To: Paul Hodson, Robert Nuij and Ruben Kubiak

From: Michael Scholand and Marie Baton, CLASP and Nils Borg, eceee

Date: 24 July 2015

Re: Stage 3 for Directional Mains-Voltage Filament Lamps in EU No 1194/2012

EU No 1194/2012 established a process and set of criteria that must be studied through a detailed market assessment in order for Stage 3 of mains-voltage filament lamps to remain in place and take effect in September 2016.[1] The process established under EU No 1194/2012 sets out three conditions that the Commission must meet:

(1) produce evidence through a detailed market assessment;

(2) communicate that evidence to the Consultation Forum; and

(3) the detailed market assessment must confirm that there are mains-voltage lamps on the market which meet four specific criteria.

At the Consultation Forum meeting on 25 June 2015, Paul Hodson made it clear that he feels the Commission has complied condition #1 to produce evidence through a detailed market assessment by its publication on 22 May 2015 titled "Market Assessment of Directional Mains-Voltage Lamps related to Stage 3 of Commission Regulation (EU) No 1194/2012" by VHK (Van Holsteijn en Kemna BV).[2] Mr. Hodson indicated that he believes the Commission has complied with condition #2 to communicate that evidence to the Consultation Forum via their email message of 22 May. And finally, Mr. Hodson made it clear that the Commission was now soliciting input from the Consultation Forum as to whether all aspects of condition #3 had been met – confirming there are mains-voltage lamps on the market that meet the four criteria listed in Table 1 below.

CLASP agrees that the Commission has complied with conditions #1 and #2, and in this memo we document how through our study of VHK's detailed market assessment and some of our own market research, we find that the four criteria contained in condition #3 have also been met.

Thus, with all three conditions of the process established under 1194/2012 met, the Commission would be justified to keep the Stage 3 requirement for mains-voltage filament lamps in place.

[1] More detail on the context for these criteria can be found on the last page of this memo.

[2] See: https://ec.europa.eu/energy/sites/ener/files/documents/Draft%20Final%20Market%20Assessment%20data.pdf

Table 1. The four criteria from 1194/2012 that mains-voltage lamps must meet[3]

Four Criteria from 1194/2012 **"***there are mains-voltage lamps on the market that are:*	**Criteria met?**
(1) compliant with the maximum EEI requirement in stage 3;	**Yes**, there are mains-voltage lamps on the market that are compliant with the maximum EEI requirements in Stage 3. We found 73% of the 490 models of mains-voltage LED lamps in the VHK draft market assessment already meet the September 2016 requirement. And, LED efficacy is improving, thus new models introduced to the market are offering better (lower) EEI values than their predecessors.
(2) affordable in terms of not entailing excessive costs for the majority of end-users;	**Yes**, from a life-cycle cost and payback period point of view, the LED replacement lamps are affordable. We performed detailed economic calculations on four lamps which are sold by LightingEurope members and represent higher-quality models in the market (and thus may be slightly more expensive than other LED lamps). If the affordability criterion is met for these four lamps, then it will also be met for lower-priced lamps. While the first-cost of LED lamps is often higher than halogen, the LCC is already lower and the payback period is very short. And, it is expected that prices for LED lamps will diminish when the MEPS take effect and LED becomes the standard product. Finally, it is important to note that this criterion assesses affordability for the "majority" of end-users in Europe, not "all" end-users.
(3) broadly equivalent in terms of consumer-relevant functionality parameters to mains-voltage filament lamps available on the date of entry into force of this Regulation, including in terms of luminous fluxes spanning the full range of reference luminous fluxes listed in Table 6;	**Yes**, as covered in detail in the VHK draft market assessment, there are replacements that are identical and/or solutions that are broadly equivalent for all flux levels listed in Table 6 and for other relevant consumer-functionality parameters, including beam angles (see our analysis in this memo). Colour rendering is highlighted as being one such parameter – and we have confirmed there are many models with CRI ≥ 90 that meet Stage 3. We also take note of literature and expert debate about the short-comings of CRI as a colour metric for white-light LED lamps from an end-user perspective.
(4) compatible with equipment designed for installation between the mains and filament lamps available on the date of entry into force of this Regulation according to state-of-the-art requirements for compatibility."	**Yes**, as demonstrated by the detailed dimmer compatibility tables published by OSRAM, Philips, GE, Havells-Sylvania and other lighting companies, LED lamps offered on the market today are compatible with dimmers that were available on the market on date of entry into force (i.e., 3 January 2013). Also, LEDs produce 80-90% less waste heat than halogen lamps, ensuring that LEDs can be operated and are compatible with fixtures designed for directional halogen lamps.

The following text offers a more detailed look at each of these four criteria and our assessment of them with respect to the summaries presented above in Table 1.

[3] If any one of these four criteria is deemed not to have been met, then Stage 3 for mains-voltage filament lamps will not take effect on 1 September 2016.

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Criterion 1 - compliant with the maximum EEI requirement in stage 3

A simple analysis of the LED lamps contained in the VHK Market Assessment shows that 73% of the LED lamps presented in the report already meet or exceed the Stage 3 requirement for LED lamps of an EEI less than or equal to 0.20. The graph below presents the LED EEI values (n=490 models) with the red line demarcating the maximum EEI value for LED lamps. The lamps that have an EEI at or below the red line pass the Stage 3 requirement.

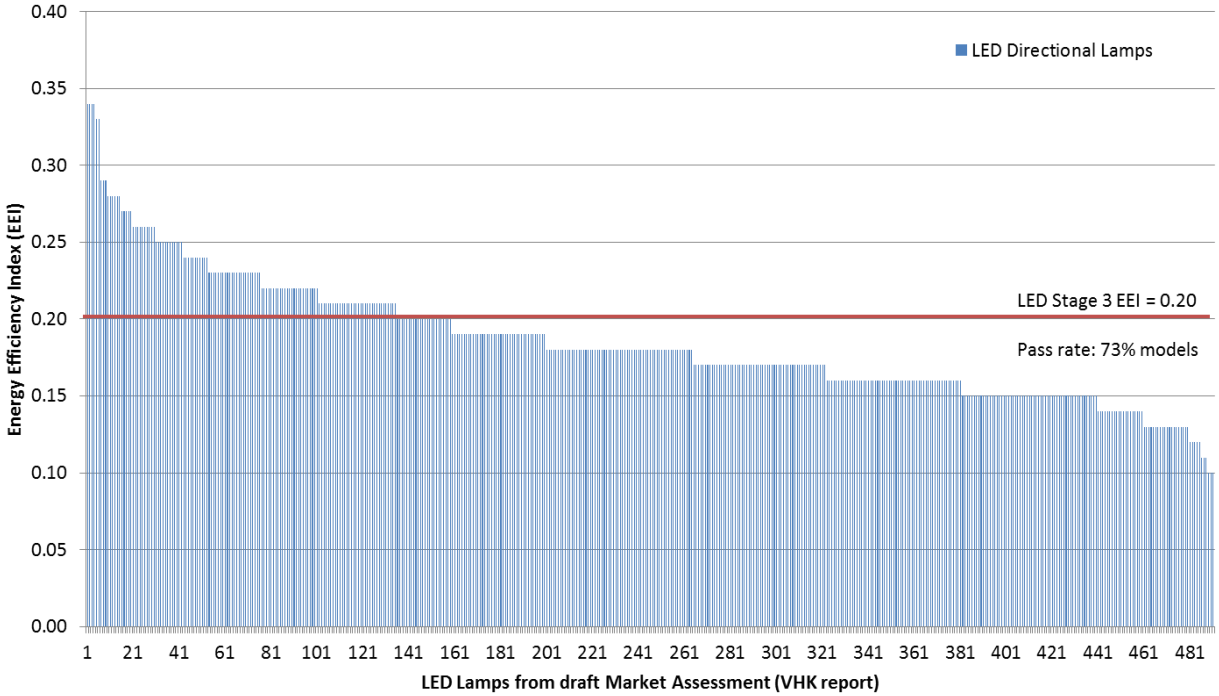


Figure 1. Distribution of EEI Values for LED Lamps Contained in the VHK Market Assessment[4]

Furthermore, LED Lamps are continuing to improve in efficacy, with companies introducing new product lines incorporating more efficacious LED every six months. The US Department of Energy has published a Multi-Year Program Plan which shows the projection of LED efficacy in the coming years.[5]

[4] See: https://ec.europa.eu/energy/sites/ener/files/documents/Draft%20Final%20Market%20Assessment%20data.pdf
[5] See Table 2.3 and Figure 4.1 in Solid-State Lighting Research and Development: Multi-Year Program Plan, SSL Program, Building Technologies Office, Office of Energy Efficiency and Renewable Energy, US Department of Energy, April 2014 (updated May 2014), Link: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf

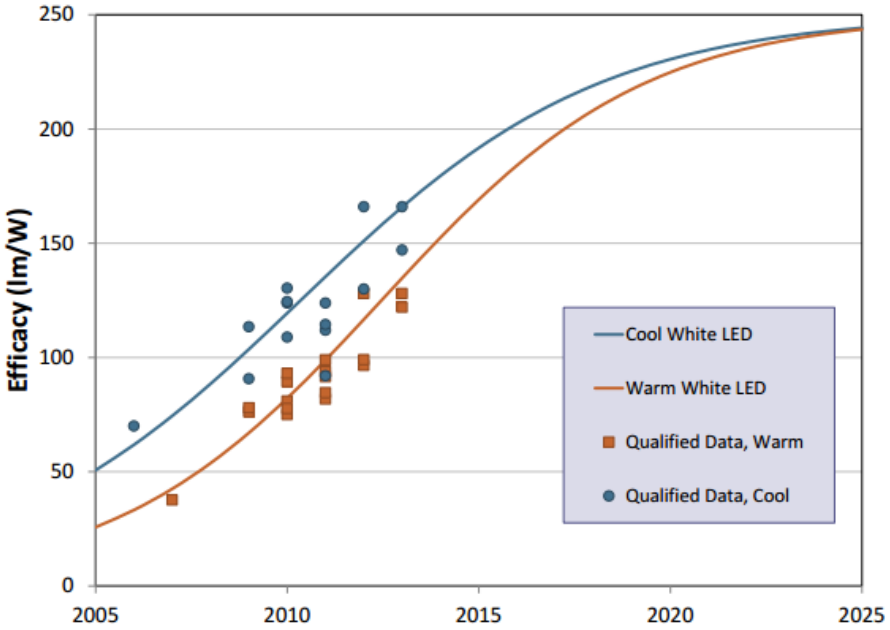


Figure 2. White-Light LEDs phosphor-coated LED package performance for commercial product (US DOE SSL MYPP, 2014)[6]

As these more efficient LEDs are incorporated into consumer products, even more models will meet and exceed the EEI Stage 3 requirement for LED lamps of 0.20, offering consumers even more choice in quality LED lighting.

Criterion 1 is met. From this evidence provided in the VHK Market Assessment, more than 70% of the LED lamps available on the market already exceed the regulation for September 2016, so this criterion has been met.

[6] Figure 4.1 from Solid-State Lighting Research and Development: Multi-Year Program Plan, SSL Program, Building Technologies Office, Office of Energy Efficiency and Renewable Energy, US Department of Energy, April 2014 (updated May 2014), Link: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf

Criterion 2 - affordable in terms of not entailing excessive costs for the majority of end-users

This criterion calls for the Commission to determine if there are Stage 3 compliant LED lamps are "affordable in terms of not entailing excessive costs for the majority of end-users", thus to meet this criteria the Commission must determine whether the majority of end-users will benefit from the improved affordability of LED lighting.

Affordability can encompass several economic factors, but during the Consultation Forum meeting on 25 June 2015, the Commission made it clear that in the context of Ecodesign, life-cycle cost has been cited as the most appropriate indicator of what is considered affordable. The Ecodesign Directive 2009/125/EC[7] of the European Parliament and of the Council of 21 October 2009 established a framework for the setting of ecodesign requirements for energy-related products (recast) in Annex II, Method for setting specific ecodesign requirements (referred to in Article 15(6)). The text from the Ecodesign Directive confirms the position of the Commission, stating that the level of energy-efficiency must be set aiming at the minimum life-cycle cost to end-users:

> *"Concerning energy consumption in use, the level of energy efficiency or consumption must be set aiming at the life-cycle cost minimum to end-users for representative product models, taking into account the consequences on other environmental aspects. The life cycle cost analysis method uses a real discount rate on the basis of data provided from the European Central Bank and a realistic lifetime for the product; it is based on the sum of the variations in purchase price (resulting from the variations in industrial costs) and in operating expenses, which result from the different levels of technical improvement options, discounted over the lifetime of the representative product models considered. The operating expenses cover primarily energy consumption and additional expenses in other resources, such as water or detergents."*

Thus, the minimum life-cycle cost (LCC) represents the targeted level at which the requirements are set under Ecodesign. Extending that definition to this criterion for affordability, CLASP prepared a series of calculations to determine whether LED lamps actually did represent the least LCC option for consumers. Four case studies were prepared looking at the net present value (using a 5% discount rate) of future life-cycle operating costs. In all cases, the LED lamps represented the least LCC option for end-users.

Table 2. Summary results of the Net Present Value (Discounted to 2015 Euros) Life-Cycle Cost calculations for Halogen vs. LED Directional Lamps

Case Study (see below)	NPV LCC Halogen	NPV LCC LED lamp	NPV LCC Savings	Payback Period (at 2 hours use/day)
#1. Small Diameter (PAR 16)	€159.37	€20.81	€138.56	0.3 years
#2. Large Diameter (PAR 38)	€861.51	€164.92	€696.59	1.4 years
#3. Small Diameter Dimmable	€159.37	€25.33	€134.04	0.8 years
#4. Medium Diameter (PAR 30)	€564.60	€90.20	€474.39	1.2 years

Note: the time period of analysis is the lifetime of the LED lamp. Detail on each of these LCC calculations appears in the following four pages, one page summarising the results of each case study. NPV uses a discount rate of 5%.

[7] Ecodesign Directive: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF

The detailed inputs such as the lamp models, cost of electricity, discount rate and other inputs to these calculations can be found on the following four pages, one page for each case study. These case study summary pages also present more detailed economic findings.

It should be noted that we intentionally performed these economic calculations on LED lamps sold by LightingEurope members, tending toward higher-quality models in the market. These LED lamps are generally more expensive compared with other models available on the market which are of 'normal' quality. The reason for this approach was that if we found the affordability criterion is valid for these slightly more expensive LED lamps, then it would also be valid for lower-priced lamps.

Making reference to this criterion on affordability, some Member States have commented that the requirement has not been met because there may be households in Europe with dimmer compatibility issues that need to replace dimmer circuits in their homes (please see our discussion on dimmer compatibility in the section on criterion 4). When considering this point, it is important to note that criterion 2 reads: "affordable in terms of not entailing excessive costs for the majority of end-users" (emphasis added). The use of the word 'majority' when referring to end-users is standard language used in policy measures like Ecodesign and other similar minimum performance standards programmes around the world. This term charges the decision-makers with a responsibility to look broadly at the market and make a choice that will benefit the majority of consumers.

Our discussion in the section on Criterion 4 and the tables in Annex C show how the issue of dimmer compatibility is very small and does not, therefore, constitute a majority of end-users (indeed, many directional lamps are used on simple switched circuits and don't use a dimmer at all). Furthermore, our calculations on affordability for Criterion 2 have found that consumers will benefit from lower life-cycle costs (i.e., more 'affordable' lighting) even at very low usage rates of 1 hour per day. The consumers who have incompatible dimmers will have to replace those circuits in their homes at some point, whether now or in the future, that issue will remain. However, the vast majority of consumers will not have this problem, and thus will benefit from affordable lighting. Our calculations show that the net present value of the life-cycle cost is substantially less with LED lighting primarily because LED technology is so much more efficient in its use of electricity (80-90% more efficient). Thus, in all cases, the LED lamp represents the least-cost LCC option when compared to halogen.

The following points emphasize this benefit when these lamps are operated for 2 hours per day:

- Case Study #1: the net present value of LCC savings from avoided replacement lamp and electricity consumption is €138.56. Those savings are 66 times greater than the difference between the price of the OSRAM halogen and the price of the OSRAM LED lamp.
- Case Study #2: the net present value of LCC savings from avoided replacement lamp and electricity consumption of €696.59. Those savings are 42 times greater than the difference between the price of the Sylvania halogen and the OSRAM LED lamp.
- Case Study #3: the net present value of LCC savings from avoided replacement lamp and electricity consumption of €134.04. Those savings are 26 times greater than the difference between the price of the halogen lamp and the Sylvania LED lamp.
- Case Study #4: the net present value of LCC savings from avoided replacement lamp and electricity consumption of €474.39. Those savings are 31 times greater than the difference between the price of the Sylvania halogen and the General Electric LED lamp.

