The relationship between the tables and the workings of the analysis in the text is not clear.

ANNEX Q: EXPERT COMMENTS, G. ZISSIS (F)

From: Prof. Georges Zissis, Deputy director of LaPlaCe (Laboratoire Plasma et Conversion d'Energie), University of Toulouse, France.

Memo on personal title, received 6/5/2013.

The regulations for 244/2009 are technologically neutral, and set requirements for non-directional household lamps according to whether they are “clear” or “non-clear” (i.e., “frosted” or opaque, like a CFL). The regulation requires non-clear lamps to achieve a CFL efficiency and then two levels for clear lamps – one at C-Class lamps for Stages 1 through 5, increasing to B-Class at Stage 6 in September 2016. It is on precisely this Stage 6 clear lamp requirement – the B-Class lamps that the Commission is calling for a review.

The maximum rated power (P_{max}) for a given rated luminous flux (Φ) is provided in Table 1.

The exceptions to these requirements are listed in Table 2 and the correction factors applicable to the maximum rated power are in Table 3.

Table 1

Application date	Maximum rated power (P_{max}) for a given rated luminous flux (Φ) (W)	
	Clear lamps	Non-clear lamps
Stages 1 to 5	$0,8 * (0,88\sqrt{\Phi}+0,049\Phi)$	$0,24\sqrt{\Phi}+0,0103\Phi$
Stage 6	$0,6 * (0,88\sqrt{\Phi}+0,049\Phi)$	$0,24\sqrt{\Phi}+0,0103\Phi$

I am concerned about this step to drop Stage 6 of 244/2009 for the reasons outlined below:

1. Stage 6 takes effect in 3.5 years (September 2016) and it is premature for the Commission to take a decision to drop Stage 6. There are many companies who may be developing Class-B or better products to launch in 2016 and this regulatory requirement is beyond the time-scale of levels under other ecodesign regulations, including lighting regulations such as the recent directional lamps measure. I am also aware that there is a rapidly evolving technology – light emitting diodes – that are entering this market, both in Europe and abroad and these lamps are already exceeding Class B requirements. In France there are literally dozens of companies working with LED technology, and I am very excited to see the emergence of this new next-generation technology industry.

2. From now until 2016, the efficacy of LEDs is projected to increase by 20-30% and the end-user price is projected to decrease by 55-60% (US DOE SSL MYPP 2012). The price reductions for LED lamps are driven not only by lower LED costs and smaller scale balance of systems for LED products enabled by the higher efficacy. In other words, more light per LED requires lower electrical currents and less waste heat per

lumen of light generated. So heat sinks are smaller (lamps will become lighter), and lower electrical current means drivers can be smaller and more components incorporated into a chip. All of these translate into cost savings in the lamp.

3. Lost energy savings potential will impact European CO2 targets. Dropping Stage 6 will forego 5 to 7 TWh of electricity savings in 2020 (as estimated by the 2009 Impact Assessment). The International Energy Agency (IEA) in Paris estimates that the world economies are still failing to put the planet on a sustainable CO2 path. In the IEA's World Energy Outlook 2012, energy demand and CO_2 emissions forecast will rise even higher. The IEA projects that global energy demand will increase by more than a third in the period to 2035, with energy-related CO_2 emissions increasing from 31.2 gigatons in 2011 to 37.0 gigatons in 2035. This trend points to a long-term average global temperature increase of 3.6°C – well above the 2°C target.

4. Holds back development of new jobs from LED technology in Europe. The VHK draft report discusses the jobs at risk from manufacturing halogen lamps in Europe – but what about the jobs in Europe after halogen? Europe's leading lamp manufacturers – Philips and Osram – are global leaders in LED technology, but they have invested in manufacturing facilities outside of Europe. While some experts may argue that manufacturing halogens as long as possible is better employment option for Europe, I see this as a short-term view. Concentrating on halogens rather than accelerating the conversion of the European market to LED lighting through Stage 6 will reduce LED technology growth potential of European companies – existing and emerging ones - and forego the employment opportunities associated with this next generation lighting technology. Ecodesign is a policy tool to support innovation –but this will not be realised if Stage 6 of 244/2009 is dropped.

