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Preparatory Studies for Eco-design Requirements of EuPs

Lot 19: Domestic lighting - Part 2
Directional lamps and household luminaires

Final Task Report
Task 4: Technical Analysis Existing Products

Study for European Commission DGTREN unit D3, contact: Andras Toth

Contractor:

Project performed in cooperation with:

Contact Vito: Paul Van Tichelen, info@eup4light.net

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Project team

Vito:
Paul Van Tichelen
An Vercalsteren
Bio Intelligence Service:
Shailendra Mudgal
Benoît Tinetti
Alexander Thornton
Energy Piano:
Casper Kofod
Kreios:
Lieven Vanhooydonck
Laborelec (reflector lamp tests):
Jean-Michel Deswert

Important note:
This report contains the updated draft results of research by the authors and is not to be perceived as the opinion of the European Commission.
This is an updated draft document intended for stakeholder communication.

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0 PREFACE

VITO and its partners are performing the preparatory study for the new upcoming eco-design directive for Energy Using Products (EuP) related to domestic lighting, on behalf of the European Commission (more info http://ec.europa.eu/enterprise/eco_design/index_en.htm).

The environmental impacts of Energy-using Products such as domestic lighting take various forms, including: energy consumption and the related negative contribution to climate change, consumption of materials and natural resources, waste generation and release of hazardous substances. Eco-design, which means the integration of environmental considerations at the design phase, is arguably the best way to improve the environmental performance of products.

The creation of a coherent framework for environmental product policy avoids the adoption of uncoordinated measures that could lead to an overall negative result; for example eliminating a toxic substance from a product, such as mercury from lamps, might lead to increased energy consumption, which could in total have a negative impact on the environment. A Community framework also ensures that divergent national or regional measures, which could hinder the free movement of products and reduce the competitiveness of businesses, are not taken. It is not the intention to decrease the quality of domestic lighting.

The objective of this draft document is to present preliminary data for discussion with stakeholders related to the EuP preparatory study for the lot 19 part 2.
You can follow the progress of our study and find general information related to lot 19 part 2 on the project website when you register as a stakeholder: http://www.eup4light.net
Please, also consult the website for timing and organisation of the tasks.

Important remark:
It must be clearly stated that this part 2 of the study relies on the draft regulation resulting from part 1 of the study on non-directional light sources. Specific items on non directional lamps that were discussed in part 1 will not be repeated in this part 2. Items that are related to all light sources can be repeated, only to improve the readability.

1 PRODUCT DEFINITION

For more info see website www.eup4light.net.

2 ECONOMIC AND MARKET ANALYSIS

For more info see website www.eup4light.net.

3 CONSUMER BEHAVIOUR AND LOCAL INFRASTRUCTURE

For more info see website www.eup4light.net.

4 TECHNICAL ANALYSIS EXISTING PRODUCTS

This chapter is a general technical analysis of current products on the EU-market and provides general inputs for the definition of the Base Case (chapter 5) as well as the identification of part of the improvement potential (chapter 7), i.e. the part that relates to better performing products on the market. Some Best Available Technologies including LEDs will only be introduced in chapter 6.

4.1 Production phase

4.1.1 Selected DLS products

The Table 4.1 below summarizes the types of reflector lamps that are taken into account as most relevant for general domestic lighting. This list is based on the types of lamps that are currently installed in Europe. As mentioned before, Best Available Technology that is nowadays less or rarely used will only be introduced in chapter 6 including LED's.

The catalogues contain a multitude of lamps for various applications, including non-domestic; for reasons of simplification only selected representative products are included in this study. These representative lamps were selected after the analysis of the market data and the current availability in the shops.

Representative lamps are discriminated into four groups:

- the blown reflector GLS-lamps (R63 with E27/B22d cap) and the similar halogen lamps,
- the PAR 38 high wattage GLS and halogen lamps (GLS-R-HW and HL-MV-R-HW),
- the small, mains voltage MR16 halogen lamps with GU10 cap and a GU10 capped compact fluorescent replacement lamp,
- the low voltage MR16 halogen lamps with GY5.3 cap.

In Table 4.1 a selection of reference lamps is made per lamp type, i.e. one typical wattage and for one type, several beam angles in the same wattage.

Blown reflector lamps have the disadvantage that the optimum position of the filament wire or the halogen bulb in the reflector varies a lot and the satination of the outer bulb increases the spill light and reduces the light output and efficacy. As a consequence, light output of different samples can considerably differ. The efficacy data in Table 4.6 try to reflect the average that can be found on the market.