More detail on these four case studies can be found on the following four pages.

Case Study #1. Small Diameter (PAR 16, GU10) Lamp Comparison[8]

- OSRAM 155591B3 Halopar 16 Alu 64824 FL 230V GU10, 50W Halogen, 2800K, 100 CRI, 2000 hours life, Energy Class D, €2.90 including tax = €2.90 total, (Link)
- OSRAM LED STAR PAR 16, 5.5W, 36 degree Spot light, 2700K, 350 lumens, 80 CRI, 15000 hours life, A+ energy Class; €4.99 including tax = €4.99 total, (Link)
- Assume electricity €0.197/kWh; 330 grams CO_2/kWh; discount rate 5%; 20 lamps / household; for this calculation assume shipping costs are zero because both retailers offer free shipping if the total order exceeds a certain value and when ordering these spot lights, users usually order multiples.

Figure 3. LCC of Halogen vs. LED – 17 years shown

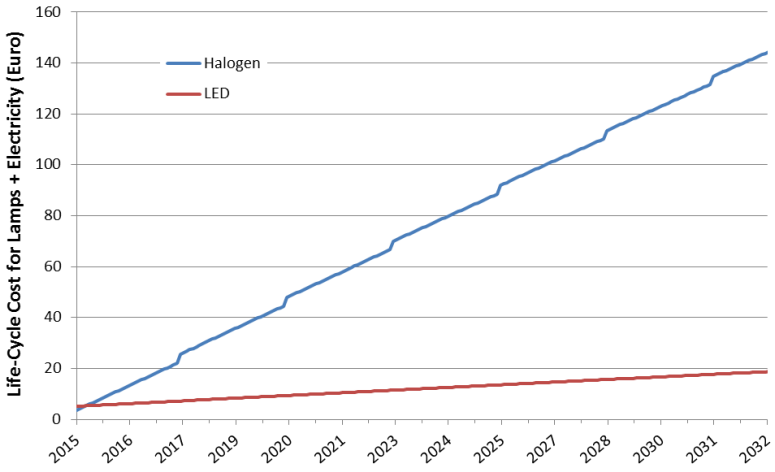


Figure 3 depicts the life-cycle cost (LCC) of halogen vs. LED from now through 2032 for the lamps operated 2 hours/day, including both lamp and electricity costs. The LCC for halogen exceeds that of LED in the first year due to the electricity operating cost, which exceeds the incremental increase in first cost within four months. And the LCC for the halogen lamp continues to grow, far exceeding the costs for the OSRAM LED over the same time period.

Note that the OSRAM LED lamp in this example is rated for 15,000 hours of life, and thus it would last an estimated 21 years in this 2 hour/day installation. Applying a 5% discount rate to future savings over the lifetime of the LED lamp, the net present value of LCC savings from avoided replacement lamp and electricity consumption is €138.56. Those savings are 66 times greater than the difference between the price of the OSRAM halogen and the price of the OSRAM LED lamp.

Table 3. Comparison of Halogen and LED – PAR16 Case Study

Calculation Outputs (per lamp):	HAL	LED	
Annual electricity consumption for each lamp type:	36.5	4.0	kWh/year
Annual electricity savings per LED lamp:	---	32.5	kWh/year
Percent electricity savings:	---	89%	percent
Annual electricity running cost per lamp:	€7.19	€0.79	€/year
Savings in electricity costs per lamp per year:		€6.40	€/year
Simple payback period in years:		0.33	years
Annual running cost for a household (20 lamps):	€143.81	€15.82	€/year
Annual household (20 lamps) savings in electricity costs:		€127.99	€/year
Annual CO2 emissions due to electricity for one lamp:	12.0	1.3	kg CO2/year
CO2 savings per lamp from switching to LED:		10.7	kg CO2/year
CO2 savings per household if all lamps were switched:		214	kg CO2/year
Expected service life of each lamp:	3	21	years
Net present value of Life-Cycle Cost over 21 years:	€159.37	€20.81	Euro/lamp
Savings (net present value) with LED:		€138.56	Euro/lamp
Discounted LCC over 21 years for a household (20 lamps):	€3,187.40	€416.18	Euro/hhld
Savings (net present value) per household with the LED:		€2,771.22	Euro/hhld

Table 3 shows other savings figures comparing the halogen baseline with LED at two hours per day. These results show that 89% of the electricity consumption is saved through LED, leading to an annual savings of €6.20 per lamp per year, or €128 savings per year for a household with twenty lamps.

Table 4. Comparison of HAL and LED for Variable Operating Hours

OSRAM LED Star PAR16 5.5W	1 hr/day	2 hr/day	3 hr/day
First cost difference vs. halogen	€ 2.09	€ 2.09	€ 2.09
Annual electricity savings (kWh)	16.2	32.5	48.7
Annual electricity savings (€)	€ 3.20	€ 6.40	€ 9.60
Payback period (years)	0.7	0.3	0.2
Payback period (months)	8	4	3
LED NPV LCC savings (2015 Euro)	€ 137.36	€ 138.56	€ 137.57

Table 4 summarises the savings for consumers based on three daily usage rates – 1, 2 and 3 hours / day. The payback period is below one year for all three usage rates – ranging from 8 months down to 3 months. The NPV LCC savings is approximately €137 per lamp (discounted to 2015 Euros). **In all cases, the LED lamp represents the least life-cycle cost option compared to halogen.**

[8] Please see Annex B of this report for 39 German consumer comments about their very positive impressions of this OSRAM LED lamp (average score is 5 stars out of a possible 5).

Case Study #2. Large Diameter (PAR 38) Lamp Comparison

- Sylvania Hi-Spot 120, 100W Halogen Lamp, PAR 38, 100W, 240V, 3000K, 1110 lumens, Energy Class D; £6.40 + £1.28 tax + £3.95 shipping = £11.63 => €16.17 total, (Link)
- OSRAM Parathom LED Lamp, PAR 38, 17W, 230V, E27 base, 2700K, 1050 lumens; 40 000 hours rated life, Energy Class A; €28.00 including tax + €4.90 shipping = €32.90 total, (Link)
- Assume electricity €0.197/kWh; 330 grams CO_2/kWh; discount rate 5%; 10 lamps / household

Figure 4. LCC of Halogen vs. LED – 17 years shown

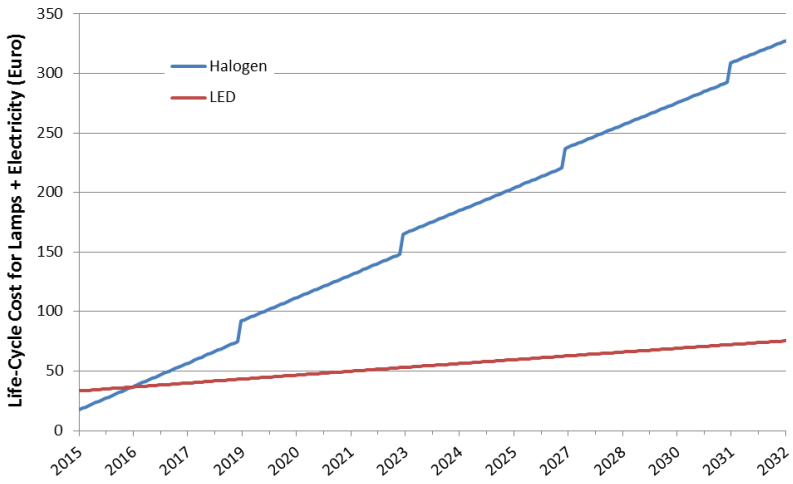


Figure 4 depicts the life-cycle cost (LCC) of halogen vs. LED from now through 2032 for the lamps operated 2 hours per day, including both lamp and electricity costs. The LCC for halogen exceeds that for LED within 1.4 years, and then grows to far exceed the costs for the LED for the same time period.

Note that the OSRAM LED lamp in this example is rated for 40,000 hours of life, and thus it would last an estimated 55 years in this 2 hour/day installation. Applying a 5% discount rate to future savings over the lifetime of the LED lamp, the net present value of LCC savings from avoided replacement lamp and electricity consumption of €696.59. Those savings are 42 times greater than the difference between the price of the Sylvania halogen and the OSRAM LED lamp.

Table 5. Comparison of Halogen and LED – PAR38 Case Study

Calculation Outputs (per lamp):	HAL	LED	
Annual electricity consumption for each lamp type:	73.0	12.4	kWh/year
Annual electricity savings per LED lamp:	---	60.6	kWh/year
Percent electricity savings:	---	83%	percent
Annual electricity running cost per lamp:	€14.38	€2.44	€/year
Savings in electricity costs per lamp per year:		€11.94	€/year
Simple payback period in years:		1.40	years
Annual running cost for a household (10 lamps):	€143.81	€24.45	€/year
Annual household (10 lamps) savings in electricity costs:		€119.36	€/year
Annual CO2 emissions due to electricity for one lamp:	24.1	4.1	kg CO2/year
CO2 savings per lamp from switching to LED:		20.0	kg CO2/year
CO2 savings per household if all lamps were switched:		200	kg CO2/year
Expected service life of each lamp:	4	55	years
Net present value of Life-Cycle Cost over 55 years:	€861.51	€164.92	Euro/lamp
Savings (net present value) with LED:		€696.59	Euro/lamp
Discounted LCC over 55 years for a household (10 lamps):	€8,615.08	€1,649.18	Euro/hhld
Savings (net present value) per household with the LED:		€6,965.90	Euro/hhld

Table 5 shows other savings figures comparing the halogen baseline with LED at two hours per day. These results show that 83% of the electricity consumption is saved through LED, leading to an annual savings of €11.94 per lamp per year, or nearly €120 savings per year for a household with ten lamps. Each LED lamp installed will save approximately 20 kilograms of CO_2 emissions per year.

Table 6. Comparison of HAL and LED for Variable Operating Hours

OSRAM PAR38 Parathom 17W	1 hr/day	2 hr/day	3 hr/day
First cost difference, HAL vs. LED	€ 16.73	€ 16.73	€ 16.73
Annual electricity savings (kWh)	30.3	60.6	90.9
Value of electricity savings (€/yr)	€ 5.97	€ 11.94	€ 17.90
Simple payback period (years)	2.8	1.4	0.9
Simple payback period (months)	34	17	11
Life-cycle cost savings (NPV, 2015)	€ 667.09	€ 696.59	€ 723.63

Table 6 summarises the savings for consumers based on three daily usage rates – 1, 2 and 3 hours / day. The payback period ranges from 2.8 years for a low usage rate of 1 hour/day up through less than 1 year (approx. 11 months) at 3 hours per day. The NPV LCC savings is approximately €723 per lamp (discounted to 2015 Euros). **In all cases, the LED lamp represents the least life-cycle cost option compared to halogen.**

Case Study #3. Dimmable LED Small Diameter (PAR 16) Lamp Comparison

- OSRAM 155591B3 Halopar 16 Alu 64824 FL 230V GU10, 50W Halogen, 2800K, 100 CRI, 2000 hours life, Energy Class D, €2.90 including tax = €2.90 total, (Link)
- Sylvania 6W RefLED ES50 Dimmable GU10, 6W, 36 degree Spot light, 3000K, 345 lumens, 80 CRI, 15000 hours life, A+ energy Class; £5.70 => €8.07 including tax = €8.07 total, (Link)
- Assume electricity €0.197/kWh; 330 grams CO_2/kWh; discount rate 5%; 20 lamps / household; for this calculation assume shipping costs are zero because both retailers offer free shipping if the total order exceeds a certain value and when ordering these spot lights, users usually order multiples.

Figure 5. LCC of Halogen vs. LED – 17 years shown

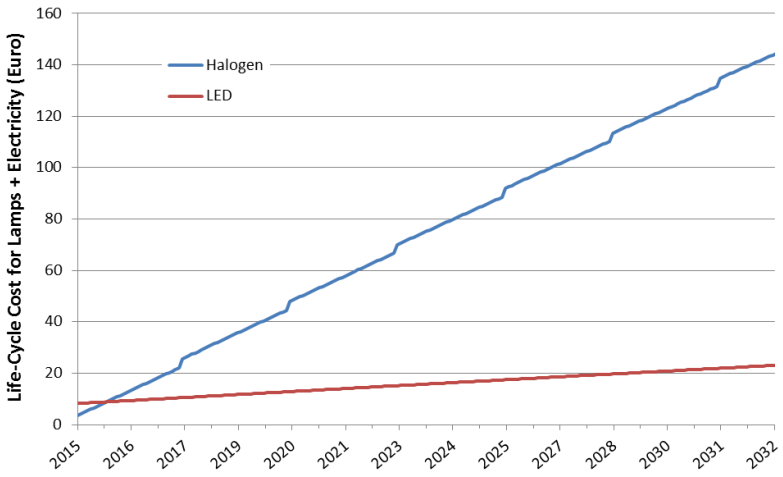


Table 7. Comparison of Halogen and LED – Dimmable PAR16 Case Study

Calculation Outputs (per lamp):	HAL	LED	
Annual electricity consumption for each lamp type:	36.5	4.4	kWh/year
Annual electricity savings per LED lamp:	---	32.1	kWh/year
Percent electricity savings:	---	88%	percent
Annual electricity running cost per lamp:	€7.19	€0.86	€/year
Savings in electricity costs per lamp per year:		€6.33	€/year
Simple payback period in years:		0.82	years
Annual running cost for a household (20 lamps):	€143.81	€17.26	€/year
Annual household (20 lamps) savings in electricity costs:		€126.55	€/year
Annual CO2 emissions due to electricity for one lamp:	12.0	1.4	kg CO2/year
CO2 savings per lamp from switching to LED:		10.6	kg CO2/year
CO2 savings per household if all lamps were switched:		212	kg CO2/year
Expected service life of each lamp:	3	21	years
Net present value of Life-Cycle Cost over 21 years:	€159.37	€25.33	Euro/lamp
Savings (net present value) with LED:		€134.04	Euro/lamp
Discounted LCC over 21 years for a household (20 lamps):	€3,187.40	€506.54	Euro/hhld
Savings (net present value) per household with the LED:		€2,680.85	Euro/hhld

Table 8. Comparison of HAL and LED for Variable Operating Hours

Sylvania PAR16 Dimmable GU10	1 hr/day	2 hr/day	3 hr/day
First cost difference, HAL vs. LED	€ 5.17	€ 5.17	€ 5.17
Annual electricity savings (kWh)	16.1	32.1	48.2
Value of electricity savings (€/yr)	€ 3.16	€ 6.33	€ 9.49
Simple payback period (years)	1.6	0.8	0.5
Simple payback period (months)	20	10	7
Life-cycle cost savings (NPV, 2015)	€ 132.81	€ 134.04	€ 133.08

Figure 5 depicts the life-cycle cost (LCC) of halogen vs. LED from now through 2032 for the lamps operated 2 hours per day, including both lamp and electricity costs. The LCC for halogen exceeds that for LED in 10 months (i.e., < 1 year), and then grows to far exceed the costs for the dimmable LED lamp for the same time period.

Note that the Sylvania LED lamp in this example is rated for 15,000 hours of life, and thus it would last an estimated 21 years in this 2 hour/day installation. Applying a 5% discount rate to future savings over the lifetime of the LED lamp, the net present value of LCC savings from avoided replacement lamp and electricity consumption of €134.04. Those savings are 26 times greater than the difference between the price of the halogen lamp and the Sylvania LED lamp.

Table 7 shows other savings figures comparing the halogen baseline with LED at two hours per day. These results show that 88% of the electricity consumption is saved through LED, leading to an annual savings of €6.33 per lamp per year, or €126 savings per year for a household with twenty lamps. Each LED lamp installed will save approximately 10 kilograms of CO_2 emissions per year.

