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Preparatory Studies for Eco-design Requirements of EuPs

Lot 19: Domestic lighting
Part 1 - Non-Directional Light Sources

Draft final task reports
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
Lea Turunen
Benoît Tinetti
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 interim draft document is to present preliminary data for discussion with stakeholders related to the EuP preparatory study for the lot 19.
You can follow the progress of our study and find general information related to lot 19 on the project website when you register as stakeholder: http://www.eup4light.net
Please, also consult the website for timing and organisation of the tasks.

1 PRODUCT DEFINITION

2 ECONOMIC AND MARKET ANALYSIS

3 CONSUMER BEHAVIOUR AND LOCAL INFRASTRUCTURE

4 TECHNICAL ANALYSIS EXISTING PRODUCTS

Important remark: This preliminary chapter 4 does only discuss part 1 of the study and does not yet discuss directional light sources such as reflector lamps. The discussion of those products will be done in part 2 of the study.

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 will only be introduced in chapter 6.

4.1 Production phase

4.1.1 Introduction

The table below summarizes the types of 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 European domestic applications and the types that are expected to be installed in the near future. As mentioned before, Best Available Technology that is nowadays rarely used will only be introduced in chapter 6.

These representative lamps were selected after the analysis of the use phase. The catalogues contain a multitude of lamps for various, also non-domestic applications; for reasons of simplification only selected representative products that fulfil the requirements of the use phase are included in this study.

Selected omnidirectional lamps:

Table 4.1: Overview of selected lamps.

Lamp type Acronym	Wattage [W]	Colour Temp [K]	Colour rendering Ra	Energy label	ILCOS-code
Incandescent lamp, clear, form A, E27/B22d **GLS-C**	200	2800	100	E	IAA/C-200-230-E27-80
Incandescent lamp, frosted, form A, E27/B22d **GLS-F**	60	2600	100	E	IAA/F-60-230-E27-55
Incandescent lamp, clear, form A, E27/B22d **GLS-C**	60	2600	100	E	IAA/C-60-230-E27-55
Incandescent lamp, frosted, form B, E14/B15d **GLS-F**	40	2600	100	E	IBB/F-40-230-E14-35
Incandescent lamp, clear, form B, E14/B15d **GLS-C**	40	2600	100	E	IBB/C-40-230-E14-35
Compact fluorescent lamp, bare, E27/B22d **CFLi**	15	2700	80≤Ra<90	A	FBT-15/27/1B-220/240-E27
Compact fluorescent lamp, enveloped form A, E27/B22d **CFLi**	15	2700	80≤Ra<90	A	FBA-15/27/1B-220/240-E27
Compact fluorescent lamp, bare, E14/B15d **CFLi**	10	2700	80≤Ra<90	A	FBT-10/27/1B-220/240-E14
Compact fluorescent lamp, enveloped form B, E14/B15d **CFLi**	10	2700	80≤Ra<90	A	FBB-10/27/1B-220/240-E14
Halogen lamp, clear, 230V, G9, **HL-MV**	40	2900	100	D	HSG/C/UB-40-230-G9-44
Halogen lamp, clear, 230V, linear, R7s **HL-MV**	300	4000	100	D	HDG-300-230-R7s-114,2
Halogen lamp, clear, 12V, GY6,35 **HL-LV**	50	3000	100	C[1]	HSGST/UB-50-12-GY6,35
Halogen lamp, clear, 12V, GY6,35 **HL-LV**	35	3000	100	C[2]	HSGST/UB-35-12-GY6,35

Linear fluorescent lamps and non-integrated compact fluorescent lamps are also used for domestic lighting. They were already discussed in the study on office lighting[3] and will not be discussed again in this study. Where needed, the data of that study shall be used in further chapters.

[1] Until now, HL-LV lamps have neither a CE-marking nor an energy label. The mentioned C-label should be applied if our proposal in chapter 8 is followed.
[2] Until now, HL-LV lamps have neither a CE-marking nor an energy label. The mentioned C-label should be applied if our proposal in chapter 8 is followed.
[3] Preparatory Studies for Eco-design Requirements of EuPs, Lot 8: Office lighting, Final Report (April 2007).