The mains voltage MR16 halogen lamps normally have a reflective layer of evaporated aluminium and the corresponding GU10 cap.

For the low voltage MR16 halogen lamps, the dichroic versions (cool beam) were chosen because the aluminized reflector versions are almost disappeared from the market. A dichroic reflector has several reflective layers, which results in a higher efficacy compared to the aluminized version (reflection coefficient of 0.90-0.95 against 0.85 for evaporated aluminium).

Selected reflector lamps:

Table 4.1: Overview of selected lamps.

Lamp type **Acronym**	**Wattage** **[W]**	**Colour Temp** **[K]**	**Colour rendering** **Ra**	**Beam Angle** **[°]**	**ILCOS-code**
Incandescent reflector lamp, R63, E27 (B22d) **GLS-R**	60 (40)	2700	100	30	IRR-60-230-E27-63/30
Halogen reflector lamp, R63, E27 (B22d) **HL-MV-R**	60	2900	100	30	HAGS/UB-60-230 E27-63/30
Incandescent reflector lamp, PAR38, E27 (B22d) **GLS-R**	(80) 120	2700	100	25	IRR-120-230-E27-120/25
Halogen reflector lamp, PAR38, E27 (B22d) **HL-MV-R**	100	2900	100	30	HAGS/UB-100-230 E27-120/30
Halogen reflector lamp, MR16, GU10 **HL-MV-R**	50 (35)	2900	100	40	HAGS/UB-50-230-GU10-51/40
Halogen reflector lamp, MR16, 12V, GU5.3 **HL-LV-R**	50 (35)	3000	100	10/24/36 -38/60	HRGS/UB-50-12-GU5.3-51/36
Compact fluorescent reflector lamp, R50, GU10 **CFLi-R**	7	2700	>80	120	FBR-7/27/1B-230-GU10-51/120
Compact fluorescent reflector lamp, R120, E27 (B22d) **CFLi-R**	20	2700	>80	120	FBR-20/27/1B-230-E27-120/120

For these typical lamps, product data are collected as needed from the VHK model, i.e. the EcoReport tool. The production phase is modelled according to the MEEuP methodology report. Detailed information on environmental impact is included in chapter 5 of this MEEuP methodology report. The method focuses on seven environmental impact parameters (Total Gross Energy Requirement, Electricity, Feedstock energy (for plastics only), Process Water, Cooling Water, Hazardous Solid Waste, Non-Hazardous Waste). This method satisfies the requirement set out in article 15 paragraph 4 (a) of the eco-design directive (2005/32/EC): *'Considering the life cycle of the EuP and all its significant environmental aspects, inter alia energy efficiency, the depth of analysis of environmental aspects and of the feasibility of their improvement shall be proportionate to their significance. The adoption of eco-design requirements on the significant environmental aspects of an EuP shall not be unduly delayed by uncertainties to regarding the other aspects'*. In order to satisfy these requirements, the most relevant products were chosen and sometimes an available similar process or material (based on physical or chemical similarity) is used when it is not directly available in the MEEUP methodology. These requirements often allow to follow a simple and straightforward approach.

In this study, types of lamps were put together within a certain range of weight of components and a range of power.

Incandescent reflector lamps in R63-form in 40 and 60W have the same dimensions and thus an almost equal Bill of Material (BOM). Moreover, in chapter 2 can be seen that these lamps are apparently the most used (>82%) incandescent reflector lamp in EU27. The 60W lamp is choosen as most representative.

This range will also allow the assessment of aberrations caused by differences in the production phase of DLS lamps. But here again, one can expect a very low total environmental impact for lighting by the 'production phase' according to part 1 of this study.
The results serve as input for the assessment of the base case, which is discussed in the next chapter.

If relevant and possible, data sets from different sources are checked on their consistency.
The BOM (Bill Of Materials) is used as input for modelling the production phase in the VHK-model. The input tables are included in the following sections. For the discussion of the end-of-life phase of materials is referred to section 4.5.

4.1.2 Selected luminaires (4) to assess the luminaire socket and space lock-in effect

As explained in chapter 1 the luminaires are treated in this study as belonging to the system environment of the lamp or light source.