Table 8 summarises the savings for consumers based on three daily usage rates – 1, 2 and 3 hours / day. The payback period ranges from 1.6 years for a low usage rate of 1 hour/day up through less than 1 year (approx. 7 months) at 3 hours per day. The NPV LCC savings is approximately €133 per lamp (discounted to 2015 Euros). **In all cases, the LED lamp represents the least life-cycle cost option compared to halogen.**

Case Study #4. Medium Diameter (PAR 30) Lamp Comparison

- Sylvania Hi-Spot 95 PAR30 Halogen, 100W lamp, 240V, 30 degrees, 2900K, Energy Class D £7.95 including VAT + £3.50 shipping = £11.45 => €16.21 total, (Link)
- GE LED PAR30, 240V, 12W, 35 degrees, very warm white (2700K), E27, 900 lumens, 25 000 hours rated life, Energy Class A+, £18.77 including VAT + £3.50 shipping = £22.27 => €31.53 (Link)
- Assume electricity €0.197/kWh; 330 grams CO_2/kWh; discount rate 5%; 10 lamps / household

Figure 6. LCC of Halogen vs. LED – 17 years shown

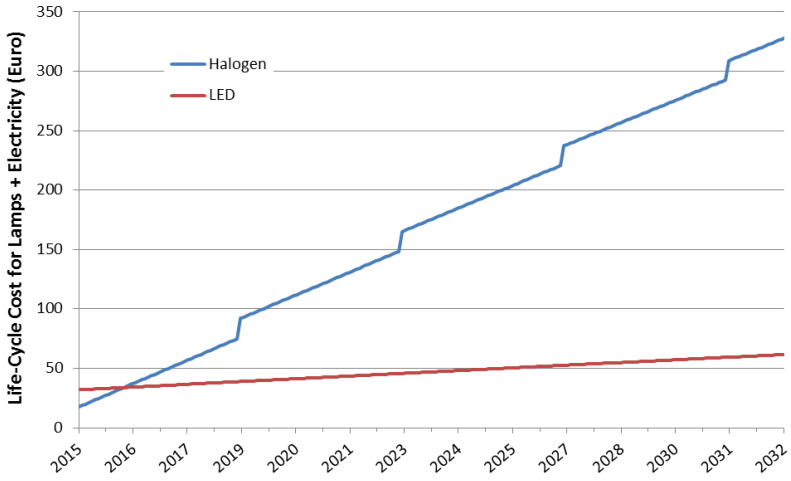


Figure 6 depicts the life-cycle cost (LCC) of halogen vs. LED from now through 2032 for the lamps operated 2 hours per day, including both lamp and electricity costs. The LCC for halogen exceeds that for LED within 1.2 years, and then grows to far exceed the costs for the LED for the same time period.

Note that the General Electric LED lamp in this example is rated for 25,000 hours of life, and thus it would last an estimated 34 years in this 2 hour/day installation. Applying a 5% discount rate to future savings over the lifetime of the LED lamp, the net present value of LCC savings from avoided replacement lamp and electricity consumption of €474.39. Those savings are 31 times greater than the difference between the price of the Sylvania halogen and the General Electric LED lamp.

Table 9. Comparison of Halogen and LED – PAR30 Case Study

Calculation Outputs (per lamp):	HAL	LED	
Annual electricity consumption for each lamp type:	73.0	8.8	kWh/year
Annual electricity savings per LED lamp:	---	64.2	kWh/year
Percent electricity savings:	---	88%	percent
Annual electricity running cost per lamp:	€14.38	€1.73	€/year
Savings in electricity costs per lamp per year:		€12.66	€/year
Simple payback period in years:		1.21	years
Annual running cost for a household (10 lamps):	€143.81	€17.26	€/year
Annual household (10 lamps) savings in electricity costs:		€126.55	€/year
Annual CO2 emissions due to electricity for one lamp:	24.1	2.9	kg CO2/year
CO2 savings per lamp from switching to LED:		21.2	kg CO2/year
CO2 savings per household if all lamps were switched:		212	kg CO2/year
Expected service life of each lamp:	4	34	years
Net present value of Life-Cycle Cost over 34 years:	€564.60	€90.20	Euro/lamp
Savings (net present value) with LED:		€474.39	Euro/lamp
Discounted LCC over 34 years for a household (10 lamps):	€5,645.96	€902.04	Euro/hhld
Savings (net present value) per household with the LED:		€4,743.92	Euro/hhld

Table 9 shows other savings figures comparing the halogen baseline with LED at two hours per day. These results show that 88% of the electricity consumption is saved through LED, leading to an annual savings of €12.66 per lamp per year, or €126 savings per year for a household with ten lamps. Each LED lamp installed will save approximately 21 kilograms of CO_2 emissions per year.

Table 10. Comparison of HAL and LED for Variable Operating Hours

OSRAM PAR38 Parathom 17W	1 hr/day	2 hr/day	3 hr/day
First cost difference, HAL vs. LED	€ 15.32	€ 15.32	€ 15.32
Annual electricity savings (kWh)	32.1	64.2	96.4
Value of electricity savings (€/yr)	€ 6.33	€ 12.66	€ 18.98
Simple payback period (years)	2.4	1.2	0.8
Simple payback period (months)	29	15	10
Life-cycle cost savings (NPV, 2015)	€ 447.15	€ 474.39	€ 478.89

Table 10 summarises the savings for consumers based on three daily usage rates – 1, 2 and 3 hours / day. The payback period ranges from 2.4 years for a low usage rate of 1 hour/day up through less than 1 year (approx. 10 months) at 3 hours per day. The NPV LCC savings is approximately €470 per lamp (discounted to 2015 Euros). **In all cases, the LED lamp represents the least life-cycle cost option compared to halogen.**

In addition to the LCC comparison, there are other aspects of affordability that may be considered including first-cost. In the 2015 European lighting market, LED lamps are able to maintain a 'price premium' because they are new, high efficiency / high value products in the market. However, if Stage 3 takes effect for mains-voltage directional lamps, we can expect to see these prices erode as volumes of LED lamps will increase and the market becomes more competitive. This will make LED lamps even more affordable (lowering the first cost), further shortening the payback period for consumers.

Competition in the lighting industry is strong, and that competition is evident in the significant price reductions observed in recent years. This cost trend has been studied by market research experts that follow product price trends, and LEDinside[9] has found that "since the beginning of 2011, LED light bulbs had their prices reduced by 30% annually". This trend may slow for certain lamp groups like the (high volume) small diameter LED lamps now that some are reaching price-parity with halogen and others have payback periods of just a few months. As in other product areas, as manufacturers gain more experience with particular technologies, they follow a learning curve[10] of product evolution through their research, continually finding less expensive ways to achieve performance. This learning curve helps to drive down prices for consumers, making high-efficiency products more affordable. Plus, as the efficacy of LEDs increases, the light output per LED will increase and the wattages will become even lower for the same light output (thereby enabling designs with less material and components), manufacturers will experience lower costs with a lower bill of materials and production cost.

Criterion 2 is met. From the evidence available in the market, LED lamps are affordable because they offer lower life-cycle costs than halogen lamps and very short payback periods (many less than one year). Furthermore, prices of LED lamps are falling and are expected to continue to decline with investment in R&D and improvements in LED efficacy.

[9] For the article from LED Inside on price trends in LED lamps (April 2015) please click on the following link: http://www.ledinside.com/news/2015/4/ledinside_osram_to_focus_on_automotive_lighting_smart_lighting_and_led_components_after_splitting_luminaire_business

[10] "A retrospective investigation of energy efficiency standards: policies may have accelerated long term declines in appliance costs", R D Van Buskirk, C L S Kantner, B F Gerke and S Chu, 2014 Environmental Research Letters, 9 114010 see: http://iopscience.iop.org/1748-9326/9/11/114010/pdf/1748-9326_9_11_114010.pdf

Criterion 3 - broadly equivalent in terms of consumer-relevant functionality parameters to mains-voltage filament lamps available on the date of entry into force of this Regulation, including in terms of luminous fluxes spanning the full range of reference luminous fluxes listed in Table 6

The three key functionality parameters which are focused on in this section include luminous flux by lamp type, colour rendering index and beam angles. In all instances, mains-voltage LED lamps have been found to be available on the market offering consumers broadly equivalent performance to mains-voltage halogen lamps.

3a) Luminous Flux by Lamp Type

Table 6 ("Reference luminous flux for equivalence claims") in Annex III of EU No 1194/2012 has three sections which are labelled: "Extra-low voltage reflector type", "Mains-voltage blown glass reflector type", and "Mains-voltage pressed glass reflector type". Of these, only the second and third sections are applicable to Stage 3 on mains-voltage filament lamps, and they contain reference power and luminous flux equivalency levels.

Table 11. The Second section of Table 6, Annex III of EU No 1194/2012: Mains-voltage Blown Glass Reflector Type Lamps

Mains-voltage blown glass reflector type			
Type	**Power (W)**	**Reference Φ 90° (lm)**	**LED Lamps available on the market?**
R50/NR50	25	90	Yes, see VHK report[11], Table 4
	40	170	Yes, see VHK report, Table 4
R63/NR63	40	180	Yes, see VHK report, Table 5
	60	300	Yes, see VHK report, Table 5
R80/NR80	60	300	Yes, see VHK report, Table 6
	75	350	Yes, see VHK report, Table 6
	100	580	Yes, see VHK report, Table 6
R95/NR95	75	350	Yes, General Electric
	100	540	Yes, Kosnic, Toshiba, Kosnic
R125	100	580	Yes, Kosnic, Kosnic
	150	1000	Yes, Toshiba, Kwazar, Sylvania

Note: Table 6 of Annex III in EU No 1194/2012 lists R95/NR95 and R125, however these are not included in the VHK draft market assessment. For this reason, CLASP did some on-line research to try and identify models from a few different manufacturers that meet or exceed the minimum lumen output at 90 degrees for those power equivalencies. Hyperlinks to some examples of specific

[11] See: https://ec.europa.eu/energy/sites/ener/files/documents/Draft%20Final%20Market%20Assessment%20data.pdf

models offered by on-line retailers are included in Table 11 above, by clicking on the manufacturer's brand name. From these models and the research in the VHK report, it is clear to see that there are LED Lamps available on the market at all of these levels of light output in these particular lamp shapes.

Table 12. The Third section of Table 6, Annex III of EU No 1194/2012: Mains-voltage Pressed Glass Reflector Lamps

Mains-voltage pressed glass reflector type			
Type	**Power (W)**	**Reference Φ 90° (lm)**	**LED Lamps available on the market?**
PAR16	20	90	Yes, see VHK report, Tables 18, 19, 20, 21 and 22
	25	125	Yes, see VHK report, Tables 18, 19, 20, 21 and 22
	35	200	Yes, see VHK report, Tables 18, 19, 20, 21 and 22
	50	300	Yes, see VHK report, Tables 18, 19, 20, 21 and 22
PAR20	35	200	Yes, see VHK report, Tables 9 and 10
	50	300	Yes, see VHK report, Tables 9 and 10
	75	500	Yes, see VHK report, Tables 9 and 10
PAR25	50	350	Yes, Megaman
	75	550	Yes, Bell, Kosnic
PAR30S	50	350	Yes, see VHK report, Tables 12, 13 and 14
	75	550	Yes, see VHK report, Tables 12, 13 and 14
	100	750	Yes, see VHK report, Tables 12, 13 and 14
PAR36	50	350	It appears that this is a low voltage lamp and may not belong in this section of Table 6 covering mains-voltage pressed glass reflector lamps. For example, see the links to: Sylvania, General Electric, others.
	75	550	
	100	720	
PAR38	60	400	Yes, see VHK report, Tables 15, 16 and 17
	75	555	Yes, see VHK report, Tables 15, 16 and 17
	80	600	Yes, see VHK report, Tables 15, 16 and 17
	100	760	Yes, see VHK report, Tables 15, 16 and 17
	120	900	Yes, see VHK report, Tables 15, 16 and 17

Note: Table 6 of Annex III in EU No 1194/2012 lists the shape and size of PAR25 and PAR36, however these are not included in the VHK draft market assessment. For this reason, CLASP did some on-line research to try and identify some models that are PAR25 and found a few from Megaman, Bell and Kosnic. Hyperlinks to some examples of specific models offered by on-line retailers are included in Table 12 above, by clicking on the manufacturer's brand name. Concerning the PAR36 lamp shape, this appears to be a mistake in the regulation because PAR36 is not a mains-voltage reflector lamp,

rather it operates on voltages less than 60V. Thus, it shouldn't be listed in a mains-voltage reflector lamp table because these lower voltages are not mains-voltage ratings.

From these models and the research in the VHK report, it is clear to see that there are LED Lamps available on the market at all of these levels of light output in the lamp shapes listed in Table 6. Thus, we conclude that for all the lamp shapes/sizes listed in Table 6, there are LED replacement lamps available on the market that meet or exceed the minimum lumen output shown for wattage equivalency in Table 6 of Annex III and therefore this *specific* aspect of the third criterion has been met.

3b) High Colour Rendering LED Lamps

During the Consultation Forum meeting held on 25 June in Brussels, participants highlighted the importance of colour-rendering index (CRI) as another aspect of consumer-relevant functionality parameters. One Member State noted that Stage 3 would remove all the high CRI lamps listed in draft VHK Market Assessment. We checked this comment and found that there are some with CRI ratings greater than 90 that would be removed, however there are still several models that are equal to 90 CRI and have an EEI ≤0.20. For example, there are four OSRAM PARATHOM PRO PAR16 lamps which have a GU10 base and CRI of 90 and which have an EEI of 0.20, and there is also one PAR38 lamp which has a CRI of 90 and an EEI value of 0.17 which also passes Stage 3 – "Lampenwelt, E27 15W LED-Reflektorlampe Roder PAR38". In addition to these, there are also four more PAR16 lamps from OSRAM with CRI of 90 and which have EEI values of 0.21 and therefore may be considered within the measurement tolerance of an EEI of 0.20.

At the time VHK conducted their market research, the efficacy of LED lamps which have an EEI of 0.20 or less and which offer high-scores on the CRI scale may have just been entering the market. For this reason, we have done some supplemental market research in July 2015 to try and identify other directional lamps which would have a CRI of 90 or greater and meet the Stage 3 LED lamp requirement of an EEI of 0.20 or less.

Table 13 presents 40 specific lamps that we identified through on-line retailers selling LED lamps in Europe which are in addition to the ones already appearing in the VHK draft market assessment. In our experience, LED lamp manufacturers offer new lamp models on the market twice a year, always offering higher efficacy and lower EEI. Therefore, as LED lamps continue to improve over the next year, more lamps will become available on the market and be ready for September 2016. It is clear from our study of VHK draft market assessment and these additional LED lamps listed in the table below that very high CRI will still be possible with LED lamps that meet or exceed an EEI of 0.20.