Selected reflector lamps** (part 2)**:

Table 4.2: Overview of selected reflector lamps

Lamp type	Wattage W	Colour Temp K	Colour rend Ra	Energy label	ILCOS-code

For these typical lamps, product data are collected as needed for the VHK model. The production phase is modelled according to the MEEuP methodology report. Detailed information on environmental impact is included in chapter 3 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.

Mercury is an essential element for the operation of compact fluorescent lamps and is inserted during the production phase. In normal circumstances, mercury stays within the lamp enclosure during its entire lifetime and can be recycled at end-of-life (see chapter 3). It should be noted that, also during use phase, mercury is released to the atmosphere due to the electricity production (see MEEuP methodology table 29 parameter HM p. 88). In chapter 5, it will be evaluated if the use phase is the most significant stage of the life cycle**.** Total lamp mercury will be calculated separately in the related Eco-Reports.
In this study, types of lamps were put togheter within a certain range of weight of components and a range of power. Incandescent lamps in bulb form (form A) in the range from 15 to 100W have the same dimensions and thus an almost equal Bill of Material (BOM); the lamp of 60W can be taken as representative for this range. Moreover, in chapter 2 can be seen that this lamp is apparently the most used incandescent lamp in EU27. The incandescent lamp of 200W will be representative for the higher wattages. For incandescent lamps in candle form (form B), the 40W lamp is taken as the most representative. For CFLi's, 10W bare and enveloped are representative replacement lamps for 40W incandescent and the 15W for the 60W incandescent. This ranges will also allow the assessment of aberrations on the potential environmental impact of other lamps. But here again, one can expect a very low total

environmental impact for lighting by the 'production phase' according to the previous studies on street and office lighting[4].
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 is referred to section 4.5.

4.1.2 Lamps production

Data on composition and weight of the lamps that are summarized in Table 4.4 are based on samples. Some data are also collected from producers' catalogues. Note that the substances in the same lamp family that have hazardous, environmental impact, are independent from the power [W] of the lamp but only dependent on technology, e.g. for CFL, mercury content is independent on lamp power but difference can be made between technologies e.g. amalgam (Hg-Pb) or not (only Hg).
For incandescent lamps, negligible differences can 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.
For CFLi's, also the weight of glass and the possible envelope, dependent on the power, and the weight of the socket can make a difference.

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

- The environmental impacts of the residual rare earth metals is assumed negligible.
- The environmental impact of the noble filling gasses (argon or krypton) is assumed negligible. A noble gas is chemically inert and therefore not an hazardous gas. Carbondioxide emission due to production of 1 kg Argon is only 0.271 kg and for 1 kg Krypton only 102 kg[5]. This is far less than other lamp parts as can be checked after chapter 5.
- For the production of the lamp mercury (max. 0.005g) no detailed data are available on the environmental impact of mercury production itself, but we take the mercury itself as environmental impact (heavy metal) into account.
  VITO performed a control on the mercury content of a limited sample CFLi's, currently available on the market. The control was made by atomic fluorescence spectrometry, conform CMA 2/I/B.3. The results are shown in Table 4.3.
  It must be stated that sample #3 significantly exceeded the maximum allowed mercury content. This is probably caused by the cheap but inaccurate method of mercury filling (drip filling) that seems to be very common in most small far eastern production plants.

[4] Preparatory Studies for Eco-design Requirements of EuPs, Lot 8 & 9: Office lighting & Street lighting
[5] Swiss Centre for Life Cycle Inventories: Ecoinvent database

Table 4.3: Measured mercury content in CFLi's

Sample	Mercury content in mg
1	1,8
2	1,1
3	6,4
4	3,5
5	0,28

An acceptable average of 4 mg will be used in this study.

The potential effects of these assumptions in the environmental impact assessment will be further dicussed 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 4.4).