In chapter 3 two improvements were identified at system level (luminaire), in this section the focus is on the so-called ‘Luminaire socket and space lock-in effect’ (see chapter 3)
Because of the wide spread of products available and the lack of reliable quantitative data on the performance of stock and sales (see chapter 2&3) this study will deal with the impact on a qualitative basis. The sole purpose is to assess the potential impact of an improvement option at luminaire level in the sensitivity analysis in chapter 8 on a qualitative basis using one or more reference luminaires, this information is not relevant for chapters 5 and 7.

Please also note that ballasts for fluorescent lamps, external transformers and power supplies for low voltage halogen lamps were already discussed in the study on office lighting[1] or on external power supplies[2].

The luminaire market in the domestic sector is very large. The production costs and material used vary significantly, almost exclusively as a function of the decorative aspects. Consistent with the system approach discussed in Chapter 1, luminaires with the minimal parts will be considered in the luminaires studied in this analysis. The section evaluating luminaires for DLS luminaires will compare differences between two selected luminaires, referred to as “reference luminaire cases.

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[1] Preparatory Studies for Eco-design Requirements of EuPs, Lot 8: Office lighting, Final Report (April 2007).
[2] Preparatory Studies for Eco-design Requirements of EuPs, Lot 7: External power supplies and battery chargers (January 2007).

Proposed reference luminaire cases for this assessment:

- **Two luminaires for DLS lamps:** GU10 mains voltage luminaire compared to GU5.3 low voltage luminaire, hereafter indicated as '**Case1DLS'**. This case should also be representative for a G9 luminaire compared to GY6.35, the improvement and additional costs are similar.
- **Two uplighter luminaire for NDLS lamps**: an up-lighter with R7s socket for a linear halogen mains voltage lamp compared to another one equipped for a Circular FL(ni), hereafter indicated as'**Case2NDLS**'

4.1.3 Average luminaire wattage to assess energy consumption

This data is included in chapter 2.

4.1.4 DLS lamps production

Data on composition and weight of the lamps that are summarized in Table 4.2 are based on samples. Some data are also collected from producers' catalogues. Note that the substances in the same lamp family that have hazardous characteristics and the substances that have environmental impact are independent from the power [W] of the lamp but only dependent on the technology.
For incandescent reflector lamps, differences could be found in the weight of glass, dependent on the bulb form, and in the weight of metal for the socket, dependent on the socket type E27/B22 versus E15/B15. Howerver, as only the R63 E27/B22d types are chosen as representative for the normal wattages and PAR38 E27/B22d for the high wattages, in the same group no difference is taken into account.

Also for the HL-MV-R GU10 types the BOM for different wattages is nearly the same and the same statement can be made for the different lamp families in HL-LV-R.

Some remarks about the environmental impacts related to this input table are:

- The environmental impacts of the residual rare earth metals are assumed negligible.
- The environmental impact of the noble filling gasses (argon, krypton and xenon) is assumed negligible. A noble gas is chemically inert and therefore not an hazardous gas. Carbon dioxide emission due to production of 1 kg Argon is only 0.295 kg, for 1 kg Krypton only 102 kg and for 1 kg xenon 710 kg[3]. Due to the very small amount of these gasses in halogen bulbs, their environmental impact is far less than for other lamp parts as can be checked after chapter 5.

The potential effects of these assumptions in the environmental impact assessment will be further discussed in chapter 8 in the sensitivity analysis.

The following tables present the input data using the terminology from the VHK model for the environmental assessment (see Table 4.2).

[3] Swiss Centre for Life Cycle Inventories: Ecoinvent database

Table 4.2: Input data for the materials extraction and production of the lamps (expressed in g)

MATERIALS Extraction & Production ***Description of component***	Incandescent reflector lamp, R63, E27 – **40/60W**	Halogen reflector lamp, R63, E27 , – **60W**	Incandescent reflector lamp, PAR38, E27 – **80/120W**	Halogen reflector lamp, PAR38, E27, – **100W**	Halogen reflector lamp, MR16, GU10 – **50W**	Halogen reflector lamp, MR16, 12V, GU5.3 – **50W**	Compact fluorescent reflector lamp, R50, GU10 – **7W**	**Category**	**Material or Process MEEUP**
Glass	28	30	361	365	36	29	20	7-Misc.	**54-Glass for lamps**
Aluminium for caps	1.5	1.5						4-Non-ferro	**26-Al sheet/extrusion**
Copper for caps / connector pins			3.5	3.5	1.5	0.3	1.5	4-Non-ferro	**30-CU tube/sheet**
Cement						0,7		7-Misc.	**58-Concrete**
Soldering	0.5	0.5	0.5	0.5					**52-Solder**
Metal Mercury							0.004		
Plastic housing							15		**PBT**[4]
Printed circuit board, assembled							10		**53-PWB assembly**
Total weight	***30***	***32***	***365***	***369***	***37.5***	***30***	**47**		

More than 98% of the total weight is modelled; the remaining materials are expected not to have a major environmental impact. Therefore, only a minor underestimation of the total environmental impact of the lamp is expected.