Table 13. Additional Examples of Directional LED Lamps available on the European Market with CRI =>90 and EEI <=0.20

Brand	Model	Socket	Watts	Voltage	Dim ?	Beam <	CCT	CRI	Lumen	EEI	Stage 3 OK?	Link
Philips	Philips LEDspot MV D 5.4-50W 927 40D GU10 (MASTER)	GU10	5.4	220-240	Yes	40	2700K	90-100	360	0.16	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-5-4-50w-927-40d-gu10-master
Philips	Philips LEDspot MV D 5.4-50W 930 40D GU10 (MASTER)	GU10	5.4	220-240	Yes	40	3000K	90-100	378	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-5-4-50w-930-40d-gu10-master
Philips	Philips LEDspot MV D 5.4-50W 927 25D GU10 (MASTER)	GU10	5.4	220-240	Yes	25	2700K	90-100	360	0.16	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-5-4-50w-927-25d-gu10-master
Philips	Philips LEDspot MV D 4-35W 927 40D GU10 (MASTER)	GU10	4	220-240	Yes	40	2700K	90-100	260	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-4-35w-927-40d-gu10-master
Philips	Philips LEDspot MV D 5.4-50W 927 25D GU10 (MASTER)	GU10	4	220-240	Yes	25	2700K	90-100	260	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-5-4-50w-927-25d-gu10-master
Philips	Philips LEDspot MV D 5.4-50W 940 40D GU10 (MASTER)	GU10	5.4	220-240	Yes	40	4000K	90-100	392	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-5-4-50w-940-40d-gu10-master
Philips	Philips LEDspot MV D 4-35W 927 25D GU10 (MASTER)	GU10	4	220-240	Yes	25	2700K	90-100	250	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-4-35w-927-25d-gu10-master
Philips	Philips LEDspot MV D 4-35W 930 25D GU10 (MASTER)	GU10	4	220-240	Yes	25	3000K	90-100	282	0.14	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-4-35w-930-25d-gu10-master
Philips	Philips LEDspot MV D 4-35W 930 40D GU10 (MASTER)	GU11	4	220-240	Yes	40	3000K	90-100	262	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-4-35w-930-40d-gu10-master
Philips	Philips LEDspot MV D 4-35W 940 25D GU10 (MASTER)	GU12	4	220-240	Yes	25	4000K	90-100	272	0.14	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-4-35w-940-25d-gu10-master
Philips	Philips LEDspot MV D 4-35W 940 40D GU10 (MASTER)	GU13	4	220-240	Yes	40	3000K	90-100	285	0.14	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-4-35w-940-40d-gu10-master
Philips	Philips LEDspot MV D 5.4-50W 930 25D GU10 (MASTER)	GU14	5.4	220-240	Yes	40	3000K	90-100	378	0.15	Yes	https://www.any-lamp.co.uk/philips-ledspot-mv-d-5-4-50w-930-25d-gu10-master
Osram	Osram Parathom Pro PAR16 Adv 6.8-50W 940 36D GU10	GU10	6.8	220-240	Yes	36	4000K	90-100	350	0.20	Yes	https://www.any-lamp.co.uk/osram-parathom-pro-par16-adv-6-8-50w-940-36d-gu10
Sunflux‡	Halo LED Pære 4,5W Dæmpbar 2700K Ra95	GU10	4.5	230	Yes	60	2700K	95	233‡	0.18‡	Yes	http://detled.dk/gu10-led-der-erstatter-35-40w/387-sunflux-gu10-halo-led-paere-45w-daempbar-2700k-ra95.html

Brand	Model	Socket	Watts	Voltage	Dim ?	Beam <	CCT	CRI	Lumen	EEI	Stage 3 OK?	Link
Sunflux‡	LED Pære 3,5W 180Lm 2700K Ra92	GU10	3.5	230	No	38	2700K	92	167‡	0.18‡	Yes	http://detled.dk/gu10-led-der-erstatter-25-30w/802-sunflux-halo-gu10-led-paere-35w-180lm-2700k-ra92.html
Sunflux‡	Indbygningsspot 13W 2700K 1000Lm		13	230	Yes	60	2700K	>90	930‡	0.18‡	Yes	http://www.prolys.dk/da/product/til-erhverv/sunflux-indbygningsspot-13w-2700k-1000lm-ra-greater-than-90-60
Hilux*	R8 GU10 Halo LED Spot 4,5W Dæmpbar 2700K 300Lm	GU10	4.5	230	Yes	60	2700K	96*	300	0.17*	Yes	http://detled.dk/gu10-led-der-erstatter-35-40w/834-hilux-r8-gu10-halo-led-spot-45w-daempbar-2700k-300lm-ra95-60.html
Hilux*	R9 GU10 Halo LED Spot 4,5W Dæmpbar 2700K 300Lm	GU10	4.5	230	Yes	40	2700K	97*	300	0.15*	Yes	http://detled.dk/gu10-led-der-erstatter-35-40w/711-hilux-r9-gu10-halo-led-spot-45w-daempbar-2700k-300lm-ra95.html
Doled*	R1 Dæmpbar GU10 Halo LED pære 5W 2700K	GU10	5	230	Yes	60	2700K	92*	470	0.18*	Yes	http://detled.dk/gu10-led-der-erstatter-35-40w/716-r1-daempbar-gu10-halo-led-paere-5w-2700k-ra90-470lm-60.html
Sunflux‡	Dæmpbar GU10 LED Spot 5W	GU10	5	230		38	2700K	95-97	233‡	0.20‡	Yes	http://detled.dk/gu10-led-der-erstatter-35-40w/212-sunflux-daempbar-gu10-led-spot-5w-250lm-2700k-ra95.html
Sunflux*	Halo LED Pære 4,5W Dæmpbar 2700K	GU10	4.5	230	Yes	40	2700K	97*	250	0.17*	Yes	http://detled.dk/gu10-led-der-erstatter-35-40w/387-sunflux-gu10-halo-led-paere-45w-daempbar-2700k-ra95.html
Sunflux‡	LED Pære 6,5W CTC 1900-2700K	GU10	6.5	230	Yes	38	2700K	95-97	326	0.20‡	Yes	http://detled.dk/gu10-led-der-erstatter-45-50w/1023-sunflux-gu10-led-paere-65w-ctc-1900-2700k-ra95-daempbar.html
Sunflux*	MINI GU10 LED Pære 3W Dæmpbar 2700K	GU10	3	230	Yes	38	2700K	92*	180	0.18*	Yes	http://detled.dk/gu10-led-mini-o35mm-erstatning/1030-sunflux-mini-gu10-led-paere-3w-daempbar-2700k-180lm-ra95.html
Soraa	SM16GW-05-25D-927-03-S3	GU10	5	230		25	2700K	95	230	0.20	Yes	http://www.soraa.com/products/specs-GU10-ROW
Soraa	SM16GW-05-25D-930-03-S3	GU10	5	230		25	3000K	95	245	0.19	Yes	http://www.soraa.com/products/specs-GU10-ROW
Soraa	SM16GW-05-36D-930-03-S3	GU10	5	230		36	3000K	95	235	0.20	Yes	http://www.soraa.com/products/specs-GU10-ROW
Soraa	SM16GW-05-50D-930-03-S3	GU10	5	230		50	3000K	95	235	0.20	Yes	http://www.soraa.com/products/specs-GU10-ROW
Soraa	SM16GW-07-25D-927-03-S3	GU10	7.5	230	Yes	25	2700K	95	410	0.20	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-25D-930-03-S3	GU10	7.5	230	Yes	25	3000K	95	435	0.19	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/

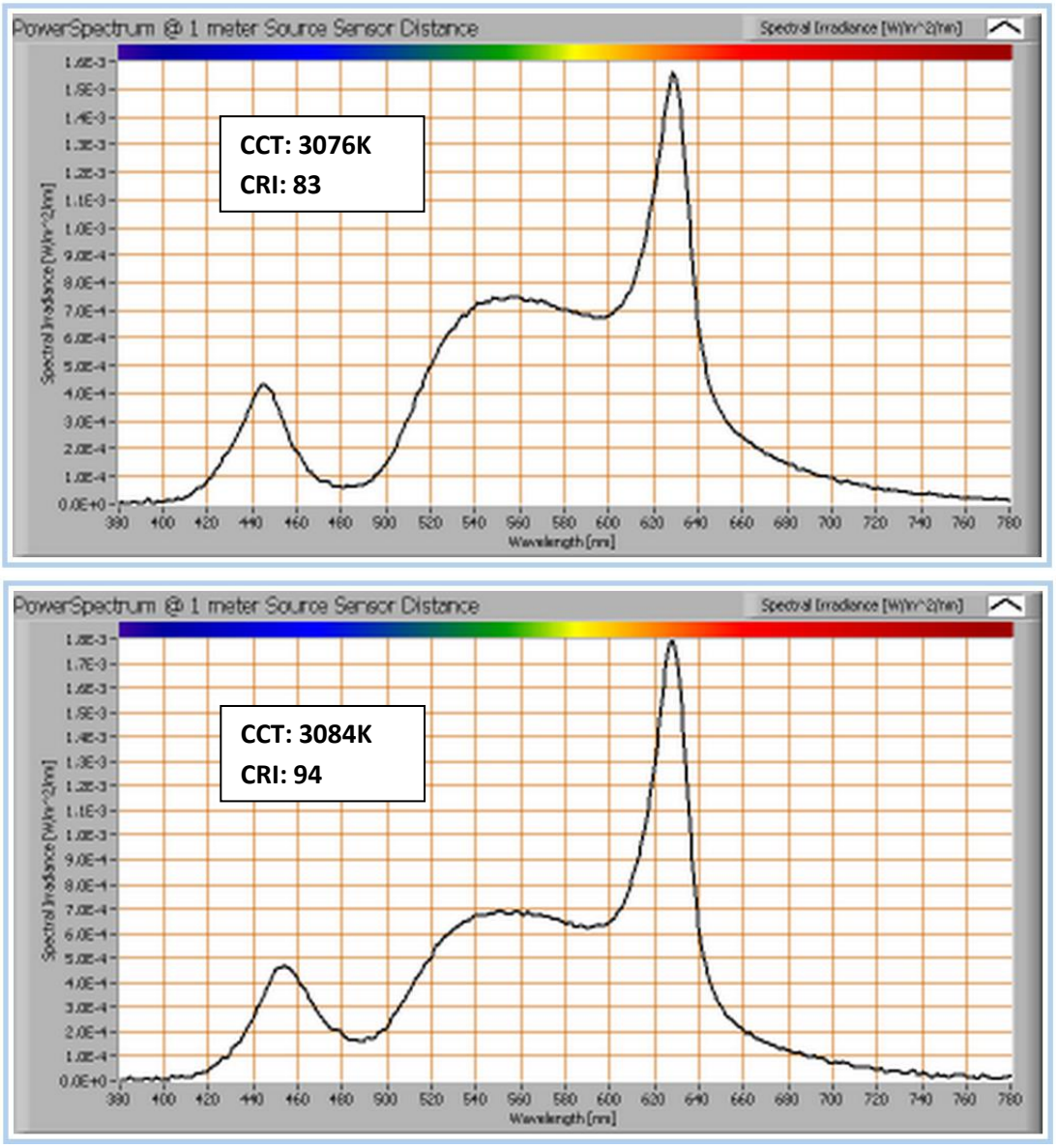
Brand	Model	Socket	Watts	Voltage	Dim ?	Beam <	CCT	CRI	Lumen	EEI	Stage 3 OK?	Link
Soraa	SM16GW-07-25D-940-03-S3	GU10	7.5	230	Yes	25	4000K	95	455	0.18	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-25D-950-03-S3	GU10	7.5	230	Yes	25	5000K	95	455	0.18	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-36D-927-03-S3	GU10	7.5	230	Yes	36	2700K	95	410	0.20	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-36D-930-03-S3	GU10	7.5	230	Yes	36	3000K	95	435	0.19	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-36D-940-03-S3	GU10	7.5	230	Yes	36	4000K	95	455	0.18	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-36D-950-03-S3	GU10	7.5	230	Yes	36	5000K	95	455	0.18	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-60D-927-03-S3	GU10	7.5	230	Yes	60	2700K	95	410	0.20	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-60D-930-03-S3	GU10	7.5	230		60	3000K	95	400	0.20	Yes	http://www.soraa.com/products/specs-GU10-ROW
Soraa	SM16GW-07-60D-930-03-S3	GU10	7.5	230	Yes	60	3000K	95	435	0.19	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-60D-940-03-S3	GU10	7.5	230	Yes	60	4000K	95	455	0.18	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/
Soraa	SM16GW-07-60D-950-03-S3	GU10	7.5	230	Yes	60	5000K	95	455	0.18	Yes	https://www.savemoneycutcarbon.com/product/soraa-led-vivid-3-gu10-7-5w-spotlight/

* The Danish Energy Agency purchased and measured (DTU Fotonik) the performance of these five lamps in July 2015.

‡ The useful luminous flux has been scaled from the total luminous flux for these five lamps, based on the measured test results from the Danish Energy Agency.

The aforementioned notwithstanding, it should also be noted that CRI is a problematic metric for comparing and assessing the quality of white-light LEDs. A high score does not necessarily mean that the colour rendition of a light source is good, instead it means that the light source renders colour on 8 tiles in the same way as the reference light source (an incandescent lamp) used in the measurement standard. Experts have identified problems with CRI, including for instance that having only 8 tiles makes it easy to optimise for a better score (i.e., more reference colours should be used), and that CRI is a simple average that can mask poor results in parts of the colour spectrum.[12] Also, very small differences in the peak values of the emission spectrum can result in very large differences in numerical scores of CRI – however the very small emission differences do not always translate into a perceivable change in the colour to the human eye. Figure 7 has two graphs, one with a CRI of 83 and the other with a CRI of 94, and very small differences in colour spectra.[13]

Figure 7. Spectral Light Distribution of LED sources with CRI 83 and 94 (Olino, 2009)



[12] A close look at the Color Rendering Index (CRI, or Ra), posted on Olino website by Marcel van der Steen, 30 November 2009. Link to this article.
[13] Ibid.

The problems with CRI as a metric for measuring light quality of LED sources have been discussed in the literature for more than a decade. For example, a study published[14] in 2002 by the Lighting Research Centre under their ASSIST programme drew the following conclusion from a study where subjects were asked to view and indicate their preference for objects illuminated by different light sources:

> *"Contrary to general belief, this study showed that a low CRI LED light source was more preferred than a high CRI halogen or incandescent light sources. In addition, the study described in this manuscript has shown that CRI has no correlation to peoples' color preference. Therefore, the authors of this manuscript do not recommend the use of CRI as a target metric in the development of solid-state light sources because it could negatively impact overall performance."*

CRI as a metric was first developed by the Commission Internationale de l'Eclairage (CIE) more than 40 years ago and most recently updated and published in CIE 13.3-1995, Method of Measuring and Specifying Colour Rendering Properties of Light Sources. With the market introduction of white-light LEDs, the CIE convened a technical committee (TC 1-62) to look at the adequacy of CRI with respect to white-light LED sources. In 2007, TC 1-62 published Technical Report 177:2007 in which they expressed reservations regarding the use of CRI to measure the performance of white light LEDs. The CIE suggested that a new metric should be developed, concluding:

> *"The conclusion of the Technical Committee is that the CIE CRI is generally not applicable to predict the color rendering rank order of a set of light sources when white LED light sources are involved in this set."*

This conclusion of the Technical Committee was based on the simple fact that the predicted CRI for white LED lamps did not correspond with the reality of the perception of good colour rendering by observers. The Committee arrived at this conclusion after studying three carefully conducted visual experiments that included simulations where the CRI of different light sources were compared to the visual perception of people. These three experiments were:

- A colour simulator on the Hiroshima City University (Japan)
- CRI simulations done by the National Institute of Standards and Technology (NIST, USA)
- Visual CRI experiments at the University of Pannonia (Veszprém, Hungary)

The results of these three studies all showed that there is a low to no correlation between the computed CRI and the visually perceived differences in colour by people. The Technical Committee stated that CRI is generally not applicable for a ranking on colour rendition when white LED sources are part of the observed illuminants. The CIE Technical Committee went on to recommend that a new metric or set of metrics is needed.

We are including this information about the limitations of CRI because it is important that Policy Makers are aware of this research and understand that very high values of CRI do not necessarily mean that people will prefer that light for the colour rendition of objects. Field research has shown there is low to no correlation between CRI value and colour preference. It therefore is perfectly

[14] "Color Rendering Properties of LED light Sources", by Dr. Nadarajah Narendran and Lei Deng, the Lighting Research Centre, Rensselaer Polytechnic Institute, Troy, NY, USA. Link to this paper.

reasonable to use LED light sources with slightly lower numerical values of CRI and still achieve very pleasant colour rendition.

3c) Beam Angle Replacements

Finally, concerning the broad equivalency check of replacement lamp shapes and sizes, there are certain niche market segments of directional lamps that were not listed in Table 6 of Annex III of EU No 1194/2012 but which appear in the VHK Market Assessment tables, or were included in comments submitted by Lighting Europe to the Consultation Forum. For these lamp shapes, our research found there are LED alternatives, but not from LightingEurope members and these models tended to emit light in larger beam angles, thus making the lamps more suitable for general illumination rather than precise display lighting. However, it should be noted that these lamps (e.g., R39) tend to be used for general room illumination in ceiling-mounted track lighting where beam angles are not as critical and all forward lumens are useful. In fact, there are even halogen R39 lamps which have a frosted lens to create a diffuse light effect.

In our research, we found R39 lamp shapes available (e.g., Stage 3-compliant LED option) which match a more diffuse light pattern. Thus, 'broadly equivalent' LED options are available. Furthermore, for those few applications where specific beam angles are needed, we agree with VHK's draft market assessment that socket/cap adaptors can be used safely (carrying the "CE" mark to demonstrate they comply with safety requirements for these products). Cap adaptors are only mentioned in the draft Market Assessment for very few lamps, for applications where a small compromise on lamp and beam angle is not possible. This only applies to specific beam angles of six different low-volume lamp shapes - G9/MR16, R39, R63, R80, R90 and PAR25 – which represent just 9% of the models in the market assessment. There are mains-voltage LED replacement options for all of these lamp shapes and lumen packages, however there may not be full coverage of all beam angles. That said, as VHK points out, in most cases a slightly different beam angle would be used ('broadly equivalent') or there is the possibility of using an adapter. These options are discussed in detail in the VHK draft Market Assessment on page 61-62. We agree with VHK that the availability of models with wider beam angles in combination with a cap adaptor would still enable those few users to find "broadly equivalent" replacement LED lamps for the halogen lamps they are purchasing today.