Table 4.4: Input data for the materials extraction and production of the lamps (expressed in g)

MATERIALS Extraction & Production ***Description of component***	Incandescent lamp, clear, form A, E27/B22d - **200W**	Incandescent lamp, frosted, form A, E27/B22d - **60W**	Incandescent lamp, clear, form A, E27/B22d - **60W**	Incandescent lamp, frosted, form B, E14/B15d - **40W**	Incandescent lamp, clear, form B, E14/B15d - **40W**	Compact fluorescent lamp, bare, E27/B22d - **15W**	**Category**	**Material or Process MEEUP**
Glass	112	25,5	25,5	14	14	25	7-Misc.	**54-Glass for lamps**
Aluminium for caps		1,5	1,5	1	1	1,5	4-Non-ferro	**26-Al sheet/extrusion**
Copper for caps	3,2						4-Non-ferro	**30-CU tube/sheet**
Metal Mercury						0,004		
Plastic housing						25		**PBT**[6]
Lamp envelope								**54-Glass for lamps**
Printed circuit board, assembled						20		**53-PWB assembly**
Total weight								

[6] **PBT** PolyButyleneTerephtalate

MATERIALS Extraction & Production *Description of component*	Compact fluorescent lamp, enveloped form A , E27/B22d - **15W**	Compact fluorescent lamp, bare, E14/B15d - **10W**	Compact fluorescent lamp, enveloped form B, E14/B15d - **10W**	Halogen lamp, clear, 230V, G9 **40W**	Halogen lamp, clear, 230V, linear, R7s - **300W**	Halogen lamp, clear, 12V, GY6,35 - **50W**	Halogen lamp, clear, 12V, GY6,35 - **35W**	**Category**	**Material or Process MEEUP**
Glass	25	17,5	17,5	2	9	2	2	7-Misc.	**54-Glass for lamps**
Aluminium for caps	1,5	1	1					4-Non-ferro	**26-Al sheet/extrusion**
Copper for caps								4-Non-ferro	**30-CU tube/sheet**
Metal Mercury	0,004	0,004	0,004						
Plastic housing	23	22	11						**PBT**[7]
Lamp envelope	22		18						**54-Glass for lamps**
Printed circuit board, assembled	20	17	16						**53-PWB assembly**
Total weight									

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

The inputs that refer to the production (manufacturing processes) of the lamps are directly deduced from the input data for the materials extraction and production . There is of course 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).

4.1.3 Ballasts (control gear) and power supply production

Nor ballasts for LFL's and CFLni's, neither transformers and power supplies for low voltage halogen lamps will be discussed in this study. They were already discussed in the study on office lighting[8] or on external power supplies[9]. The BOMs of ballasts in CFLi's are included in the tables in section 4.1.2. Note that all currently available CFLi's use electronic ballasts.

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

4.2 Distribution phase

The environmental impact of the distribution of the 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 lamp, clear, form A, E27/B22d - **200W**	Incandescent lamp, frosted, form A, E27/B22d - **60W**	Incandescent lamp, clear, form A, E27/B22d - **60W**	Incandescent lamp, frosted, form B, E14/B15d - **40W**	Incandescent lamp, clear, form B, E14/B15d - **40W**	Compact fluorescent lamp, bare, E27/B22d - **15W**	**Category**	**Material or Process MEEUP**
Volume per packaged retail product	1,25	0,35	0,35	0,13	0,13	0,40		**62-per dm³ retail product**

MATERIALS Extraction & Production ***Description of component***	Compact fluorescent lamp, enveloped form A , E27/B22d - **15W**	Compact fluorescent lamp, bare, E14/B15d - **10W**	Compact fluorescent lamp, enveloped form B, E14/B15d - **10W**	Halogen lamp, clear, 230V, G9 **40W**	Halogen lamp, clear, 230V, linear, R7s - **300W**	Halogen lamp, clear, 12V, GY6,35 - **50W**	Halogen lamp, clear, 12V, GY6,35 - **35W**	**Category**	**Material or Process MEEUP**
Volume per packaged retail product	1,1	0,30	0,27	0,05	0,15	0,15	0,15		**62-per dm³ retail product**

4.3 Use phase (product)

In this paragraph, 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 paragraph also includes a representative overview of the performance parameters found for products on the market anno 2007. 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 Formulas that relate energy use to performance parameters

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

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

where,

- P_{lamp} = lamp power in Watt as defined in chapter 1,
- $t_{operating}$ = burning hours per year as defined in chapter 3.