The inputs that refer to the production (manufacturing processes) of the lamps are directly derived from the input data for the materials extraction and production. There is a significant difference in the production parameters per lamp family: incandescent, halogen or compact fluorescent. Following the VHK case study, it is taken into account that for the production of 1 kg sheet metal for lamps, 1.25 kg sheet metal is needed as input material (20% sheet metal scrap).

[4] **PBT** PolyButyleneTerephtalate

4.1.5 Production of luminaires (4) selected to assess the luminaire socket and space lock-in effect

In line with the system approach explained in chapter 1 only the minimum relevant parts will be taken into account for the selected reference luminaires. Only the differences between the two reference luminaires will be compared per luminaire case as defined in section 4.1.2.

Case1DLS: GU10 mains voltage luminaire compared to GU5.3 low voltage luminaire.

Only price and BOM of low voltage transformer 60 VA (lot 7 preparatory study) will be used, see Table 4.3. The estimated average price was € 10.00.

Table 4.3 BOM of low voltage transformer 60 VA lot 7

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Upper case	65,6	4-Non-ferro	26-Al sheet/extrusion
3	Bottom case	17,9	1-BlkPlastics	10-ABS
4	Electronic assembly			
5	PWB	17,2	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
6	Big caps & coils (THT)	99,7	6-Electronics	44-big caps & coils
7	Diodes, transistors, varistors	6,9	6-Electronics	47-IC's avg., 1% Si
8	ICs	0,0	6-Electronics	47-IC's avg., 1% Si
9	SMD /LED's (others)	0,0	6-Electronics	48-SMD/ LED's avg.
10	Terminal block	3,3	6-Electronics	45-slots / ext. ports
11	Miscellaneous			
12	Polyester film	4,1	1-BlkPlastics	1-LDPE
13	Packaging			
14	Back paper packaging	5,0	7-Misc.	56-Cardboard
15	Plastic slide pack	8,0	1-BlkPlastics	8-PVC

Case2NDLS: an up-lighter with R7s socket for a linear halogen mains voltage lamp compared to another one equipped for a Circular FL(ni).

Only price and BOM of a fluorescent lamp electronic ballast (lot 8 preparatory study on office lighting) will be used. BOM data is included in Table 4.4. The estimated average price was 29 euros. For the lamp the equivalent BOM of a LFL T5-28W will be used from lot 8 (p. 114), current price is about 4 euro.

Table 4.4 BOM of a typical electronic ballast for fluorescent lamp.

MATERIALS Extraction & Production ***Description of component***	**Electronic ballast for 1xLFL T5-54W (EEI=A2)**	**Category**	**Material or Process**
PCB	25,00	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
Housing_Steel sheet	127,50	3-Ferro	**21-St sheet galv.**
PET film	5,00	1-BlkPlastics	**2-HDPE**
solder paste	2,50	6-Electronics	**52-Solder SnAg4Cu0.5**
Coil	70,00	6-Electronics	**44-big caps & coils**
Metal film capacitor_Aluminium	7,50	4-Non-ferro	**26-Al sheet/extrusion**
ELKO component_Aluminium sheet	5,00	6-Electronics	**44-big caps & coils**
luster terminal_PP	3,75	1-BlkPlastics	**4-PP**
luster terminal_steel	3,75	3-Ferro	**22-St tube/profile**
Total weight (g)	***250***		

4.1.6 Production of an average luminaire to assess energy consumption

In line with the system approach explained in chapter 1 only the minimum relevant parts will be taken into account for the selected reference luminaires.
Hence the average luminaire BOM is not relevant for this assessment. If there are significant material differences connected to improvement options (if any), those differences will be included in chapter 6.

4.2 Distribution phase

4.2.1 Distribution phase of reflector lamps

The environmental impact of the distribution of lamps is modelled according to the VHK-model. The input parameters for the lamps are shown in the table below. The main difference can be found in the volume of the packaged final product, which is based on the dimensions of the respective lamps.