5. Global Leadership in Europe. Bearing in mind the global CO_2 emission issue, decisions made in Brussels will resonate and impact countries around the world, particularly those who harmonise with European regulations for improved trade relations. Thus, a downgrading of the regulation in Europe will trigger a similar downgrading in Middle Eastern, African and other countries around the globe who are harmonising with ecodesign.

6. There are promising LED alternatives already entering market that could exceed the B-class requirement and provide Europe with even greater energy savings. See Attachment A for some of the clear lamp LED products on the market in 2012. Over the next 3.5 years, this technology will continue to improve and new commercialised products that meet or exceed the Class B will be ready and affordable in 2016 (see DOE projections).

   For example, see the Cree LED lamp discussed in Attachment B. Cree is a North American semiconductor manufacturer who has now started selling LED lamps. Cree is currently selling an 83 lm/W mains-voltage LED lamp at €11 lamp. This lamp is the equivalent to 60W incandescent, lasts for 25,000 hours, 10 year warranty, is fully dimmable and instant-on. The table below presents a simple payback calculation, if the lamp were sold in Europe. This finds that the LED lamp would be a <1 year payback.

Type	Wattage	Hours	Efficacy	Lumens	Cost	kWh/yr	Price/kWh	Simple Payback
Halogen	52	3	15	780	1.5	56.9	0.22	
CFL	15	3	55	825	3	16.4	0.22	0.17
LED	9.5	3	83	789	11	10.4	0.22	0.93

7. Philips made a halogen lamp in the past that converted line voltage to low-voltage, operating an infrared-reflective coated (IRC) capsule. This product was withdrawn by Philips, however other companies in Europe may be planning to introduce it – indeed, one was shown at Light + Build in 2012 by ADLT. There are no technical impediments to producing a halogen B-class lamp in Europe – it's already been demonstrated and commercialised.

8. Global competition – European companies are competing in a global market and there are some extremely powerful competitors who will be vying for the LED lighting market. These include multi-million/billion Euro companies such as Seoul Semiconductor (Korea), Nichia (Japan) and Cree (USA) also manufacture LEDs, and with a large number of consumer electronics companies such as LG, Toshiba and Samsung. The ecodesign policy measure will give a home-market advantage of Philips, Osram and smaller emerging businesses in Europe to grow their revenue base and build their intellectual property in LED technology. This will ultimately make European companies more competitive with global firms like those mentioned. As the March 2013 LED Magazine article shows (Attachment B), Philips is already losing to CREE in the North American market, and dropping Stage 6 will eliminate any home market advantage, making it harder for them to compete overseas.

Overall I consider it premature to make a decision on the regulatory requirement of Stage 6, and I recommend that the Commission to postpone its decision until mid-2014 when I will have a better idea of the new B-class and higher products entering the market. This will also allow more time for more testing to be done and results compared for product performance and consumer satisfaction – enabling a more informed decision on a more robust evidence base. Indeed, Article 7 of EC No 244/2009 calls for the review to be prepared five years from adoption, which is April 2014 – so we are a year early with the VHK study.

There are at least four policy options that could emerge from a review in 2014 on non-directional lamps, including:

1) Keep the regulation at B-Class halogen in 2016
2) Drop the regulation, retaining C-Class halogen in 2016
3) Delay the regulation for B-Class halogen from 2016 to 2017
4) Split the 2016 requirement so that <1200 lumens goes to A-Class and >1200 lumens goes to C-class.[56] This allows for some off-setting of the energy savings that would have been made by keeping the B-Class requirement, and supports LED lamp market penetration.

[56] Due to the fact that lower lumen packages are easier to produce in LED and have already been demonstrated by the Philips IRC halogen capsule lamp, it may be possible to split the clear lamp requirements are split into low lumen (LL) and high lumen (HL) outputs and then Stage 6 for LL are increased from B-class to A or A+ class (which would require a LED lamp) and the HL are allowed to drop from B-class to C-class.

Attachment A. Sample of Clear Lamp LED Products in 2012.

Panasonic LED filament lamp

The yellow part is the LED, designed to light up and look like an incandescent lamp.

These two lamps use AC LEDs

Attachment B. LED Magazine Article on 11 Euro LED Lamps

Cree and Philips take divergent approaches to sub-$15 LED lamps
12 Mar 2013
http://ledsmagazine.com/news/10/3/9

Cree Lighting and Philips Lighting both announced 60W-equivalent LED lamps at less than $15, but the companies took decidedly different design approaches to the SSL retrofits.