4.3.1.2 Formulas related to consumption of lamps per lighting point

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

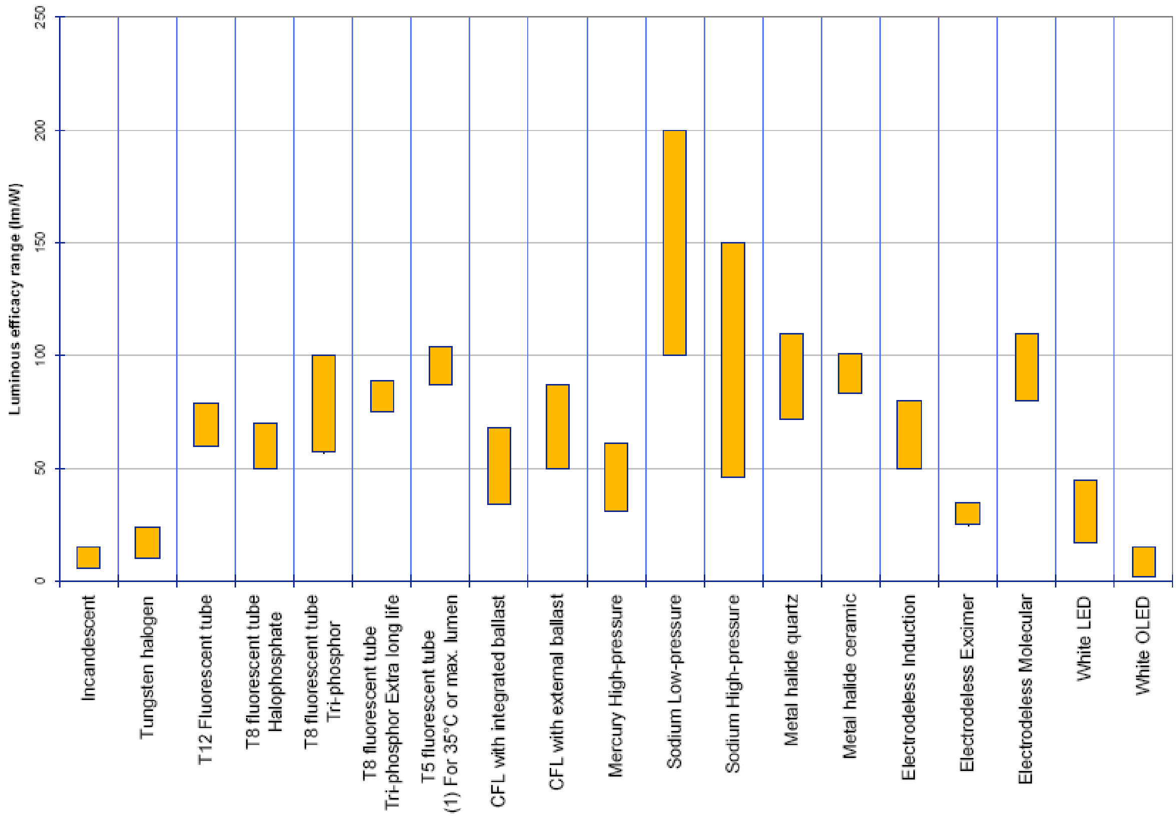

Figure 4.1: Luminous efficacy range of lamp technology (source: Laborelec)