Table 4.5: Input data for the environmental assessment of the distribution of the lamps (expressed in dm³)

MATERIALS Extraction & Production ***Description of component***	Incandescent reflector lamp, R63, E27 – **60W**	Halogen reflector lamp, R63, E27, – **60W**	Incandescent/halogen reflector lamp, PAR38, E27 – **100/120W**	Halogen reflector lamp, MR16, GU10 – **50W**	Halogen reflector lamp, MR16, 12V, GU5.3 – **50W**	Compact fluorescent reflector lamp, R50, GU10 – **7W**	**Category**	**Material or Process MEEUP**
Volume per packaged retail product	0.41	0.41	1.70	0.40	0.40	0.23	7-Misc.	**62-per dm³ retail product**

4.2.2 Distribution phase of luminaires

As stated before the focus is on differences for luminaire cases (two by two). It will be assumed that the identified luminaire cases have identical packed volume, hence no impact difference will be taken into account.

4.3 Use phase (product)

In this section, an overview is included of the calculation of the annual resources consumption and the direct emissions related to the defined performance parameters in chapter 1 and 3 under standard and non-standard conditions. This section also includes a representative overview of the performance parameters found for products on the market year 2008-2009.

The purchase prices of the lamps that are mentioned in Table 4.6 are prices found on the retailer market. They can vary with 50% plus or minus and this will be taken into account in the sensitivity analysis.

In chapter 6, dedicated to the Best Available Technology (BAT) and Best Not Yet Available Technology (BNAT), upcoming products are considered with more improved performance parameters but with a high actual price and/or a low actual trade volume or products that are only in the R&D phase.

4.3.1 Rated annual resources consumption (energy, lamps) during product life according to the test standards defined in chapter 1

4.3.1.1 Annual energy consumption formula

The annual energy consumption (E_y) of a lamp in standard conditions is straightforward related to the lamp power and burning hours per year:

$$E_y \text{ [kWh]} = P_{lamp} \text{ [kW]} \times t_{operating}.$$

where,

- P_{lamp} = lamp power in kW as defined in chapter 1,
- $t_{operating}$ = burning hours per year as defined in chapter 2.

4.3.1.2 Annual lamp consumption formula

The annual consumption of lamps per lighting point in standard conditions is straightforward and related to the lamp lifetime in hours. It is assumed that in domestic lighting, lamps are used until end of life.

$$N_y = t_{operating} / t_{life}$$

where,

- t_{life} of the lamp is usually taken at LSF = 0,5 (LSF is the Lamp Survival Factor see chapter 1).

4.3.1.3 Assessment of relevant lamp types and product performance parameters

For incandescent lamps, the typical declared operational lifetime t_{life} is 1000h and for halogen lamps, operational lifetimes vary from 2000 to 5000h and are declared by manufacturers. For CFLi's, different declared operational lifetimes can be found on the market: e.g. 6000, 8000, 12000 and 15000h.

The colour rendering Ra for incandescent and halogen lamps is accepted to be 100.
For CFLi's, usually the colour rendering Ra and varies between 80 and 90.

Colour temperature T_C for incandescent lamps is in the range from 2400K to 2900K, for mains voltage halogen lamps from 2700K to 2900K and for low voltage halogen lamps T_C is about 3000K. Most currently used CFLi's have T_C = 2700K, but also lamps with a higher T_C are available on the market.

Table 4.6 includes the performance parameters for the selected base-case lamp types that are used further in this study. Lamp lifetime data were retrieved from the data supplied by manufacturers on their products and in their catalogues.

The performance of a reflector lamp in catalogues is mostly expressed in candela (cd) and beam angle (θ). The luminous efficacy (lm/W) of a reflector lamp (η_{lamp}) is in most cases not given in manufacturers catalogues. Measurement data were provided by ELC members. From this data it can be concluded that the real measured peak intensity and beam angle can vary compared to the nominal value, therefore working with functional lumen output is more stable for the purpose of this study. This is also illustrated in Table 4.6 with HL-LV-R lamps with different beam angles; as can be seen there the beam angle has a small influence on efficacy in the same technology.