In the German written comments submitted to the Commission, there is a lot of focus and emphasis on whether there is an exhaustive set of LED lamps to replace every beam angle package for halogen. For example, the written comment expresses that there are no LED lamps available below a 9 degree beam angle because they have all been removed by Stage 3. In fact, only 8 degree beam angle LEDs are removed, and there are 9 degree beam angle LEDs available which are Stage 3 compliant (note: these are also included in the German analysis). Thus from our read of this criterion, there are 'broadly equivalent' LED options in place – the substitutes are only one degree different, and would have an extremely small difference in the illumination pattern at a one to three metre distance from the light source.

Germany also comments that certain high-flux lamps are not available as LED lamps, and specifically identifies the Philips PAR56 300W 230V GX16d halogen lamp as not having an LED replacement. We

investigated this gap they identified and found that this conclusion is not correct. We identified at least one supplier in China (where most of the world's LED lamps are produced) which offers lumen packages that even exceed that of the Philips halogen lamp:

High lumen factory IP68 GX16D base 20W 36W 50W AC 95v-265v

At 50W, this PAR56 lamp is reported to produce 5000 lumens ±5%, which is more than double the Philips PAR56 identified in the German analysis and uses just one sixth of the power (50W instead of 300W).

Germany also comments that there are no replacement LED lamps at 12°, 15° and 55° beam angles as shown in their figure "Bild 6" of their written comments submitted to the Commission. We conducted some research to determine whether this was indeed the case, and again we did not arrive at the same conclusion as Germany. In our research, we were able to identify LED replacements at each of these three specifically mentioned beam angles, as evidenced by the examples given below (and a slightly wider product search than was conducted for the German analysis):

Examples at 12 degrees[15]: Example 1, Example 2, Example 3

Examples at 15 degrees: Example 1, Example 2, Example 3

Examples at 55 degrees[16]: Example 1, Example 2, Example 3

However, in addition to these replacement options, we also note that Criterion 3 is not intended to identify exhaustive completeness when it comes to beam angle substitutes. First of all, the criterion does not mention beam angles specifically - it only explicitly mentions Table 6 in Annex III, which itself does not include beam angles. Secondly, the criterion calls for 'broadly equivalent' consumer functionality requirements, and as discussed in the VHK draft Market Assessment, there are often similar beam angles available, and in those few applications where precision is necessary, then cap adaptors can be used. In our view, for those very few applications where any real gaps exist (i.e., we are not aware of any), then an approach of similar beam angle replacements in combination with socket adaptors could address the requirement of broad equivalency in criterion 3.

Criterion 3 is met. From the evidence available, the LED lamps offered on the market provide the important functionality parameters of halogen including light output (meeting or exceeding all requirements of lamp shapes in Table 6 of Annex III), of models with very high colour rendering, and of beam angle equivalencies in LED are available. The requirement that the market offer broadly equivalent replacements that are Stage 3 compliant has been met.

[15] There are many LED options available at 9°, 10° and 20° beam angles in the VHK draft Market Analysis report.
[16] There are many LED options available at 50° and 60° beam angles in the VHK draft Market Analysis report.

Criterion 4 - compatible with equipment designed for installation between the mains and filament lamps available on the date of entry into force of this Regulation according to state-of-the-art requirements for compatibility

In the Consultation Forum meeting in Brussels on 25 June, participants discussed the fact that this criterion was primarily related to two key compatibility tests – one is thermal performance in a lamp socket (and whether that would significantly reduce LED lamp lifetime) and the second is compatibility with dimmers. This section addresses both points and shows that neither of them presents a problem with respect to this fourth criterion.

4a) Thermal compatibility in existing fixtures

Halogen lamps produce >95% of the energy consumed as waste heat, thus fixtures that use halogen lamps often have maximum wattage rating tags which are meant to inform the consumer of the highest safe wattage they can install in a given fixture. LED lamp replacements operate at around one tenth of the wattage of the halogen lamps they replace, therefore the waste heat generated in the fixture will generally be around 90 percent lower with LED lamps. However, LED lamps do not project their heat in their light emission, therefore the much lower waste heat produced in the driver and the LED die must be conducted and removed from the lamp while it is installed in the fixture. LED manufacturers have taken this fact into consideration and LED lamps are designed so that they incorporate any necessary heat sinks or other thermal management design features (e.g., heat fins, ventilation access points) for the LED lamp while still conforming to the size and shape of the halogen lamp. Here are two examples, a PAR38 (E27) and PAR16 (GU10):

In addition, due to the very high proportion of waste heat generated by halogen lamps (including heat that is radiated, conducted and convected from the lamp), fixtures designed to accommodate halogen lamps also have design features and materials that are better able to tolerate high heat – including for example, ventilation holes, metal construction, a ceramic socket, etc. The significant reduction in waste heat from the LED lamp (about 90% lower wattage) will ensure they will function effectively and safely in these luminaires. The lower wattage LEDs are also an advantage for those few applications where consumers may choose to use a socket adaptor, as that adaptor will be subject to less waste heat.

With on-going increases in LED efficacy (see Figure 2, the US DOE efficacy curve in Criterion 1 of this memo), thermal management of LED lamps will become even easier, and the heat sinks on LED lamps will diminish in size or simply be incorporated into the lamp housing so they are no longer visible. We have seen no evidence that there is a problem concerning reduced LED lamp life time in directional lamp fixtures, and even if there was a problem with this aspect of LED lamps, it would disappear with increasing efficacy. The US Department of Energy research[17] has shown there is still a lot of energy savings potential left in LEDs – in a recent report, DOE found the 2014 efficacy of a warm-white packaged LED is 146 lumens/Watt, and they project that by 2020, it will be 220 lumens/Watt. The US DOE goal is to achieve 250 lumens/Watt for packaged warm-white LED lamps. If a 6W PAR16 lamp designed in 2014 uses an LED at 146 lm/W, by 2020 it will only be a 4W (while producing the same light), and ultimately reaching 3.5W for the same light output when LEDs reach the DOE's goal. As the LED lamp wattages decline with increasing efficacy, the waste heat will reduce further and thereby continue to ensure there are no issues with waste heat affecting LED lifetime.

4b) Compatibility with dimmers

LED lamp dimmer technology has advanced significantly in the last few years, with intelligent dimmers becoming part of the lamp circuits, and offering end-users great compatibility. These intelligent dimmers offer an 'adaptive circuit' detection system that enables LED lamps to determine what type of dimming circuit is installed, and to operate correctly in that application. Manufacturers can therefore use intelligent LED drivers which can detect and adapt to an installed dimmer. Such integrated circuit (IC) solutions have been promoted by companies like Cirrus Logic, Marvell and iWatt since early 2012 [18,19]. These dimmable drivers are programmed to recognise the characteristics of the connected dimmer and select a compatible operating mode.

As part of the reporting requirements under Ecodesign, manufacturers introducing 'dimmable' lamps into the European market must provide a list of the dimmers with which they can be operated. The screen captures in the following pages are taken from these submissions by OSRAM, Philips Lighting, GE Lighting and Havells-Sylvania. These reports provide an indication of the

[17] Solid-State Lighting, R&D Plan, published by the Solid-State Lighting Program, Building Technologies Office, Office of Energy Efficiency and Renewable Energy, US Department of Energy, May 2015, Link: http://energy.gov/sites/prod/files/2015/06/f22/ssl_rd-plan_may2015_0.pdf

[18] Marvell and iWatt: http://www.ledsmagazine.com/articles/2012/02/marvell-headlines-led-driver-ic-exhibits-at-sil.html

[19] Cirrus Logic: http://www.ledsmagazine.com/articles/2012/03/cirrus-logic-enters-led-driver-ic-market-linear-tech-and-power-integration-announcements.html

extensive list of dimmers with which they offer directional mains-voltage LED Lamps that are compatible. The fact that these lamps are compatible with so many dimmers is a reflection of the investment in research and development by these companies into developing widely-compatible dimmable LED lamp drivers.

That aspect notwithstanding, it should be noted that the fourth criterion requires LED lamps to be "compatible with equipment designed for installation between the mains and filament lamps available on the date of entry into force". The date of entry into force for EU No 1194/2012 was 3 January 2013, thus LED lamps are not required by this criterion to be compatible with the entire installed stock of dimmers in Europe, but rather with those that were available for sale on 3 January 2013 – which the manufacturer tables provided indicate there is excellent coverage.

This is not to say that dimmers installed prior to 2013 will not be compatible with LED lamps – on the contrary, it will be possible for nearly all consumers to find dimmable LED lamps that are compatible, and thus avoiding the need to replace an existing dimmer in a circuit. And, as stated by Sweden during the Consultation Forum on 25 June, EU Consumer Law allows consumers to take back to the retailer a product (e.g., a lamp) if it doesn't work as was expected or it is broken, etc. This means that consumers could buy a lamp, try it out at home, and take it back if they are not satisfied.

That said, there is a possibility that there could be a small number of dimmers in the installed base which may have compatibility problems, where households would either simply operate the LED lamps at full brightness (i.e., not dimmed) or only in the interval full to half brightness, or they would have to replace the dimmer. Germany has commented that this means the market assessment fails to meet the Criterion 2 for affordability, because those few households who have to replace their dimmer will experience a high cost. However we disagree with that conclusion because this will only be a very, very small percentage of the market and the affordability criterion applies to the "majority" of consumers - not all European consumers. And furthermore, manufacturers provide lots of information to assist consumers in their choices (see manufacturer tables in Annex C) to help avoid potential issues. Thus, even if these two criteria – that of compatibility and affordability were looked at jointly – one would arrive at the same conclusion that the *majority* of European consumers would be better off if Stage 3 remains in place for mains-voltage filament lamps.

The tables included in Annex C are screen captures to give a few examples of the public information issued by OSRAM, Philips, General Electric and Havells-Sylvania for the dimmer compatibility with directional LED lamps. Some of these PDF files are dated from 2014 (e.g., Philips' PDF is dated February 2014) and thus are representative of dimmers offered on the market in 2013 because that is when dimmers would have been purchased to conduct these compatibility tests. The high degree of compatibility is clearly evident by all the green-shaded boxes, and for this reason and those stated above, we conclude that this criterion on compatibility has been met.

Criterion 4 is met. The evidence available supports the finding that there are LED lamps offered on the market today that are compatible with equipment designed for installation between the mains and filament lamps available on the date of entry into force of this Regulation according to state-of-the-art requirements for compatibility.

Annex A. Background on Stage 3 for Mains Voltage Filament Lamps

Commission Regulation (EU) No 1194/2012[20] of 12 December 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 establishes a set of requirements and a schedule for four classes of directional lamps. Stage 1 took effect on 1 September 2013; Stage 2 took effect on 1 September 2014 and Stage 3 takes effect on 1 September 2016.

A screen capture from the regulation below shows the requirements given in Table 2 of Annex III:

Table 2

Application date	Maximum energy efficiency index (EEI)			
	Mains-voltage filament lamps	Other filament lamps	High-intensity discharge lamps	Other lamps
Stage 1	If Φ_{use} > 450 lm: 1,75	If Φ_{use} ≤ 450 lm: 1,20 If Φ_{use} > 450 lm: 0,95	0,50	0,50
Stage 2	1,75	0,95	0,50	0,50
Stage 3	0,95	0,95	0,36	0,20

Although this is presented in Table 2, there is a conditional clause that applies to the EEI value of 0,95 for mains-voltage filament lamps. The regulation states that:

> "*Stage 3 for mains-voltage filament lamps shall apply only if no later than 30 September 2015, evidence is produced by the Commission through a detailed market asses[s]ment and communicated to the Consultation Forum that there are mains-voltage lamps on the market that are:*
> - compliant with the maximum EEI requirement in stage 3;
> - affordable in terms of not entailing excessive costs for the majority of end-users;
> - broadly equivalent in terms of consumer-relevant functionality parameters to mains-voltage filament lamps available on the date of entry into force of this Regulation, including in terms of luminous fluxes spanning the full range of reference luminous fluxes listed in Table 6;
> - compatible with equipment designed for installation between the mains and filament lamps available on the date of entry into force of this Regulation according to state-of-the-art requirements for compatibility."

The EEI value of 0,95 for mains-voltage filament lamps at Stage 3 is set at a level that will phase-out mains-voltage filament lamps – in other words, this product will be removed from the market because there are no mains-voltage filament lamps that can achieve an EEI of 0,95. This is, therefore, a shift in the market to LED. At Stage 3, the LED category (called "Other lamps") also has an EEI increase, moving from 0,50 EEI to 0.20. This step increase removes some of the poor

[20] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:342:0001:0022:en:PDF

performing (low efficacy) directional LED lamps from the market (approximately 30% of the LED models available in the VHK draft market assessment).

Annex B. Consumer Comments on an OSRAM PAR 16 (GU10) LED Lamp

This Annex provides German consumer comments expressing their satisfaction with an OSRAM LED lamp used in our LCC analysis. This is included because it relates to criterion #2 (affordability) and #4 (compatibility) because consumers are satisfied with their purchase and the lamp must therefore be affordable and compatible with dimmers in their homes. There are 39 comments and this lamp received an average score of 5 out of 5 stars (the highest score). Comments are in German, but we have prepared an unedited Google Translate to English. Click here to link to these comments.

German Consumer Comments (original):	**Google Translation to English (unedited):**
Guter Ersatz zu den Halogenleuchten Von Herbert Gstrein (9. Mai 2015) Habe inzwischen sowohl mein Wohnung als auch die gesamte Wohnanlage auf LED umgestellt. Ist nur zu empfehlen	Good replacement for halogen lamps From Herbert Gstrein (May 9, 2015) Have now both my apartment and the entire condominium on LED switched. Is only recommended
Sehr Schönes Leuchtmittel Von Helmut (10. Februar 2015) Spar Effizienz,Sehr Hoch ! Haltbarkeit,Wird Sich Zeigen !	Very nice lamps From Helmut (February 10, 2015) Saving efficiency, very high! durability, it will be shown!
Farbtemperatur und Leuchtstärke hervorragend Von Ralf (12. Dezember 2014) Wir sind sehr zufrieden mit dem Produkt und hoffen auf eine lange Lebensdauer.	Color temperature and luminosity excellent From Ralf (12 December 2014) We are very pleased with the product and look forward to a long life.
Sehr zufrieden ,Ersatz für 50 Watt Halogen Von Willi St. (27. Oktober 2014) Nach einigen nicht sehr erfolgreichen Tests mit LED bin ich bei Osram angekommen . Bin von den Lampen begeistert . Lichtfarbe , Helligkeit , alles stimmt . Meiner Meinung nach ein guter Ersatz für 50 Watt Halogen .	Very satisfied, replacement for 50 Watt halogen From Willi St. (October 27, 2014) After some not very successful tests with LED I arrived at Osram. Am excited about the lamps. Light color, brightness, everything is right. In my opinion, a good replacement for 50 Watt halogen.
Sehr gut! Von Andreas (24. Oktober 2014) Alles gut!	Very good! From Andreas (24 October 2014) All good!
Sehr guter Ersatz für 50 Watt Halogen Von Sven Rembges (6. September 2014) Guter Service, sehr gutes Licht und ich hoffe das die Lampen jetzt auch mindestens 5-10 Jahre halten.	Very good replacement for 50 Watt halogen From Sven Rembges (September 6, 2014) Good service, very good light and I hope to keep the lights now at least 5-10 years.
Alles Super Ersatz für 50W Halogen Von Andreas J. (2. September 2014) Super Produkt und ein sehr geringer Stromverbrauch.	All Super replacement for 50W halogen From Andreas J. (September 2, 2014) Super product and a very low power consumption.
Super Von Walter (1. August 2014) TOP Ware	Great From Walter (August 1, 2014) TOP goods

100%
Von Schneeberg (26. Juli 2014)
Im Austausch oder im Neubau installiert...einfach nur freuen das es endlich zu "normalen" preisen ,led leuchtmittel gibt.
Aus meiner erfahrung ist die farbwiedergabestufe das wichtigste merkmal.
Super leuchtmittel

100%
From Schneeberg (July 26, 2014)
Installed in the exchange or in the new building ... just happy that it finally praise to "normal", LED bulbs are.
From my experience, that is color rendering, the most important feature.
Super bulbs

Bin absolut zufrieden!
Von Gerhard Lustig (4. Juli 2014)
Ersetzt locker eine 50 Watt Halogen Lampe .