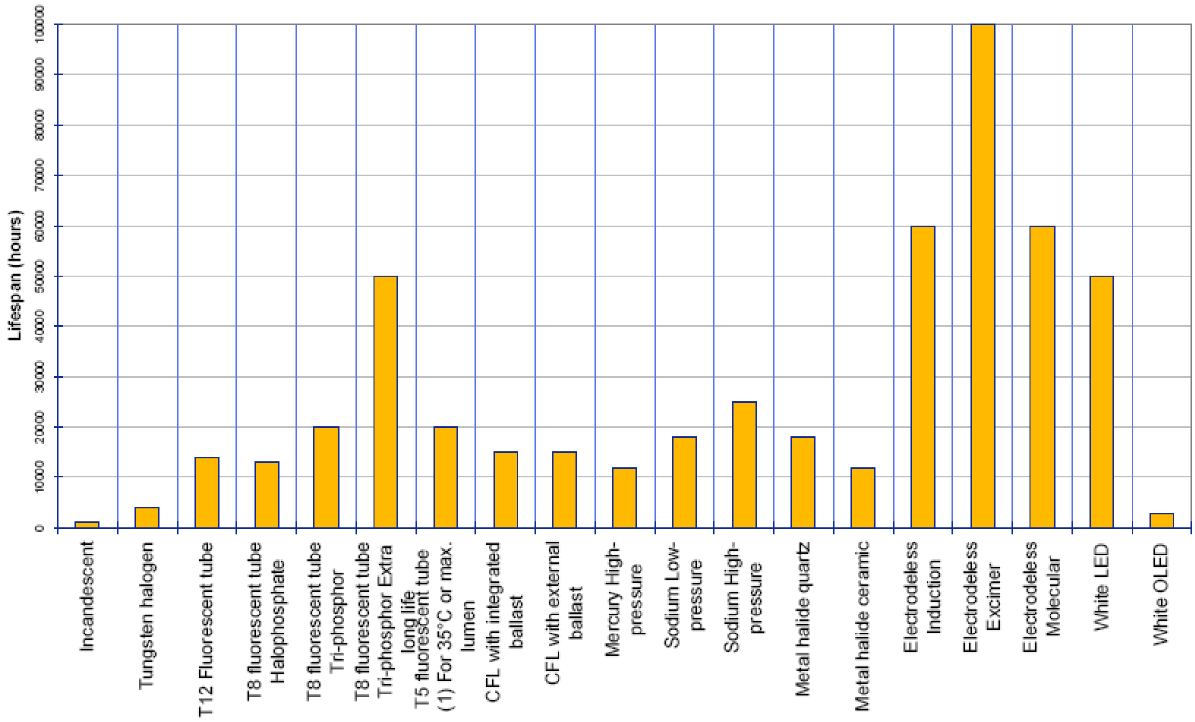

Figure 4.2: Typical life span range of lamp technology (source: Laborelec)

In Figure 4.1 typical luminous efficacy ranges are included per lamp technology and in Figure 4.2 typical lamp life span ranges are given.

For incandescent lamps, the typical declared operational lifetime t_{life} is 1000h and for halogen lamps, operational lifetimes from 2000 till 5000h 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 of incandescent and halogen lamps is accepted to be 100.
For CFLi's, usually the colour rendering Ra is : $80 \leq Ra < 90$.

Colour temperature T_C for incandescent lamps is in the range from 2400K till 2900K and for 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 lamp types that are used further in this study.
Lamp lifetime and ηlamp (luminous efficacy of the lamp) data were retrieved from the data supplied by manufacturers on their products and in their catalogues.

It is very important to notice that lamp efficacy, for lamps in the same category, also depends on lamp wattage: lamp efficacy rises with the wattage. This does of course not mean that one should simply replace lamps with lower wattage by lamps with higher wattage to save energy; preferably, one should replace a luminaire with many, low wattage lamps by a luminaire with less lamps but higher wattage.