Please note that most of the sold CFLi reflector lamps are NDLS, e.g. the typical 7 Watt GU10 (MR16) or equivalent E14 (R50) lamp which has only about 68 % lumen (130/190) in a solid angle of π. Therefore these lamps will not be considered as a base case in chapter 5. The few CFLi-R lamps that really are DLS are efficient and have few improvement options, see E27 (R120) compared to others in a simular solid angle. In chapter 6 CFLi-R might be considered as improvement options for HL-LV-R lamps, however as already can be seen the improvement potential is poor. Especially because BAT HL-LV-R lamps are not yet included (see chapter 6).

Please also note that not all lamps are retrofit solutions for each other, hence there is a lock-in effect (see also chapter 3).

Table 4.6: Selected lamp efficacy, cost data and life time

Lamp type **Acronym**	**Wattage**	**Average LWFt**[5]	**Intensity**	**Beam angle**	**Luminous flux in a solid angle of 2π**	**Luminous flux in solid angle π (angular beam 120°)**	**Functional lumens in an angular beam of 90°**	**ηlamp(90°) @25 °C (without LWFt)**	**Life time**	**Unit price (for end user)**
	[W]		**[cd]**	**[°]**	**[lm]**	**[lm]**	**[lm]**	**[lm/W]**	**[h]**	**[€]**
Incandescent reflector lamp, R63, E27 (B22d) **GLS-R**	40	1	321	53	296	264	209	5.2	1000	1.3
Incandescent reflector lamp, R63, E27 (B22d) **GLS-R**	60	1	836	29	487	427	328	5.5	1000	1.3
Halogen reflector lamp, R63, E27 (B22d) **HL-MV-R**	40	1	714	23	315	275	213.7	5.3	2000	4.5

Halogen reflector lamp, R63, E27 (B22d) **HL-MV-R**	60	1	1037	29	529	475	379.8	6.3	2000	4.5
Incandescent reflector lamp, PAR38, E27 (B22d) **GLS-R**	80	1	1882	27	699	677	617	7,7	1000	5.4
Incandescent reflector lamp, PAR38, E27 (B22d) **GLS-R**	120	1	3562	25	1230	1176	1131	9,4	1000	5.4
Halogen reflector lamp, PAR38, E27 (B22d) **HL-MV-R**	100	1	2620	30	1251		1081	10.8	2000	13.5
Halogen reflector lamp, MR16, GU10 **HL-MV-R**	35	1	416	36	219	202	175	5.0	2000	4.1
Halogen reflector lamp, MR16, GU10 **HL-MV-R**	50	1	851	31	367	346	313	6.3	1000	3.1
Halogen reflector lamp, MR16, GU10 **HL-MV-R**	50	1	790	34	392	369	329	6.6	2000	4.1
Halogen reflector lamp, MR16, 12V, 38°, GU5.3 **HL-LV-R**	35	1.11	1297	26	392	370	333	9.5	2000	1.5
Halogen reflector lamp, MR16, 12V, GU5.3 **HL-LV-R**	35	1.11	1261	39	537	519	471	13,5	4000	3.3
Halogen reflector lamp, MR16, 12V, 38°, GU5.3 **HL-LV-R**	50	1.11	1290	34	546	521	470	9.4	2000	1.5
Halogen reflector lamp, MR16, 12V, 10°, GU5.3 **HL-LV-R**	50	1.11	8800	10	744	709	640	12.8	4000	3.3
Halogen reflector lamp, MR16, 12V, 24°, GU5.3 **HL-LV-R**	50	1.11	2500	24	763	737	677	13.5	4000	3.3
Halogen reflector lamp, MR16, 12V, 38°, GU5.3 **HL-LV-R**	50	1.11	1500	36	782	765	714	14.3	4000	3.3
Halogen reflector lamp, MR16, 12V, 60°, GU5.3 **HL-LV-R**	50	1.11	1100	60	828	809	750	15.0	4000	3.3
Compact fluorescent reflector lamp, MR16, GU10 **CFLi-R**	7	1.05	60	130	190	130	85	12.1	6000	6
Compact fluorescent reflector lamp, R120, E27 (B22d) **CFLi-R**	20	1,05	265	110	638	440	385	19,3	6000	15.0

Remarks: the xxx highlighted values are not measured but calculated based on the adjacent values,
the CFLi-R do not meet the requirements for a DLS (≠ 80% light output in the 120° cone angle),
all mentioned luminous fluxes are initial luminous fluxes.