Am absolutely satisfied!
From Gerhard Lustig (July 4, 2014)
Replaces loose a 50 Watt halogen lamp.

gutes Preis/Leistungsverhältnis
Von Dietmar Köhler (10. Juni 2014)
Ich habe schon mehrere Sparlampen probiert und weggeworfen. Hier gibt es warmes, weiches und vor allem helles Licht und das unschlagbar günstig.

good price / performance ratio
From Dietmar Köhler (10 June 2014)
I have already tried and discarded several bulbs. There warm, soft and particularly bright light and the unbeatable price.

Klasse Leuchtmittel
Von Bernd Wöhrle (5. Juni 2014)
Super LED Leuchtmittel ersetzt locker eine 50 Watt Halogen Lampe .

Class Lamp
From Bernd Wöhrle (June 5, 2014)
Super LED bulb replaces a 50 watt halogen bulb loose.

Endlich habe ich Sie gefunden
Von Bernd Wöhrle (5. Juni 2014)
Nach jahrelangem suchen habe ich endlich das richtige LED Leuchtmittel gefunden und das auch noch zu einem super Preis .

At last I've found you
From Bernd Wöhrle (June 5, 2014)
After years of looking, I finally found the right LED bulbs and that too at a great price.

Sehr schöne Lichtfarbe!
Von Marc Brüggemann (15. April 2014)
Endlich scheint die LED-Technik so weit zu sein, um nahezu warmes Licht zu "produzieren"!
Wir sind begeistert sowohl von der Lichtfarbe aber auch der Helligkeit, die die 50W-Halogen-Spots mehr als gleichwertig ersetzt.
Nach der LED-Umstellung der gesamten Büroräume, werden wir auch im privaten Bereich komplett auf diese und die dimmbaren Pendants umstellen.
Lieferung und Verpackung waren ebenfalls top!

Very nice light color!
From Marc Brüggemann (from 15 April 2014)
Finally, the LED technology seems so far to "produce" almost warm light on!
We are excited by both the light color as well as brightness, which replaces 50W halogen spots more than equivalent.
of After the LED switch total office space, we will completely change this and the dimmable counterparts in the private sector.
Delivery and packaging were also top!

"sehr zufrieden"
Von Möller (26. März 2014)
Schneller Versand, guter Kontakt,1A Ware

"Very satisfied"
From Möller (26 March 2014)
Fast shipping, good contact, 1A goods

mind. genauso hell wie 50 W Halogen
Von ruediger (24. März 2014)
Guter und günstiger Ersatz für 50 W Halogen

min. as bright as 50W Halogen
From Ruediger (March 24, 2014)
Good and effective replacement for 50W halogen

PrPreis-Leistung: sehr gut
Von Christoph H. (22. März 2014)
Habe 7 Osram LED Star 6,5 Watt GU10 Lampen gekauft und bin sehr zufrieden. Ich habe allerdings keine Langzeiterfahrung.
Lichtfarbe ist sehr gut. Bisher alles gut.

PrPreis-performance: very good
From Christoph H. (March 22, 2014)
Have 7 Osram LED Star 6.5 watts GU10 lamps purchased and am very satisfied. However, I do not have long-term experience.
Light color is very good. So far everything well.

Sehr gut
Von Jochen Willsch (22. März 2014)
Genau das richtige Leuchtmittel für die Beleuchtung unserer Küche. Nicht zu kalt (weiss) und trotzdem sauberes Licht für einen wohnlichen Arbeitsplatz. 6 Spots mit insgesamt 40 Watt machen nun fast das selbe Licht, wo vorher 300 Watt Halogen von der Decke brannte. Diese Leuchtmittel (in der dimmbaren Ausführung) haben wir auch über dem Esstisch (4 Stk.) und als Bodenleuchten. Leicht gedimmt ist es das ideale Licht zum Essen und wenn mal mehr Power gebraucht wird, drehen wir den Dimmer voll auf. Dann sind durchaus vergleichbar mit den vorher verbauten 50 Watt Halogen, also verdammt hell.

Very good
From Jochen Willsch (March 22, 2014)
Just the right bulbs for lighting our kitchen. Not too cold (white) and still clean light for a domestic work station. 6 spots with 40 Watt make now almost the same light, where previously 300 watt halogen burning from the ceiling. These lamps (in the dimmable version) we have also over the dining table (4 pcs.) And as floor lights. Light dimmed, it is the ideal light to eat and when times more power is needed, we turn the dimmer fully on. Then are quite comparable with the previously installed 50 watt halogen so damn bright.

"Einfach super LEDs"
Von Frank S. (14. März 2014)
Bin sehr überzeugt von dem Produkt, selbst meine Frau ist einverstanden. Bestell sofort noch einige nach! Prima:-)

"Just great LEDs"
By Frank S. (March 14, 2014)
I am very confident of the product, even my wife agrees. Order now for some! Prima :-)

Sehr gut
Von Uwe (10. März 2014)
Das Licht der LED-Strahler ist sehr hell, angenehm im Farbton, das in Verbindung mit dem Sparpotenzial ist unschlagbar.

Very good
By Uwe (10 March 2014)
The light from the LED spotlight is very bright and pleasant in the shade, which is in conjunction with the savings potential unbeatable.

So muss Licht sein!
Von Jens G. (8. März 2014)
Wir haben für unser Paulmann URail System in der Küche Ersatzlampen gesucht, weil die origianl Halogenlampen wenig Licht, dafür aber umso mehr Hitze produziert haben.
Die Osram LED-Strahler liefern für die Küche ein sehr angenehmes, helles Licht, das relativ wenig blendet und lkaum Strahlungswärme produziert. Ich bin begeistert! Und die LEDs strahlen sofort nach dem Einschalten mit voller Leistung. So muss Licht sein!

So light must be!
From Jens G. (March 8, 2014)
We were looking for our Paulmann URail system in the kitchen replacement lamps because the original halogen lamps have little light, but it produces even more heat.
The Osram LED spotlights provide for the kitchen a very pleasant, bright light that dazzles relatively little and lkaum produces radiant heat. I'm excited! And the LEDs emit immediately after turning at full power. So light must be!

echter Ersatz für 50W Halogen
Von Drechsle (2. März 2014)
echter Ersatz für 50 Watt Halogen. Lichtqualität sehr schön. Sehr hell. Über Langzeitzuverlässigkeit kann ich noch keine Aussage treffen.

ideal replacement for 50W halogen
From Drechsle (March 2, 2014)
ideal replacement for 50 Watt halogen. Quality of light very nice. Very bright. About long-term reliability I can not comment.

vielversprechend
Von charlie-freak (1. März 2014)
Dieser LED-Strahler ist tatsächlich sehr hell. Als Ersatz für 50 W Halogen auf jeden Fall zu empfehlen. Die Lichtfarbe mit 2700 K ist bereits sehr nah am Halogenlicht. Endlich ein vollwertiger Ersatz. Jetzt wünsche ich mir von Osram nur noch eine genau so gute Lampe mit 120 Grad Abstrahl-Winkel als Ersatz für die Deckenbeleuchtung.

promising
From Charlie Freak (March 1, 2014)
This LED spotlight is very bright indeed. Recommended as a replacement for 50 W halogen definitely. The light color of 2700 K is already very close to the halogen light. Finally a full replacement. Now I would like to see from Osram only an equally good lamp with 120 degree radiating angle to replace the overhead lights.

toll
Von Leopold (14. Februar 2014)
Sehr gutes, helles Licht, für die Küche ideal!

great
From Leopold (14 February 2014)
Very good, bright light, ideal for the kitchen!

sehr gutes Produkt
Von Pfeiffer Jürgen (13. Februar 2014)
Hatte vorher noname LED Produkt mit 9W eingesetz, die nach kurzer Zeit dann defekt waren. Versuchte es dann mit 2 Osram LED´s mit 7,3W und war begeistert. Die 2 weiteren Osram LED´s haben jetzt nur noch 6,5W und sind genau so hell wie die 7,3W.
Ich bin total begeistert und werde meine noch 3 verbleibenden noname LED´s gegen Osram ersetzen.

very good product
From Pfeiffer Jürgen (13 February 2014)
Had previously noname LED product is translated with 9W, which were then broken after a short time. Then tried it with 2 Osram LEDs with 7,3W and was thrilled. The 2 other Osram LEDs have now only 6.5W and are just as bright as the 7,3W. I am very excited and will replace them with Osram my 3 remaining noname LEDs.

sehr gut
Von von Fraunberg (10. Februar 2014)
Ich bin voll überzeugt von ihrem Produkt.

very good
From of Frauenberg (February 10, 2014)
I am fully convinced of their product.

Die Zukunft ist da: LED
Von Weiss (6. Februar 2014)
Endlich ein bezahlbarer und superheller LED-Spot von einem Marktenhersteller.

The future is here: LED
From White (February 6, 2014)
Finally a more affordable and super bright LED spot by a market maker.

Harry Seidel
Von Harry (5. Februar 2014)
Als Ersatz für 50 Watt Halogen bestens geeignet.

Harry Seidel
From Harry (February 5, 2014)
As a replacement for 50 Watt halogen ideal.

nur Vorteile
Von Chris (15. Januar 2014)
Das Licht ist heller, weißer aber auch brillianter als 50W-Halogen. Dazu kommen weniger Hitze, geringer Verbrauch und keine UV-Emissionen. Wir haben eine ganze Werkstatt so ausgeleuchtet und sind begeistert. Zu diesem Preis bislang nur Vorteile. Die Langzeitbewährung steht noch aus.

only benefits
From Chris (15 January 2014)
The light is bright white but also brilliant than 50W halogen. There are also less heat, low consumption and no ultraviolet emissions. We have a whole workshop illuminated so and are thrilled. At this price so far only benefits. The long-term viability is still pending.

solides Produkt guter Preis
Von Markus Schneider (19. Dezember 2013)
gleichwertiger Ersatz für 50 w Halogenstrahler, gute Verarbeitung, angenehme Lichtfarbe, minimalste Einschaltverzögerung

solid product good price
From Markus Schneider (19 December 2013)
an equivalent to 50W halogen spotlights, good workmanship, pleasant mood light, minimal delay

super led
Von andreas (18. Dezember 2013)
ist wirklich zu 95% so hell wie eine 50w halogen lampe

Super LED
From Andrew (18 December 2013)
is really 95% as bright as a 50W halogen lamp

Sehr gut
Von Ludwig Block (17. Dezember 2013)
Gestern habe ich meine letzten 11 50W-Halgen Lampen gegen 7W LED STAR von OSRAM ausgetauscht. Das Licht der LEDs ist meiner Meinung nach noch etwas heller (5 oder 6W hätten wahr- scheinlich auch ausgereicht) und die Fassungen der Lampen werden bei Weitem nicht so in Mitleidenschaft gezogen wie bei den extrem heissen Halogen-Leuchtmitteln.

Very good
From Ludwig block (17 December 2013)
Yesterday I exchanged my last 11-50W lamps halgen against 7W LED from OSRAM. The light of the LEDs in my opinion a little brighter (5 or 6W would probably also have been enough) and the versions of the lamps are not nearly as affected as the extremely hot halogen bulbs.

Super
Von Uwe K. (16. Dezember 2013)
Farbe ist etwas weisser als die Halogen, stört aber nicht wirklich. Bin auf jeden Fall positiv überrascht.

Great
By Uwe K. (16 December 2013)
Color is slightly whiter than the halogen, but does not really bother. Am definitely pleasantly surprised.

Top Preis top Service
Von Martin (6. Dezember 2013)
Die LED Spots ersetzen die Halogenspots mehr als 100%ig!
Die Lichtfarbe ist sehr angenehm und hell.
Da einer meiner Spots einen Defekt hatte habe ich an den Service geschrieben und umgehend Ersatz geschickt bekommen !
Weiter so, gute Preise und top Service!

Top Top Service
From Martin (December 6, 2013)
The LED spots replace the halogen spotlights more than 100%!
The light color is very pleasant and bright.
As one of my spots had a defect I have written to the service and immediately sent substitute get!
Way to go, good prices and great service!

Super Ersatz für Halogenstrahler
Von Heike R. (27. November 2013)
Helligkeit und Lichtfarbe entspricht einem 50 Watt Halogenstrahler . Minimal verzögertes einschalten , fällt aber nur auf , wenn in der gleichen Lampe verschiedene Strahler verwendet werden . Habe schon einige verschiedene LED-Strahler ausprobiert , bis jetzt eindeutig der Beste . Über die Haltbarkeit , kann ich noch nichts sagen.

Super substitute for halogen spotlights
By Heike R. (November 27, 2013)
Brightness and light color corresponds to a 50 Watt halogen spotlight. Minimal delayed turn on, but only noticeable when different lamps are used in the same lamp. Have been a number of different LED spotlight tried until now clearly the best. About the durability, I can not say anything yet.

Energiesparer
Von Pietsch (18. November 2013)
Top-Energiesparer

Energy saver
From Pietsch (18 November 2013)
Top energy savers

solides Produkt
Von Ralf Peters (18. November 2013)
stabile Ausführung, nur geringfügig länger als die ersetzte Halogenlampe, Lichtfarbe wie erwartet (warmweiß)

solid product
From Ralf Peters (18 November 2013)
solid construction, only slightly longer than the superseded halogen lamp, light color as expected (warm white)

Sehr guter Ersatz für 50W Halogen
Von Michael Povlin (13. November 2013)
Habe gerade alle meine 50W GU10 Halogenstrahler im Haus durch LED STAR 7W LED Spots ersetzt. Vor dem Kauf hatte ich Bedenken bezüglich der Lichtqualität, ich wurde jedoch positiv überrascht. Sogar meine Frau, die sonst beim Licht sehr pingelig ist und schon einige Sparlampen aus dem Haus geworfen hat, ist begeistert. Ich habe zwei Kinder und das Licht wird gerne ein- aber nicht wieder ausgeschaltet. Mit dem niedrige Verbrauch sieht man die Sache etwas entspannter. Über die Langzeitzuverlässigkeit kann ich noch keine Aussage mache.

Very good replacement for 50W halogen
From Michael Povlin (November 13, 2013)
Just all my 50W GU10 halogen lamps replaced with LED STAR 7W LED spots in the house. Before buying I had concerns about the quality of light, I was however pleasantly surprised. Even my wife who is very picky otherwise the light and has already thrown some bulbs out of the house, is enthusiastic. I have two children and the light is like one but not off again. With the low consumption you can see things a bit more relaxed. I can make no statement about the long-term reliability.

:-)
Von Rosa (18. Oktober 2013)
Warmweißes Licht überzeugt und verleiht einen gewissen touch.

:-)
From Rosa (18 October 2013)
Convinced Warm white light and gives a certain touch.