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

Lamp type Acronym	Wattage rated [W]	Colour Temp [K]	Colour rend Ra	LWFt [10]	ηlamp @25 °C [lm/W]	Operational Life time [h]	Unit price (for end user) [€]	ILCOS-code
Incandescent lamp, clear, form A, E27/B22d **GLS-C**	200	2800	100	1	15,2	1000	2	IAA/C-200-230-E27-80
Incandescent lamp, frosted, form A, E27/B22d **GLS-F**	60	2600	100	1	11,4	1000	0.5	IAA/F-60-230-E27-55
Incandescent lamp, clear, form A, E27/B22d **GLS-C**	60	2600	100	1	11,8	1000	0.5	IAA/C-60-230-E27-55
Incandescent lamp, frosted, form B, E14/B15d **GLS-F**	40	2600	100	1	9,9	1000	0.7	IBB/F-40-230-E14-35
Incandescent lamp, clear, form B, E14/B15d **GLS-C**	40	2600	100	1	10,4	1000	0.7	IBB/C-40-230-E14-35
Compact fluorescent lamp, bare, E27/B22d **CFLi**	15	2700	80≤Ra<90	1,05	50	6000	4	FBT-15/27/1B-220/240-E27
Compact fluorescent lamp, enveloped form A, E27/B22d **CFLi**	15	2700	80≤Ra<90	1,05	45	6000	6	FBA-15/27/1B-220/240-E27
Compact fluorescent lamp, bare, E14/B15d **CFLi**	10	2700	80≤Ra<90	1,05	50	6000	3.5	FBT-10/27/1B-220/240-E14
Compact fluorescent lamp, enveloped form B, E14/B15d **CFLi**	10	2700	80≤Ra<90	1,05	40	6000	5	FBB-10/27/1B-220/240-E14
Halogen lamp, clear, 230V, G9 **HL-MV**	40	2900	100	1	12,3	1500	5,5	HSG/C/UB-40-230-G9-44
Halogen lamp, clear, 230V, linear, R7s **HL-MV**	300	3000	100	1	17,7	1500	3	HDG-300-230-R7s
Halogen lamp, clear, 12V, GY6,35 **HL-LV**	50	2800	100	1,11	17,1	3000	3	HSGST/UB-50-12-GY6,35
Halogen lamp, clear, 12V, GY6,35 **HL-LV**	35	2800	100	1,11	15,4	3000	3	HSGST/UB-35-12-GY6,35

4.3.2 Assessment of energy consumption during product life, taking into account the system

4.3.2.1 Influence of the power factor

See for this item also section 3.2.5.
For lamps operating on a ballast or electronics such as CFLi's, this power factor can go down to 0,50[11]; the lower the power factor, the higher the electrical current that is needed to result in the same real power. This higher current causes 5% more losses in the electrical grid that

[10] LWFt = Total Lamp Wattage Factor = LWFp x LWFe (see section 0).
[11] IAEEL newsletter 3-4/95, 'Power Quality for Beginners'

feeds the lamp. Therefore a correction factor 'Lamp Wattage Factor LWFp' is introduced; for values see Table 4.7.

Table 4.7 LWFp correction factors for power quality used in this study

lamp type	LWFp
GLS	1
HL types	1
CFLi	1,05

The formula for the real power becomes:

P_{real} [W] = Plamp x LWFp.

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

E_{yreal} [kWh] = E_y [kWh] x LWFp.

4.3.2.2 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[12], 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
$0 < P \leq 60$	80 %	92.5 %
$60 < P \leq 105$	84 %	
$105 < P \leq 210$	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.

[12] Preparatory Studies for Eco-design Requirements of EuPs, Lot 8 & 9: Office lighting & Street lighting and Lot 7: External power supplies and battery chargers.

Table 4.9: LWFe correction factors for the influence of the external power supply or external ballast

lamp type	LWFe
GLS	1
HL-MV types	1
HL-LV	1,11
CFLi	1
CFLni	1,11

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 Use phase (system)

This chapter is important to understand the limitations that are imposed to 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.

In domestic lighting, luminaires are assumed to constitute the most important part of the system environment of the lamp. Therefore, it is very important to understand the limitations that could be imposed by the luminaires.
This analysis will be elaborated in part 2 of the study.

Another important element of the system environment are dimming devices that are installed in the electrical grid. Not all CFLi lamps can be operated with a standard dimmer, more information will be included in chapter 6.

Also an external power supply or ballast[13] can be needed for low voltage lamps or CFLni's.

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

[13] Preparatory Studies for Eco-design Requirements of EuPs, Lot 8 & 9: Office lighting & Street lighting and Lot 7: External power supplies and battery chargers.