4.4 Use phase (system)

This chapter is important to understand the limitations that are imposed on domestic light sources and also aspects related to the 'putting into service of domestic lighting equipment'. This section identifies and describes the functional system to which the product in question belongs and identifies and quantifies, to the extent possible, those product features that can reduce the environmental impact not only of the product but of the system as a whole. Please note that the scope of the system analysis is wider than the scope of the EuP Directive. The question that should be posed during the analysis is whether and how the system performance could be improved leading to environmental benefits with measures that are restricted only to issues that can be influenced by technical features or additional information of the product under investigation as defined in chapter 1. Furthermore, the system analysis serves as an addition to the more traditional product-specific analysis in paragraph 4.3, i.e. to design product specific legislation (if any) in such a way that it would not make system-oriented innovations impossible.

4.4.1 Assessment of energy consumption of the reflector lamps during product life, taking into account the system

4.4.1.1 Influence of the power factor

See for this item also section 3.2.8. For lamps operating on a ballast or electronics, the power factor can go down to 0,50[6]; the lower the power factor, the higher the electrical current that is needed to provide in the same amount of real power. . Use of higher current to compensate for a lower power factor than 1 is assumed to cause 5% more losses in the electrical grid that feeds the lamp. Therefore a correction factor 'Lamp Wattage Factor LWFp' is introduced as shown in Table 4.7.

Table 4.7 Adjustment to correct for Power Factor (LWFp) used in this study

lamp type	LWFp
GLS-R	1
HL-LV-R types	1
CFLi-R	1.05
LED retrofit for HL-MV-R	1.05
LED retrofit for HL-LV-R	1

The formula for the real power becomes:

$$P_{real}\ [W] = Plamp \times LWFp.$$

The real annual energy consumption (E_{yreal}) per lamp is related to the standard energy consumption by:

$$E_{yreal}\ [kWh] = E_y\ [kWh] \times LWFp.$$

4.4.1.2 Influence of the external power supply or external ballast

The low voltage halogen lamps need an external power supply and CFLni's need an external ballast. Those transformers and ballasts are mostly incorporated in the luminaire. As discussed in other EuP studies[7], this also causes power losses in the system.

Table 4.8: Transformer efficiencies (source BIOIS)

Rated Lamp Load (P) (in watts)	Full load Efficiencies Assumption for EuP preparatory study	
	Magnetic transformers	Electronic transformers
0 < P ≤ 60	80 %	92.5 %
60 < P ≤ 105	84 %	
105 < P ≤ 210	90 %	
210 < P	92 %	

To take into account those losses, a 'Lamp Wattage Factor LWFe' for low voltage halogen lamps is introduced. According to the values in Table 4.1, and a transformer distribution of 70% electronic vs. 30% magnetic, a value LWFe = 1,11 is taken into account; the same value is used for external ballasts on CFLni's.

Table 4.9: Adjustment to correct for Power Supply Losses or external ballast (LWFe)

lamp type	LWFe
GLS-R	1
HL-MV –R types	1
HL-LV –R types	1,11
CFLi-R	1
LED retrofit HL-MV-R	1
LED retrofit HL-LV-R	1.17

The formulas for the real power and the real electricity consumption are the same as for the compensation of the power factor with LWFp replaced by LWFe.

4.4.2 Assessment of the use phase of the luminaires (4) selected to assess the luminaire socket and space lock-in effect when assessing the energy consumption

This will be done based on the energy consumptions of the selected lamp types for comparison. Therefore equivalent BAT lamp types (GU10 vs GU5.3, R7s vs CFLni) will be selected based on chapter 6 data.

4.4.3 Other elements of the system environment

Another important element of the system environment are dimming devices that are installed in the electrical grid. Very few CFLi lamps can be operated with a standard dimmer.

Also an external power supply or ballast[8] can be needed for low voltage lamps or CFLni's.

Please note that both elements were already discussed in part 1 of the study.

Finally, also the room itself belongs to the system. Improvement can be obtained by increasing use of day lighting, brighter and more reflective surfaces (wall, ceiling, floor, carpet, furniture, etc.) and the positioning of the light source.

4.5 End-of-life phase

The NDLS lamps are treated equal to DLS lamps, please see part 1 of this study.

For luminaires it will be assumed that identified luminaire cases or improvement options have identical end of life behaviour, hence there are no difference to be taken into account in line with the approach explained in chapter 1.

5 DEFINITION OF BASE-CASE

6 TECHNICAL ANALYSIS BAT

7 IMPROVEMENT POTENTIAL

8 SCENARIO- POLICY- IMPACT- AND SENSITIVITY ANALYSIS

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