Cree Lighting has launched its first LED-based A-lamps featuring an omni-directional light distribution and dimming support, and ranging in price from $9.97 to $13.97. Philips Lighting, meanwhile has begun selling a 60W-equivalent lamp for $14.97 that only radiates over the upper hemisphere of the dome. Both of the companies produced designs with traditional incandescent lamp looks, but took very different approaches in the solid-state lighting (SSL) product designs.

Philips $14.97 lamp

The new products foreshadow the quickly approaching day when we see a 60W-equivalent LED lamp from a major vendor sell for less than $10. In fact, Philips Lighting CEO Ed Crawford promised that Philips would deliver such a product this year.

The Cree LED bulb family comes to market with three product options – a 6W $9.97 450-lm 2700K lamp (40W equivalent), a 9W $13.97 800-lm 5000K lamp (60W equivalent), and a 9.5W $12.97 800-lm 2700K lamp (60W equivalent). The omnidirectional designs all have a CRI of 80 and support dimming with legacy triac-based and other phase-cut dimmers.

The Philips design eliminated dimming support to hit the low price point. The 10.5W lamp delivers 800 lm at a price of $14.97. For more information on both lamps, see our story on our Illumination in Focus website (www.illuminationinfocus.com/news/4/3/2).

Philips lamp design

Here, lets discuss the design approaches inside the new lamps. Philips has been widely known for its remote-phosphor technology in retrofit lamps. Even in the warm-white lamp announced last December, that's white in the off state, the company relied on an inner dome that was coated with remote phosphor (www.ledsmagazine.com/news/9/12/10)

The new 3000K lamps actually still use remote phosphor, although the geometry implied by the word remote has changed quite a bit. Crawford explained that the new lamps use blue LEDs with the remote phosphor applied on the dome of the individual packaged LEDs. In contrast, most remote phosphors are implemented on secondary optics. Meanwhile, phosphor converted LEDs typically have phosphor on the die inside the primary optic of the packaged LED.

The new approach certainly can reduce cost and improve optical efficiency by eliminating an optic between the LEDs and the outer globe. But does it maintain the advantage of remote phosphor? One key advantage is moving the phosphor material away from the LED where heat is generated that can cause the phosphor to shift in color over time. Crawford said that lessons learned in thermal management by Philips engineers allowed the company to reliably locate the phosphor on the LED.

The phosphor is actually deposited by Philips Lumileds in the back end of the LED manufacturing process. Crawford said, "It's so important for us to be a vertically integrated company" in discussing Philips Lighting's ability to bring such a product to market. Still we would expect Lumileds to sell such LEDs to other SSL vendors at some point.

Cree's filament tower

Cree, in contrast, took a more conventional approach using its phosphor-converted XLamp XT-E high-voltage LEDs. The LEDs are amounted on what Cree calls a Filament Tower that is a vertical structure upon which the LEDs are mounted in pairs around what is essentially a circular structure (see photo).

Cree’s Filament Tower

The concept of an LED filament, at least in usage of that word that comes from the incandescent world, is one that is being more frequently used in the SSL industry. At the recent Strategies in Light (SIL) conference, Intematix announced a small remote-phosphor optic that it calls a filament for A-lamps. Likewise, Epistar demonstrated reference designs that used strings of LEDs that president MJ Jou referred to as a filament. Clearly filament is quickly becoming shorthand for the light-engine assembly inside an LED retrofit lamp.

The Cree design is clearly a robust one based on a few days of usage. The dimming support works well. And the design seems to have no compromises despite the low cost. The light is uniform, and the 2700K version emits pleasant warm light.

Indeed the most interesting discussion about Cree's lamps comes down to what it cost the company to make them. The lamps use 20 LEDs arranged in 10 pairs. The XT-E LEDs cost $1.50 each in low volume. High volume customers are paying well under a dollar. Still Cree's internal manufacturing cost would have to be substantial – perhaps accounting for more than half of the price of the 60W-equivalent lamps.

Cree Omni-directional LED bulb

The high-voltage LEDs would certainly simplify the driver design. Still the driver adds cost, as does the glass silicone-coated dome. And Cree is assembling the lamps in the US for now and backing them with a ten-year warranty. When all costs are accounted for, the profit margin has to be super slim. Indeed the prices listed above are retail at Home Depot, and the retailer has to get a cut as well.