Preliminary conclusions:

1. The performance of domestic lighting sources could be improved through the luminaire design (detailed requirements to be elaborated in part 2 of this study).
2. The performance of domestic light sources can be improved if CFLi's with compatible dimmers are used (more technical info in chapter 6).
3. It should be noted that improvements can also be made at home design level (more daylight, ..) and interior design (brighter surfaces, orientation of the light source, location of the light source, ..).

4.5 End-of-life phase

The environmental impact of the end-of-life phase is modelled according to the VHK-model. The parameters used as input for this environmental assessment are shown in the following table and are identical for all types of lamps. Most input data in the end-of-life phase are directly related to the input parameters for the production. An important factor that must be defined here is the percentage of mercury content that is not captured during the processing of the waste lamps.

Collected CFLi's at end of life are crushed in a closed installation and sieved. The mercury containing fraction is distilated at 600°C to separate the mercury. The pure, metallic mercury is used again by lamp industry.

There is a lack of reliable information about collecting rates of CFLi's used in households.

At this moment it will be assumed that 80% of the used CFLi's is not collected and as a consequence 80% of the mercury present in lamps is emitted during the end-of-life processing.

The assumption is based on the following information:

- an annual report from a German recycling organization[14] that states that only 20% of used CFLi's from households is collected;
- a report from UNU[15] in August 2007 that states that 27,9% of all lamps is collected at end of life;
- the results of an inquiry made by a large vendor[16];
- the assumptions made by ELC and presented at the EEB Conference on 'Mercury-containing Lamps under the Spotlights', held in Brussels on 27th June 2008.

Not any other public information on this average percentage of fugitive mercury in EU-25 was found.

The data of the first two mentioned sources seem identical and also the most reliable information at this moment. If the UNU-study reports a collection rate of 27,9% for all lamps and knowing that the rate for professional lamps is normally higher than for household lamps, an assumption of 20% collected CFLi's is completely in line with the German report and is also used in this study.

Because many initiatives in the EU were started up (see also chapter 3) and other initiatives are taken such as spots on TV in Germany and in The Netherlands, similar with the initiatives for collecting batteries, it can be assumed that the rate will grow significantly in

[14] Lightcycle RetourlogistiK und Service GmbH : Jahresbericht 2006.

[15] United Nations University (August 2007): '2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipement (WEEE) Final Report'.

[16] Consumer inquiry made by IKEA in Sweden; this study was not published.

the near future. In the sensitivity analysis in chapter 8, the influence of higher collection rates will be discussed.

Table 4.10: Input data for the environmental assessment of the end-of-life processing of the lamps

DISPOSAL & RECYCLING	Lamp Type		unit
Description	**GLS / HL**	**CFLi**	
Substances released during Product Life and Landfill			
Refrigerant in the product (Click & select)	0	0	g
Percentage of fugitive & dumped refrigerant	0%	0%	
Mercury (Hg) in the product	0	≤ 0.005	g Hg
Percentage of fugitive & dumped mercury	0	80%	
Disposal: Environmental Costs per kg final product			
Landfill (fraction products not recovered) in g en %	100	5	%
Incineration (plastics & PWB not re-used/recycled)			g
Plastics: Re-use & Recycling ("cost"-side)			g
Re-use, Recycling Benefit		**in g**	**% of plastics fraction**
Plastics: Re-use, Closed Loop Recycling (please edit%)			1%
Plastics: Materials Recycling (please edit% only)			9%
Plastics: Thermal Recycling (please edit% only)			90%
Electronics: PWB Easy to Disassemble ? (Click&select)			**NO**
Metals & TV Glass & Misc. (95% Recycling)			

The parameters that are taken into account for the modelling of the environmental impact of the lamps are assumed to be identical. According to the VHK default values it is assumed that 5% of the materials go to landfill, 90% of the plastics is incinerated, 9% is recycled and 95% of the metals and glass is recycled.

5 DEFINITION OF BASE-CASE

6 TECHNICAL ANALYSIS BAT

7 IMPROVEMENT POTENTIAL

8 SCENARIO- POLICY- IMPACT- AND SENSITIVITY ANALYSIS

For more info see website www.eup4light.net.