Annex C. Manufacturer Info on Dimmer Compatibility of Mains-Voltage Directional Lamps

SUPERSTAR® REFLECTOR Dimmer Compatibility*

OSRAM

Dimmability traffic light system:

- **Green** very good dimmability habits (Dimming range ≥ 75%)
- **Yellow** good dimmability habits (Dimming range ≥ 60%)
- **Red** partial critical dimmability habits (flickering or accoustic noises may occure) (Dimming range < 60%)
- **White** not tested

Lamp

Type	SUPERSTAR PAR16 35 36°	SUPERSTAR PAR16 50 36°
Product Picture		
EAN	4008321882653	4008321882745
Product Code	AA44077	AA44094
EAN	4008321882684	4008321882714
Product Code	AA44079	AA44092

Dimmer

Brand	Model	Voltage range	Power	Type	Number of Lamps on dimmer: 1 Lamp	5 Lamps	1 Lamp	5 Lamps
ABB	STD 50-3	230V/50Hz	60-500	L				
Berker	2874	230V/50Hz	20-525	T				
Berker	281902	230V/50Hz	60-400	L				
Busch-Jaeger	2250 U	230V/50Hz	60-600	L				
Busch-Jaeger	6523 U	230V/50Hz	2-100	LED-L				
Busch-Jaeger	6513 U-102	230V/50Hz	40-420	T				
Busch-Jaeger	6517 U-101	230V/50Hz	60-400	L				
Ehmann	4660c0026	230V/50Hz	20-315	T				
ELKO	174200 (ATD300R)	230V/50Hz	40-315	T				
EVERFLOURISH	EFM700DB	230V/50Hz	50-300	L				
Gira	0300 00	230V/50Hz	60-400	L				
Gira	030700	230V/50Hz	20-525	T				
Gira	117600	230V/50Hz	50-420	U				
Jung	225 NVDE	230V/50Hz	20-500	L				
Jung	225 TDE	230V/50Hz	20-525	T				
Kopp	80.33	230V/50Hz	20-275	T				
Legrand	775903	230V/50Hz	420	T				
LUMEX Loadsmart	LT1D450LS Series	230V/50Hz	450					
Merten	5771-99	230V/50Hz	20-315	T				
Merten	5725-99	230V/50Hz	20-500	L				
OSRAM	HTi DALI 315 DIM	230V/50Hz	20-315	DALI-T				
PEHA	D 80.433 V	230V/50Hz	60-600	L				
PEHA	433 HAB	230/50Hz	20-315	T				
PEHA	435 HAN	230V/50Hz	60-600	L				
Schneider	40300 RC	230V/50Hz	20-300	T				
Schneider	40600 RL	230V/50Hz	40-600	L				
Schneider	ATD315	230V/50Hz	10-315	T				
Schneider	STD400T RC/RL	230V/50Hz	20-400	U				
Siemens	5TC8 284	230V/50Hz	20-525	T				
Siemens	5TC8 256	230V/50Hz	50-400	L				

PARATHOM® / PARATHOM PRO®
PAR16 Dimmer Compatibility

Dimmability traffic light system:

- **Green** — very good dimmability habits (Dimming range ≥ 75%)
- **Yellow** — good dimmability habits (Dimming range ≥ 60%)
- **Red** — partial critical dimmability habits (flickering or accoustic noises may occure) (Dimming range < 60%)
- **White** — not tested

UK Dimmer

Brand	Model	Voltage range	Power	Type	Lamp: Type	SUPERSTAR PAR16 35 36°	SUPERSTAR PAR16 50 36°
					Product Picture		
					EAN	4008321882653	4008321882745
					Product Code	AA44077	AA44094
					EAN	4008321882684	4008321882714
					Product Code	AA44079	AA44092
						Number of Lamps on dimmer: 5 Lamp / 10 Lamps / 20 Lamps	Number of Lamps on dimmer: 5 Lamp / 10 Lamps / 20 Lamps
AURORA	DSP 400	230V/50Hz	400	R			
Hamilton	KP1X40	230V/50Hz	400				
MK	K4501	230V/50Hz	180	L			
NEXUS	881P-01	230V/50Hz	400	L			
VARILIGHT	HQ3W	230V/50Hz	400				
VARILIGHT	JQP401W	230V/50Hz	400	T			
ZANO	WH401	230V/50Hz	400	L			
ZANO	WH251	230V/50Hz	250				
ZANO	Z GRID 500	230V/50Hz	500				
ZANO	Z GRID 700	230V/50Hz	250	LED			

PARATHOM® / PARATHOM PRO® PAR16 Dimmer Compatibility

OSRAM

Dimmability traffic light system:

- **Green** — very good dimmability habits (Dimming range ≥ 75%)
- **Yellow** — good dimmability habits (Dimming range ≥ 60%)
- **Red** — partial critical dimmability habits (flickering or accoustic noises may occure) (Dimming range < 60%)
- **White** — not tested

Lamp

	PARATHOM PAR16 35 36° ADV	PARATHOM PAR16 50 36° ADV	PARATHOM PAR16 65 36° ADV	PARATHOM PRO PAR16 35	PARATHOM PRO PAR16 50
Type					
Product Picture					
EAN	4008321881960	4008321882097	4052899926929	4052899902213	4008321988560
Product Code	AA44077	AA44092	AA69347	AA41371	AA51782
EAN	4008321882035	4008321882127		4052899902220	4052899901384
Product Code	AA44078	AA44093		AA41375	AA44095
EAN	4008321882066	4008321882158		4052899902237	4052899901414
Product Code	AA44079	AA44094		AA41379	AA44098
EAN				4052899902244	4052899901421
Product Code				AA41372	AA44099
EAN				4052899902251	4052899901438
Product Code				AA41376	AA44100
EAN				4052899902268	
Product Code				AA41380	
EAN				4052899914735	
Product Code				AA63777	

Dimmer

Brand	Model	Voltage range	Power	Type	Number of Lamps on dimmer: 1 Lamp	5 Lamps	1 Lamp	5 Lamps	1 Lamp	5 Lamps	1 Lamp	4 Lamps	1 Lamp	3 Lamps
ABB	STD 50-3	230V/50Hz	60-500	L										
AURORA	DSP 400	230V/50Hz	400	R										
Berker	2874	230V/50Hz	20-525	T										
Berker	2861	230V/50Hz	50-420	U										
Berker	281902	230V/50Hz	60-400	L										
Busch-Jaeger	2247U	230V/50Hz	20-500	L										
Busch-Jaeger	2250 U	230V/50Hz	60-600	L										
Busch-Jaeger	6523 U	230V/50Hz	2-100	LED-L										
Busch-Jaeger	6513 U-102	230V/50Hz	40-420	T										
Busch-Jaeger	6517 U-101	230V/50Hz	60-400	L										
Busch-Jaeger	6591UJCGL-101-214	230V/50Hz	40-420	U										
Ehmann	4660c0026	230V/50Hz	20-315	T										
ELSO	174120 (T39)	230V/50Hz	20-500	L										
ELSO	174200 (ATD300R)	230V/50Hz	40-315	T										
EVERFLOURISH	EFM700DB	230V/50Hz	50-300	L										
EVERFLOURISH	EFM700DC			T										
Gira	0300 00	230V/50Hz	60-400	L										
Gira	030700	230V/50Hz	20-525	T										
Gira	117600	230V/50Hz	50-420	U										
Jung	225 NVDE	230V/50Hz	20-500	L										
Jung	225 TDE	230V/50Hz	20-525	T										
Jung	254 UDIE 1	230V/50Hz	50-420	U										
Jung	244020300	230V/50Hz	60-400	L										
Kopp	80.33	230V/50Hz	20-275	T										

PARATHOM® / PARATHOM PRO®
PAR16 Dimmer Compatibility

OSRAM

Dimmability traffic light system:

- **Green** — very good dimmability habits (Dimming range ≥ 75%)
- **Yellow** — good dimmability habits (Dimming range ≥ 60%)
- **Red** — partial critical dimmability habits (flickering or accoustic noises may occure) (Dimming range < 60%)
- **White** — not tested

Lamp

	Type	PARATHOM PAR16 35 36° ADV	PARATHOM PAR16 50 36° ADV	PARATHOM PAR16 65 36° ADV	PARATHOM PRO PAR16 35 36° ADV	PARATHOM PAR16 35 36° ADV
	Product Picture					
	EAN	4008321881960	4008321882097	4052899926929	4052899902213	4008321988560
	Product Code	AA44077	AA44092	AA69347	AA41371	AA51782
	EAN	4008321882035	4008321882127		4052899902220	4052899901384
	Product Code	AA44078	AA44093		AA41375	AA44095
	EAN	4008321882066	4008321882158		4052899902237	4052899901414
	Product Code	AA44079	AA44094		AA41379	AA44098
	EAN				4052899902244	4052899901421
	Product Code				AA41372	AA44099
	EAN				4052899902251	4052899901438
	Product Code				AA41376	AA44100
	EAN				4052899902268	
	Product Code				AA41380	
	EAN				4052899914735	
	Product Code				AA63777	

Dimmer

Brand	Model	Voltage range	Power	Type	Number of Lamps on dimmer: 1 Lamp	5 Lamps	Number of Lamps on dimmer: 1 Lamp	5 Lamps	Number of Lamps on dimmer: 1 Lamp	5 Lamps	Number of Lamps on dimmer: 1 Lamp	4 Lamps	Number of Lamps on dimmer: 1 Lamp	4 Lamps
Legrand	775903	230V/50Hz	420	T										
LUMEX Loadsmart	LT1D450LS Series	230V/50Hz	450											
Merten	5771-99	230V/50Hz	20-315	T										
Merten	5725-99	230V/50Hz	20-500	L										
Merten	SBD315RC	230V/50Hz	20-315	T										
NIKO	310-014	230V/50Hz	60-300	L										
OSRAM	HTi DALI 315 DIM	230V/50Hz	20-315	DALI-T										
PEHA	D 80.433 V	230V/50Hz	60-600	L										
PEHA	433 HAB	230/50Hz	20-315	T										
PEHA	435 HAN	230V/50Hz	60-600	L										
Schneider	40300 RC	230V/50Hz	20-300	T										
Schneider	40600 RL	230V/50Hz	40-600	L										
Schneider	ATD315	230V/50Hz	10-315	T										
Schneider	STD400T RC/RL	230V/50Hz	20-400	U										
Siemens	5TC8 284	230V/50Hz	20-525	T										
Siemens	5TC8 256	230V/50Hz	50-400	L										
VADSBO	TD350	230V/50Hz	50-350	T										
WUYUN	W13-AI52	230V/50Hz	20-400	L										

PARATHOM® / PARATHOM PRO®
PAR16 Dimmer Compatibility

OSRAM

Dimmability traffic light system:

- **Green** — very good dimmability habits (Dimming range ≥ 75%)
- **Yellow** — good dimmability habits (Dimming range ≥ 60%)
- **Red** — partial critical dimmability habits (flickering or accoustic noises may occure) (Dimming range < 60%)
- **White** — not tested

Lamp

Type	PARATHOM PAR16 35 36° ADV	PARATHOM PAR16 50 36° ADV
Product Picture		
EAN	4008321881960	4008321882097
Product Code	AA44077	AA44092
EAN	4008321882035	4008321882127
Product Code	AA44078	AA44093
EAN	4008321882066	4008321882158
Product Code	AA44079	AA44094
EAN		
Product Code		
EAN		
Product Code		
EAN		
Product Code		

UK Dimmer

Brand	Model	Voltage range	Power	Type	Number of Lamps on dimmer: 5 Lamp	10 Lamps	20 Lamps	Number of Lamps on dimmer: 5 Lamp	10 Lamps	20 Lamps
AURORA	DSP 400	230V/50Hz	400	R						
Hamilton	KP1X40	230V/50Hz	400							
MK	K4501	230V/50Hz	180	L						
NEXUS	881P-01	230V/50Hz	400	L						
VARILIGHT	HQ3W	230V/50Hz	400							
VARILIGHT	JQP401W	230V/50Hz	400	T						
ZANO	WH401	230V/50Hz	400	L						
ZANO	WH251	230V/50Hz	250							
ZANO	Z GRID 500	230V/50Hz	500							
ZANO	Z GRID 700	230V/50Hz	250	LED						

OSRAM

PARATHOM/PARATHOM PRO® REFLECTOR Dimmer Co

Dimmability traffic light system:

- **Green** very good dimmability habits (Dimming range ≥ 75%)
- **Yellow** good dimmability habits (Dimming range ≥ 60%)
- **Red** partial critical dimmability habits (flickering or accoustic noises may occure) (Dimming range < 60%)
- **White** not tested

Type	PARATHOM PAR20 50 30°	PARATHOM PAR30 100 30°	PARATHOM PAR38 120 30°
Product Picture			
EAN	4052899931299	4052899105829	4052899105669
Product Code	AA73560	AA76435	AA53203
EAN			
Product Code			
EAN			
Product Code			
EAN			
Product Code			
EAN			
Product Code			
EAN			
Product Code			

Dimmer

Brand	Model	Voltage range	Power	Type	Number of Lamps on dimmer: 1 Lamp	Number of Lamps on dimmer: 1 Lamp	Number of Lamps on dimmer: 1 Lamp
ABB	STD 50-3	230V/50Hz	60-500	L			
Berker	2874	230V/50Hz	20-525	T			
Berker	281902	230V/50Hz	60-400	L			
Busch-Jaeger	2247U	230V/50Hz	20-500	L			
Busch-Jaeger	2250	230V/50Hz	60-600	L			
Busch-Jaeger	6523 U	230V/50Hz	2-100	LED-L			
Busch-Jaeger	6513 U-102	230V/50Hz	40-420	T			
Busch-Jaeger	6517 U-101	230V/50Hz	60-400	L			
Ehmann	4660c0026	230V/50Hz	20-315	T			
ELSO	174200 (ATD300R)	230V/50Hz	40-315	T			
EVERFLOURISH	EF0700DC	230V/50Hz	20-300	T			
EVERFLOURISH	EFM700DB	230V/50Hz	50-300	L			
Gira	0300 00	230V/50Hz	60-400	L			
Gira	030700	230V/50Hz	20-525	T			
Gira	117600	230V/50Hz	50-420	U			
Jung	225 NVDE	230V/50Hz	20-500	L			
Jung	225TDE	230V/50Hz	20-525	T			
Kopp	80.33	230V/50Hz	20-275	T			
Legrand	775903	230V/50Hz	420	T			
LUMEX Loadsmart	LT1D450LS Series	230V/50Hz	450				
Merten	5771-99	230V/50Hz	20-315	T			
Merten	5725-99	230V/50Hz	20-500	L			
OSRAM	HTi DALI 315 DIM	230V/50Hz	20-315	DALI-T			
PEHA	D 80.433 V	230V/50Hz	60-600	L			
PEHA	433 HAB	230V/50Hz	20-315	T			
PEHA	435 HAN	230V/50Hz	20-500	L			
Schneider	40300 RC	230V/50Hz	20-300	T			
Schneider	40600 RL	230V/50Hz	40-600	L			
Schneider	ATD315	230V/50Hz	10-315	T			
Schneider	STD400T RC/RL	230V/50Hz	20-400	U			
Siemens	5TC8 284	230V/50Hz	20-525	T			
Siemens	5TC8 256	230V/50Hz	50-400	L			

PHILIPS

Consumer LED Range Main

February 2014

x-y	Dimmable, with x to y lamps
	Lamps are dimmable across full
	The majority of configurations sh
	Configuration not tested

This document is for information purposes and must be trea ht contain faults

Brand	Type #	Type	Spots		
			35W D 	40W D 	35W D 
ABB	6523U	LED	1 - 20		1 - 14
ABB	6524U	LED	1 - 20		1 - 14
Arnould	60595	RL			
AVE	Sistema 45 45349L Noir AX	RL			
Berker	2867 10	RL			
Berker	2830 10	R	1-10	1-10	
Berker	2866 10		1-4	1-4	
BTICINO	L4406	RL			
BTICINO	L4407	RC			
Busch Jaeger	2200	RL	1-10	1-10	
Busch Jaeger	2247U	RL	1-13	1-13	
Busch Jaeger	2250U	R	1-13	1-13	
Busch Jaeger	6513 U-102	RC			
Busch Jaeger	6523U	LED	1 - 20		1 - 14
Busch Jaeger	6524U	LED	1 - 20		1 - 14
Philips	UID8670	LED	1 - 20		1 - 14
Crabtree	CPU-2W400 (DL22010/C)	RC			
Crabtree	DV21912		1-4	1-4	
DANLERS	DQDGD MK400W + RESLOAD	RC			
Delta Dore	TYXIA 4840	RC			
Delta Dore	TYXIA 4850	RC			
DINUY	RE PLA LE1	LED	1 - 12		
Drespa	814	RL			
ELKO	RS16/400 GLI PH	RL			1-2
ELKO	CCTEL12013	RC			
ELKO	CCTEL11013	RL			1-3

PHILIPS

Consumer LED Range Main

February 2014

x-y	Dimmable, with x to y lamps
	Lamps are dimmable across full
	The majority of configurations sh
	Configuration not tested

This document is for information purposes and must be trea ht contain faults

Brand	Type #	Type	Spots		
			35W D 	40W D 	35W D 
Eltako	EUD61 NPN -UC	RLC			
Eltako	FUD61 NPN-230V	RLC			
Eltako	EUD12D-UC	RL			
Eltako	EUD12NPN-UC	RL			
Eltako	LUD12-230V	RL			
Finder	15.51.8.230.0400	RC?			
Finder	15.81.8.230.0500	RLC			
Gira	117600/I01	RLC			
Gira	117600/I03	RC			
Gira	030000/I01	R			1
Gira	030600/I00	RL			
Gira	226200/I00	RL			
Gira	0302 00/I01	R	1-4	1-4	
Gira / Insta	0302 00/I00	R			
Hager	WS063	RL			
Hager	WS064	RC			
Hager	EVN 011	RC			
Hager	EVN 012	RC			
Hager	EVN 002	RC			
Hager	EVN 004	RL			
Hager Kallysta	WK064	RC			
HomeMatic	HM-LC-Dim1	RC	1-4	1-4	
Intellibus	IB LED 90 P				
Jung	225TDE	RL			
Jung	225NV DE	RL	1-13	1-13	
Jung	266 GDE	R			
Jung	254 UDE	RLC			
Jung	1254UDE	RLC			
Legrand	67081				
Legrand	67082				
Legrand	67084				
Legrand	67085	RLC	1-15	1-15	
Legrand	67086	RLC			
Legrand	67083	UNI/LED			
Legrand	774161				