Still Cree has taken much of the sting out of buying an LED lamp. Most people will see payback in about one year if the lamp is installed in a high-usage socket.

Attachment C. Extracts from 2012 US DOE Solid-State Lighting Multi-Year Programme Plan

Table 3.2: Summary of LED Package Price and Performance Projections

Metric	2011	2013	2015	2020	Goal
Cool White Efficacy (lm/W)	135	164	190	235	266
Cool White Price ($/klm)	9	4	2	0.7	0.5
Warm White Efficacy (lm/W)	98	129	162	224	266
Warm White Price ($/klm)	12.5	5.1	2.3	0.7	0.5

Notes:

1. Projections for cool white packages assume CCT=4746-7040K and CRI=70-80, while projections for warm white packages assume CCT=2580-3710K and CRI=80-90. All efficacy projections assume that packages are measured at 25°C with a drive current density of 35 A/cm^2.
2. Package life is approximately 50,000 hours assuming 70 percent lumen maintenance at a drive current density of 35 A/cm^2.

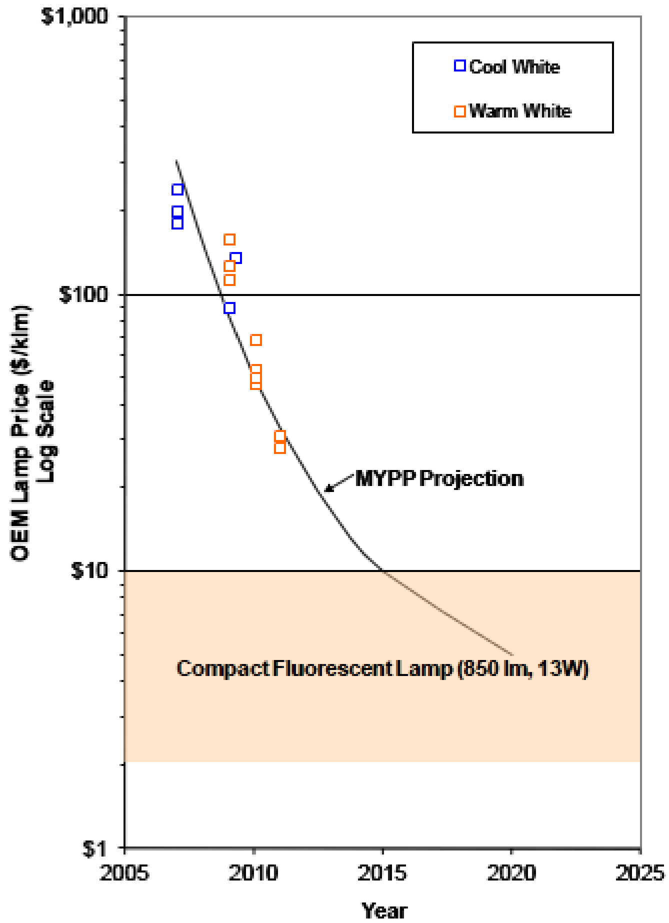


Figure 3.4: White Light Integrated LED Lamp Price Projection (Logarithmic Scale)
Note: Assumes current prices for compact fluorescent price range (13W self-ballasted compact fluorescent; non-dimmable at bottom, and dimmable at top).

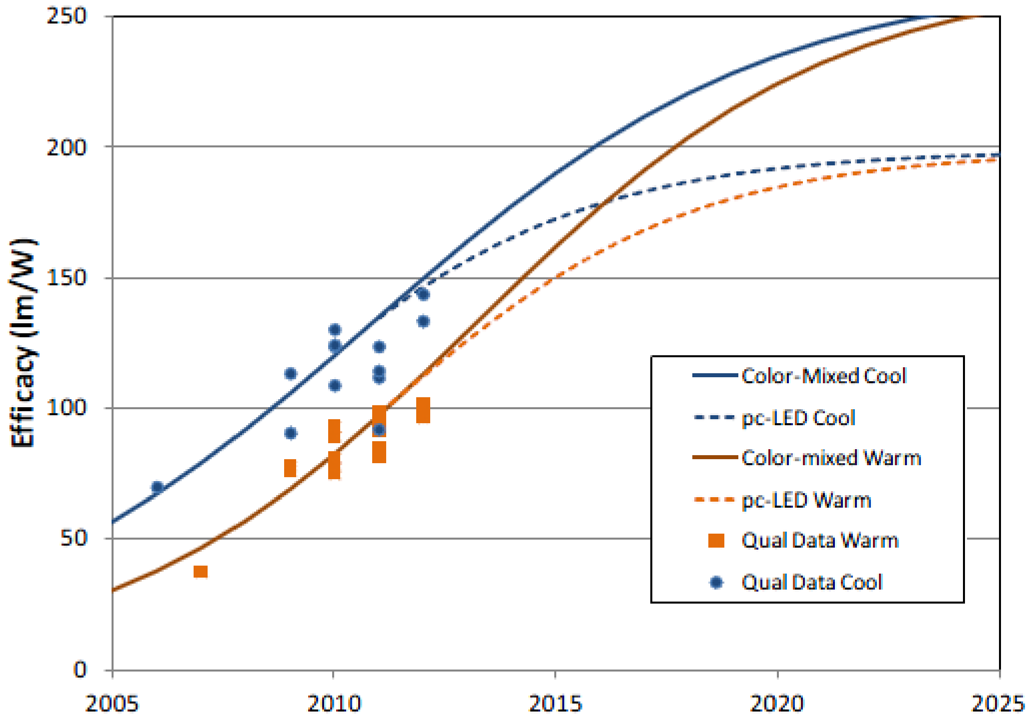


Figure 5.5: White Light LED Package Efficacy Projections for Commercial Product

Notes:

1. "Qualified" data points are confirmed to satisfy the following criteria or may have been normalized for current density if not reported at 35 A/cm^2:
2. Cool White: CRI 70-80; CCT 4746-7040K
3. Warm White: CRI 80-90; CCT 2580-3710K
4. Current density: 35A/cm^2
5. These results are at 25°C package temperature, not steady state operating temperature. Thermal sensitivity may reduce efficacies by as much as 24 percent or so in normal operation, depending on luminaire thermal management.

ANNEX R: LED EFFICACY 2012 (MISC. SOURCES)