PHILIPS

Consumer LED Range Main

February 2014

x-y	Dimmable, with x to y lamps
	Lamps are dimmable across full
	The majority of configurations sh
	Configuration not tested

This document is for information purposes and must be trea ht contain faults

Brand	Type #	Type	Spots		
			35W D 	40W D 	35W D 
LK	506DA120				
LK	506DA109				
LK	506N5114				1
LK	506NA110				
LK	506NA121				
LK	820BA234				
Lumeo Eco	T39.08	RL			
Lumeo Eco	T46.03	RC			
MK	K1501 WHILV	RLC	1-4	1-4	
MK	K1535	R			
MK	Special	RL			
MK	K1526WHI	LED	1-12	1-12	1-8
MK	K1527WHI	LED	1-12	1-12	1-8
MK	K14523BSS	LED	1-12	1-12	1-8
MK	K14523BSS	LED	1-12	1-12	1-8
MK	WDSS 19076	RL			
Merten	5771	RC			
N&L	28956/433/4	R			
N&L	28969/435 HAN	RL	1-15	1-15	
Niko	09-013	R	1-8	1-8	
Niko	330-00700	R	1-10	1-10	
Niko	330-00700	RC	1-10	1-10	
Niko	310-01900	R	1-10	1-10	
Niko	310-01900	RC			
Niko	310-02800	RC	1-2	1-2	
Niko	310-02801	RL	1-8	1-8	
OPUS	852.390	R	1-10	1-10	
OPUS	852.392	RL	1-15	1-15	
PEHA	435HAN	RL			
PEHA	436	R			
PEHA	433 HAB	RC			
PEHA	431 HAN	LED	1-12	1-12	
R&D	500W RES/ 400W IND				
Relco	RL1724	RL			
Relco	RT65R0A	R			
Relco	RM34DSL	RL			
Relco	RM0587-RT ES	RLC			1-3
Relco	706 2	R			

GE Lighting

Brand	Type	Power rate (W)	GU10 6W	GU10 3.5 & 5.5W	GU10 3.5W	PAR20, R63	PAR30
Ace*	3247913	600				1-3	1-3
Berker	2830 10	40-1000	1-5	1-5	1		
Bticino	NT4402	60-500				2-3	1-3
Busch-Jaeger	6513U102			1-5			
Busch-Jaeger	2247U	500	1-5	1-5	1-5		
Busch-Jaeger	6523U	2-100		1-5			
DANLERS limited	DQDGD MK400W	40-400					
DETA	S1261	400		1			
Drespa/Lichtregler	S/N005616-00	60-400				1-3	1-3
DUWI	DW700DA	50-300	1-5	1-5	1-5	1-3	1-3
DUWI 26346	EFS700DE	40-300				1-3	1-3
Elko	RS16/400	60-400	1-5	1-5	1-5		
Elko	SMR-S	10-150	1-5	1-5	1-5		
Elko	315GLE	20-315					
Elko	400GLI	40-400		1-5	1-5		
Elko	315GLE/2Pol	20-315					
Eltako	EUD61NPN-230V	20-400		1-5	1-5		
ETN	CDAE-01/02	250		1-5	1-5		
ETN	CDAE-01/03	250		1-5	1-5		
Everflourish	EF0700DA	50-300	1-5	1-5	1-5	1-3	1-3
GEWISS	GW 20 802	100-500				1-3	1-3
GHNT		600		1-5			
GIRA	1176 00/I03	50-420		1-5	1-5		
GIRA	2262 00/I00	20-500		1-5	1-5		
GIRA	0493 09/I01	20-420		1-5	1-5		
Hamilton	LITESTAT	40-400		1-5	1-5		
KOPP		40-400	1-5	1-5	1-5	2-3	1-3
KOPP		50-300					
KOPP Topaz		40-400				1-3	1-3
Legrand	CXM14	3-75					
Legrand R	Pro 21-7756 54	400	2-5				
Leviton*	No.IPI10-1LM	1000				2-3	1-3
Leviton*	# 6681	600				1-3	1-3
Lutron*	S-10PR-WH	1000				1-3	1-3
Lutron*	D-600PH-DK	600				1-3	1-3
Lutron*	Listed 6B38	600				1-3	1-3
Lutron*	S-600PR-LA	600				1-3	1-3
Micromatic	DIM LED500	20-500	1-5	1-5	1-5		
MK	S1535						
Niko	310-013	60-300	1-5	1-5	5	1-3	1-3
Niko	310-017		1-5				
OPUS	852.390	60-400	1-5	1-5	1-5	1-3	1-3
OPUS	852,392	20-500				1-3	1-3
Peha/Tronic	433HAB		1-5				
RELCO	RT34DMA	100-500				1-3	1-3
Schneider	STD400RC/RL-DIN	1000	1-5	1-5	1-5		
Schneider	Pek-H5 kb2	20-500	1-5	1-5	1-5		

GE Lighting

Brand	Type	Power rate (W)	GU10 6W	GU10 3.5 & 5.5W	GU10 3.5W	PAR20, R63	PAR30
Schneider	ALT400902						
Schneider	MGU5.512.18ZD	60-300	1-5	1-5	1-5		
Schneider	AYA22000121	60-500				1-3	1-3
Siemens	5TC8284		1-5				
Siemens		40-500				1-3	1-3
SOLOGIC	28956	60-400	1-5	1-5	1-5	1-3	1-3
SOLOGIC	28969	60-400				1-3	1-3
Vi-Ko		600				2-3	2-3
V-Pro	1-way	400		1-5			
V-Pro	2-way	400		1			
VIMAR	PLANA	100-500				1-3	1-3
Yokis	MTV500E-54052	500	1-5				

For more information, see: http://www.gelighting.com/LightingWeb/emea/products/dimming-compatibility/dimmer-compatibility.jsp

Havells-Sylvania

Brand	nr	Model	Max Load (Incandecent)	Type	Load type	Eg. Code Transformer	RefLED Coolfit ES50 345Lm 0026363	RefLED Superia ES50 V2.1 380Lm 0026639	RefLED+ ES50 V2 360Lm 0026818
ABB/Busch-Jaeger	24	2210	400	Rotary	R	Finland			
	9	2247U	500	Rotary	RL	Finland			
	4	2250U	600	Rotary	R	Greece			
	20	6513U	420	Rotary	RC	Finland			
		6591U-101	420	Rotary	RLC	Europe			
	87	6523U	100	Rotary	RL	Netherlands			
AURORA	105	AU-DSP400X	400	Rotary	RL	UK		Trim	Trim
Berker	61	286710	360	Rotary	RC	Germany			
	127	8542 12 00	400	Push	RLC				
	62	283010	400	Rotary	R	Germany			
Bticino	104	AM5707	250	Push	C	Italy			
	103	L4402N	500	Rotary	R	Italy			
	114	N4401	500	Rotary	RL	France			
	113	N4407N	200	Push	RC	France			
	115	N4409N	200	Push	RLC	France			
Clipsal	28	32E450LM	450	Rotary	RL	Australia			
		E2031LPD600	600	Push	R	Europe			
		E3031HD	600	Push	RLC	Europe			
		KB31RD400	400	Push	R	Australia			
	29	32E450TM	450	Rotary	RC	Australia			
	81	E8431EPD4		Push	RLC	Hongkong			
Danlers	19	DQDGD	400	Push	RC	UK			
	16	DSSGD MK400W	400	Push	RLC	UK			
Doyle&Tratt	40	400W/VA (JQP401W) 1202038	400	Rotary	RC	UK			
	43	P250 (TQP251W) 1010024	250	Rotary	R	UK			
	42	P400 (TQP401W) 1110085	400	Rotary	R	UK			
	41	P500 (TQP501W) 1109021	500	Rotary	R	UK			
	44	R250 (TQR251W) 1109025	250	Rotary	R	UK			
	39	Z0J401MZ120201400W	400	Push	RC	UK			
	7	ZOI401MC-C	400	Touch	RC	UK			
	120		850	Rotary	RC	UK			
Eaton	77	CDAE-01/02	250	Din	RC	Austria			
	75	CDAU-01/02	250	Din	RC	Austria			
	76	CDAU-01/03	125	Din	RC	Austria			
Efapel	107	21211	500	Rotary	RL	Spain			
Elimpo	100	ECODIM920/921		Din	RC	Belgium			
ELIX		EFGT700DA	300	Rotary	RL	Europe			
Elko	71	315GLE	315	Rotary	RC	Sweden			
		RS16/300GLI/8A	300	Push	RL	Europe			
		630GLE	630	Rotary	RC	Europe			
	12	RS16/400GLI PH	400	Rotary	RL	Sweden			
Eltako	63	EUD61NPN-UC	400	Din	RLC	Sweden			
Feller (Schneider)	96	31000RL	1000	Rotary	RL	Switzerland			
	82	40300RC	300	Rotary	RC	Switzerland			
	83	40420RLC	420	Rotary	RLC	Switzerland			
	85	40600RC	600	Rotary	RC	Germany			
	84	40600RL	600	Rotary	RL	Switzerland			
Finder	98	15.81	500	Din	RLC	Italy			
	99	15.91	100	Din	R	Italy			
Fuga	78	1067003133(MEK-S300CR)	300	Touch	RC	Denmark			
	80	1067003146(MEK-S300LR)		Touch	RL	Denmark	3	Trim	Trim
	79	1067003861(TOUCH IR350UNI)	350	Touch	RLC	Denmark			
Gira	52	030200/I01	600	Rotary	R	Germany			
	54	030700/I02	520	Rotary	RC	Germany			
	89	117600/I03	420	Rotary	RLC	Germany			
	88	226200/I01	500	Rotary	RL	Netherlands			
	53	226300/I00	260	Push	RLC	Germany			

Havells-Sylvania

Brand	nr	Model	Max Load (Incandecent)	Type	Load type	Eg. Code Transformer	RefLED Coolfit ES50 345Lm 0026363	RefLED Superia ES50 V2.1 380Lm 0026639	RefLED+ ES50 V2 360Lm 0026818
HAGER	36	EVN004	500	Din	RLC	UK			
	112	EVN011	300	Din	RLC	France			
	128	EVN012	300	Din	RLC				
		WH103002		Rotary	RC	Europe			
		WH103401		Rotary	RL	Europe			
	129	TXA210AN	300	Din	RLC				
Hamilton	35	HDP-250	250	Rotary	R	UK			
	34	HDP-400	400	Rotary	R	UK			
	31	H-GDM250W VA	250	Rotary	RLC	UK			
	33	H-GDMTM250	250	Push	RLC	UK			
	32	L400/2 VER02	400	Rotary	R	UK			
Jung	60	225NVDE	500	Rotary	RL	Germany			
	70	225TDE	525	Rotary	RC	Germany			
	65	243EX	360	Rotary	RC	Germany			
	69	266GDE	600	Rotary	R	Germany			
	131	224HEX	60-400	Rotary	RL	Germany			
Kopp	86	8072.0000.7	275	Rotary	RC	Germany			
	90	8078.1308.1		Rotary	RC	Germany			
LAP	46	VKDM400E	400	Rotary	R	UK			
Legrand	1	770074	600	Push	RL	Greece			
	72	670 84	400	Push	R	France			
	17	67083 / 67085 Céliane	300	Push	RLC	France			
	73	784 01	400	Push	R	France			
	30	CAT 400L	400	Rotary	RL	Australia			
	27	Cat 400T	400	Rotary	RC	Australia			
Lichtregler	25	be T10		Rotary	R				
		T46		Rotary	RC	Europe			
LightwaveRF	102	JSJSLW200C	250	Push	RC	UK			
	101	JSJSLW831WH		Din	RLC	UK			
Lutron		SM112850847 210	250	Push	RLC	UK			
LK		400-UNI	400	Push	RLC	Europe			
Merten	66	20-315VA	315	Rotary	RC	Germany			
		5680		Push	RLC	Europe			
	97	MEG5170-0300	200	Push	RLC				
MK	2	47352SL	450	Rotary	R	UK			
	121	52455SL	250	Rotary	R	UK			
		K1524 WHILV	300	Rotary	RLC	UK			
		K1523 WHILV	300	Rotary	RLC	UK			
		K4501 WHILV	220	Rotary	RLC	UK			
	45	52471SL (MK K1501WHILV)	500	Rotary	RLC	UK	2		
N&L	68	28985	315	Rotary	RC	Germany			
Niko	47	05-703	400	Din	RLC	Belgium			
	48	05-704	450	Din	RL	Belgium			
	18	05-715	750	Din	RLC	Belgium			
	8	310-01300	250	Rotary	R	Belgium			
	26	310-014xx	420	Rotary	R	Belgium			
	3	310-01600	400	Rotary	RL	Belgium			
	50	310-01700	250	Rotary	RC	Belgium			
	13	310-0190x = 330-00700	325	Rotary	RLC	Belgium			
	51	310-02600	550	Push	RL	Belgium			
	49	310-02700	450	Push	RL	Belgium			
	22	310-02800	100	Push	RC	Belgium			
NVC (Leishi)		A5D11-01	400	Rotary	RC	Europe			
Opus	57	852.39	400	Rotary	R	Germany			
	59	852.392	500	Rotary	RL	Germany			
	58	852.395	315	Rotary	RC	Germany			
	126	852.397	110	Rotary	RL	Netherlands			
Öve	56	8078		Rotary	RC	Germany			

Havells-Sylvania

Brand	nr	Model	Max Load (Incandecent)	Type	Load type	Eg. Code Transformer	RefLED Coolfit ES50 345Lm 0026363	RefLED Superia ES50 V2.1 380Lm 0026639	RefLED+ ES50 V2 360Lm 0026818
Peha	93	431	120	Rotary	RL				
	55	433 HAB	315	Rotary	RC	Germany			
	92	434 (208013)	400	Rotary	R				
	91	439 HAB (279013)	800	Rotary	RC				
	67	433 (207913)	315	Rotary	R	Germany			
	94	435 HAB (217113)	600	Rotary	RC				
	95	435 HAN (209713)	600	Rotary	RL				
Relco	38	RT34DMA	500	Rotary	R	Italy			
	37	RTM34SSL	300	Push	RLC	Italy			
RPP	109	RPP-DSP400	400	Rotary	RLC	UK			
Schneider	125	CCTDD20003	1000	Din	RL	France			
	6	ATD315	315	Rotary	RC	Sweden	2		
		AD2DS		Push	RL	Sweden			
	124	CCTDD20001	400	Din	RLC	France			
	10	CCTDD20002	400	Din	RLC	Sweden			
	122	CCTDD20004-STD1000RL	1000	Din	RL	France			
	123	MGU3.511.18	400	Rotary	RL	France			
	119	MGU3.515.18	350	Push	RLC	France			
	118	S520511	600	Rotary	RL	France			
	23	SBD315RC	315	Rotary	RC	Finland			
	11	SBD420RCRL	420	Rotary	RLC	Finland			
	15	SBD600RCRL	600	Rotary	RLC	Finland			
	21	SBD630RC	630	Rotary	RC	Finland			
	10	STD400TRC/RL	400	Push	RC/R	Sweden			
		5680	200	Push	RLC	Sweden			
	14	SBDSPL	100	Rotary	RL	Finland			
Siemens	64	5TC8284	600	Rotary	RC	Germany			
Simon	5	75313-39	500	Rotary	RL	Spain			
		313-40 50VA	500	Rotary	RC	Europe			
	108	75319-39	500	Rotary	RLC	Spain			
ULTI		U201DST600	600	Push	RLC	Europe			
Vadsbo	74	LD22	200	Din	RLC	Sweden			
Vimar	111	14135	500	Rotary	R	Greece			
	110	14136	500	Rotary	R	Greece			
	106	20135	500	Push	RLC	Italy			
Yokis	116	MTV500E		Din	RLC	France			
	117	MTV500M		Din	RLC	France			