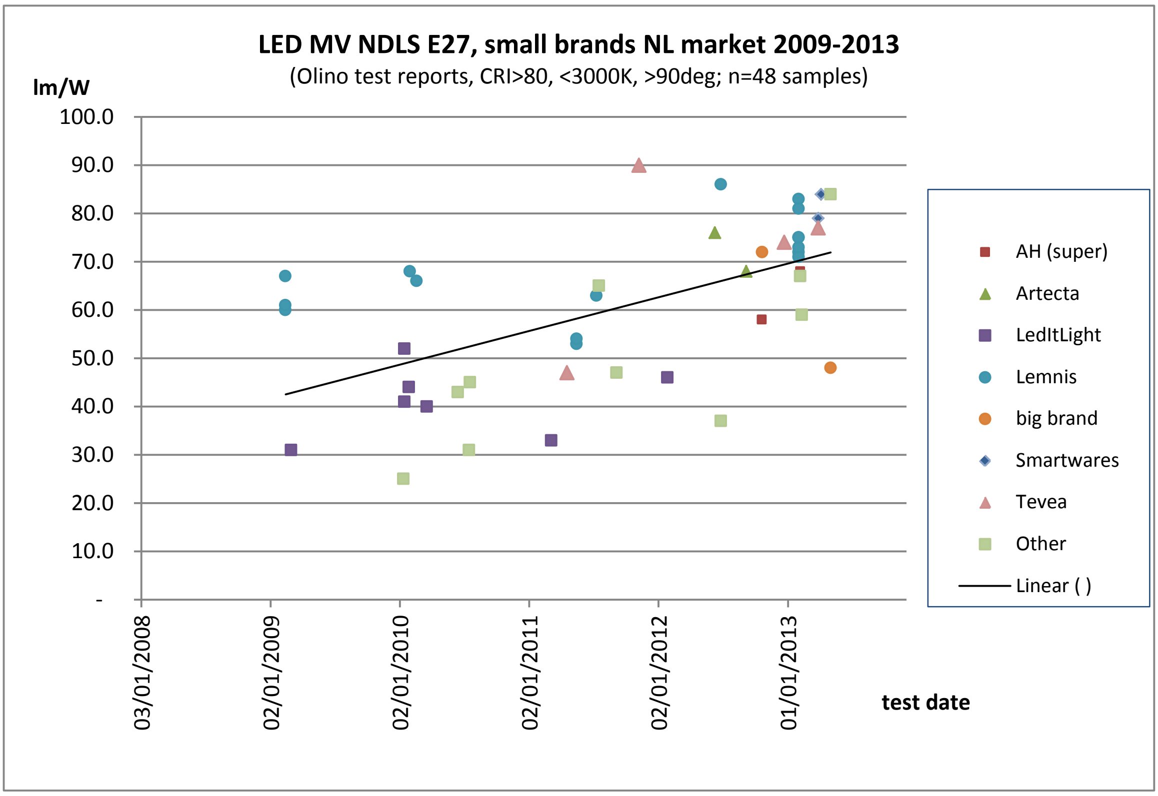


Figure P1. Analysis of test reports at www.olino.org for LED MV NDLS E27 lamps from small brands on the Netherlands market 2009-2013 (analysis: VHK 2013)

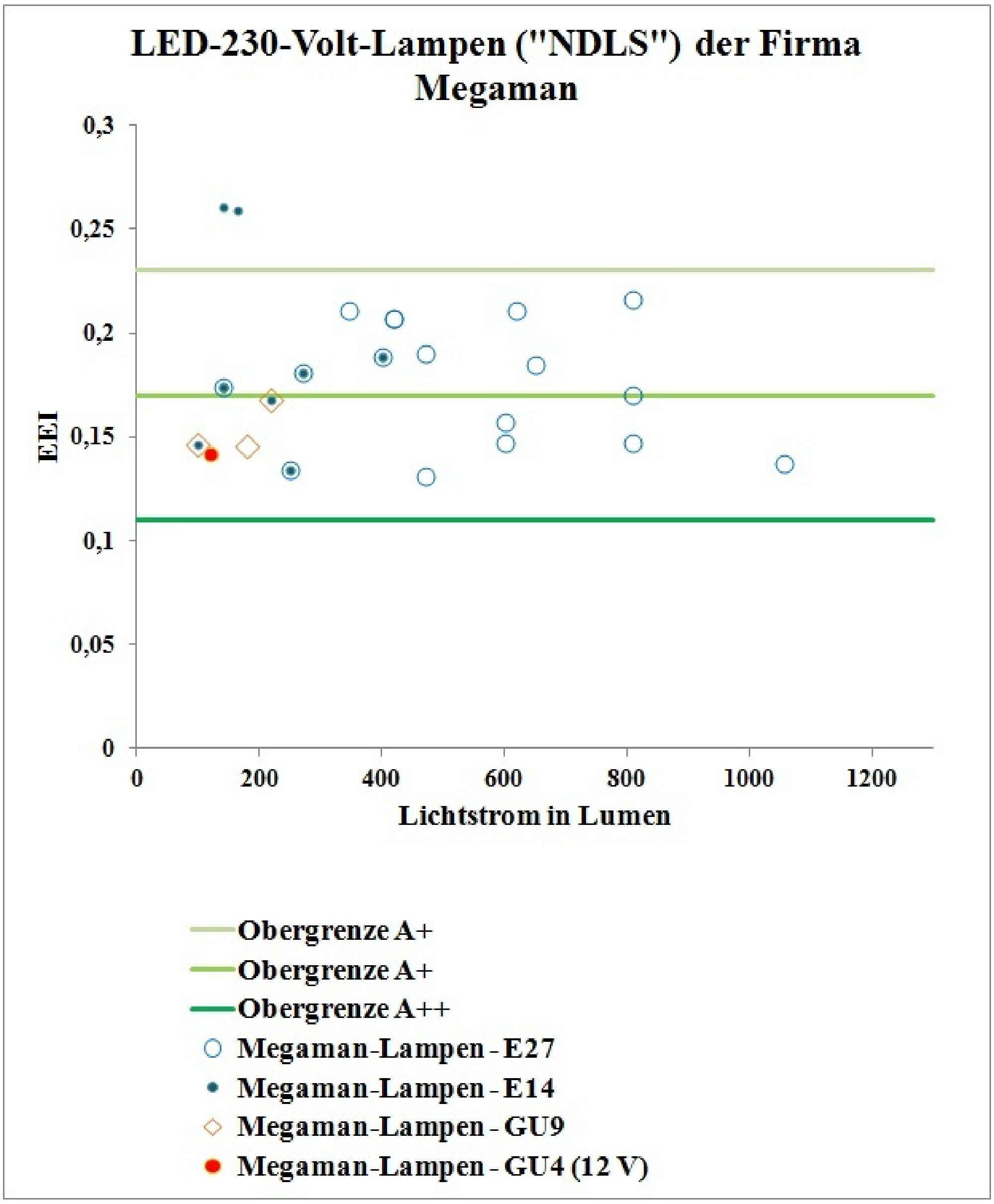


Figure P2. Analysis of manufacturer catalogue Megaman (source: C. Mordziol, UBA, pers. Comm. 2013)

Table P1. 2012 LED Non-directional lamps, with E27 cap - All lamps are tested - selection of lamps with high sales (source C. Kofod, EnergyPiano/ expert for DEA/ Premium Light project, pers. comm., 2013)

	Manufacturer	Watts	Product/model	Lm	lm/W	Pref	EEI	A+ 0.11< EEI ≤0.17	A 0.17< EEI ≤0.24	Life-time (h)	Colour temp (K)	CRI >85
Tested in Premium Light	Philips	11	A60 LED Bulb	806	73	64.5	0.17	1		15000	2700	80
	Samsung	10	LEDA19	650	65	54.3	0.18		1		2700	80
	AustroLed	6	G50 Birne klar	550	92	47.6	0.13	1		30000	2700	
	Bioledex	17	LIMA 17W	1200	71	89.3	0.19		1	30000	2900	85
	LEDON	10	G95 (Globe)	600	60	51.0	0.20		1	25000	2700	90
	Philips	11	LED 11W	806	73	64.5	0.17	1			2700	
	Megaman	11	LED Classic Professional	810	74	64.7	0.17	1		25000	2800	80
	Megaman	11	LED Classic, MM21015	620	56	52.3	0.21		1	25000	2800	80
	Osram	13	Parathom Classic A75 32	1055	81	80.3	0.16	1		30000	2700	80
	Philips	17	Master LED bulb	1055	62	80.3	0.21		1	25000	2700	80
	V-Light	9.5	Bulb	810	85	64.7	0.15	1		25000	2700	85
	IKEA	8.1	LEDARE Clear bulb	400	49	37.2	0.22		1	20000	2700	85
	IKEA	8.1	LEDARE Frosted bulb	400	49	37.2	0.22		1	20000	2700	85
	LG Innov	7.5		485	65	43.1	0.17	1		25000	2700	83
	Chinese/Climacare	8		500	63	44.2	0.18		1	50000	3100	80
	Lysexperten	6		500	83	44.2	0.14	1		30000	3000	75
	Luxinia	7	Luxinia LED	470	67	42.1	0.17	1		15000	2600	90
	Kanlux	8	Kanlux LED	650	81	54.3	0.15	1		40000	3100	70
	LEDURO	12		1050	88	80.0	0.15	1		40000	3000	80
	Philips	12	My ambiance	806	67	64.5	0.19		1	25000	2700	80
	Philips	9.5	LED stdr 48W	600	63	51.0	0.19		1		2700	80
	Philips	4	LED Flame 4W	330	83	32.2	0.12	1			2700	80
	Osram	4	LED star Flame	200	50	22.2	0.18		1		3000	80
	Megaman	11		810	74	64.7	0.17	1			2800	80
	Silver	7	Silver LED 7W	450	64	40.7	0.17	1		50000	3000	
Danish market sur-veillance test	Philips	9	My Vision - measured	652	72	54	0.17	1		25000	2700	91
	Philips	12	My Ambiance	852	71	67	0.18		1	25000	2700	80
	IKEA	8.1	LEDERA frosted bulb	364	45	35	0.23		1	20000	2700	93
	IKEA	4.3	LEDERA	189	44	21	0.20		1	20000	2600	93
	Osram	12	Parathom - measured	743	62	60	0.20		1	25000	3000	81
					68			**15**	**15**			