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Preparatory Studies for Eco-design Requirements of EuPs

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

Interim Task Report
Task 5: DEFINITION OF BASE-CASE

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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.

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.

This report includes results concerning part 2 of the study concerning DLS (reflector lamps).

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, not for new discussion.

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

For more info see website www.eup4light.net.

5 DEFINITION OF BASE-CASE

Chapter 5 comprises of an assessment of average EU products, the so called “base-cases”.

A base-case is “a conscious abstraction of reality”. The description of the base-cases is the synthesis of the results of tasks 1 to 4. The environmental and life cycle cost analysis are built on these base-cases throughout the rest of the study and it serves as the point-of-reference for chapter 6 (technical analysis of BAT), chapter 7 (improvement potential), and chapter 8 (policy analysis).

According to the MEEuP methodology, the scope of a preparatory study should be covered by one or two base-cases in chapter 5. Nevertheless, as discussed in chapter 1, a wide range of lamps are available and chapter 2 highlighted that their sales amounts are significant. Therefore, it was decided to analyse a larger number of base-cases to portray the market reality in a comprehensive manner. Detailed analysis of several base-cases will also allow a more realistic assessment of improvement potentials in the subsequent tasks and EU-27 total environmental impact.

From section 2.2.3, 4 base-cases were considered to be representative of the current European market of directional light sources (DLS):

- **Incandescent lamp, reflector (GLS-R): 50 W**
- **Halogen lamp, mains voltage, reflector, high wattage (HL-MV-R-HW): 100 W**
- **Halogen lamp, mains voltage, reflector, low wattage (HL-MV-R-LW): 50 W**
- **Halogen lamp, low voltage, reflector (HL-LV-R): 35 W**

The choice of the wattage of the base-cases was based on the outcomes of primary the EU R&D project EURECO and others (see chapter 2, section 2.2.3) which provided information about the use of lighting sources by wattage groups for several European countries.

The average yearly use times are different for all base-cases and figures presented in chapter 2 for all sectors (see section 2.2.4) are used in this chapter:

- Incandescent lamp, reflector (GLS-R): 400 hours/year
- Halogen lamp, mains voltage, reflector, high wattage (HL-MV-R-HW): 450 hours/year
- Halogen lamp, mains voltage, reflector, low wattage (HL-MV-R-LW): 450 hours/year
- Halogen lamp, low voltage, reflector (HL-LV-R): 500 hours/year

As already mentioned in chapter 4 (section 4.1.3), neither ballasts for CFLi-R, nor transformers and power supplies for low voltage halogen lamps will be discussed in detail in this study as they were already detailed in the study on office lighting[1] and on external power supplies[2].

Please note that CFLi reflector lamps will not be considered as a base-case lamp in part 2 related to DLS lamps. As can be concluded from chapter 4 most of them are NDLS and belong to part 1. Moreover the sales of CFLi reflector lamps are low as presented in chapter 2. Also the current sales of LEDs are low and are therefore not considered as base case lamps in order not to complicate the calculation model. Both LEDs and CFLi-R will be discussed in chapter 6 as improvement options for the base-cases.

Luminaire cases were presented in section 4.1.2 and the environmental assessment will be discussed in qualitative terms in Chapter 8.

The environmental impacts of the base-cases are evaluated with the EuP Eco-Report tool as specified in the MEEuP methodology. This allows identifying the significance of the different phases of the life cycle in terms of environmental impacts.

Inputs used in this chapter were defined in previous chapters. Chapter 4 provides the required technical data, Bill of Materials (BOM), packaging and packaged volume, energy consumption during the use phase and considerations regarding the end-of-life of materials for existing products. Economic data (sales and stocks in EU-27, as well as product price and electricity tariff) were established in chapter 2.

For each of the 4 base-cases, the electricity consumption used in chapter 5 is for real life conditions. Thereby, the correction lamp wattage factors for power quality (LWFp) and external ballasts (LWFe) presented in section 4.4.1 have been taken into consideration. Further, the average lamp lumen maintenance factor (LLMF), as discussed in chapter 3 of Part 1, is used to calculate the lamp efficacy of the base-cases.

5.1 Product-specific inputs

5.1.1 Base-case GLS-R (General Lighting Service)

As stated in section 4.4.1, the BOM and packaged volume for 40 W and 60 W GLS are the same. Therefore, an average wattage of 50 W is assumed, and the BOM and packaged volume are taken from the 60 W GLS.

- **Bill of Material**

The BOM of this base-case is derived from the products presented in chapter 4 (section 4.1.2) for the incandescent lamp of 50 W (see Table 5.1).

[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, Final Report (January 2007).

Table 5.1: Eco-Report material input table for base-case GLS-R

Nr	Product name		Date	Author
	Base-Case GLS-R			BIO

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Glass	28	7-Misc.	54-Glass for lamps
2				
3	Aluminium for caps	1.5	4-Non-ferro	26-Al sheet/extrusion
4				
5	Soldering	0.5	6-Electronics	52-Solder SnAg4Cu0.5

- **Primary scrap production during sheet metal manufacturing**

It was assumed that the production of 1 kg sheet metal for lamps required 1.25 kg sheet metal, which leads to 20 % of sheet metal scrap. **This assumption is valid for the 4 base-cases.**

- **Volume and weight of the package volume**

The weight of the base-case is 30 g and it has a packaged volume of 0.41 dm^3.

- **Annual resource consumption and lamp efficacy**

The power rating of the base case GLS-R is 50 W as the correction factors are equal to 1, with a lamp lifetime of 1000 hours. With a yearly use of 400 hours (taking into consideration the use in all sectors and not only the domestic one), the lifespan of a typical incandescent lamp is 2.5 years.

Luminous efficacy is taken as the average of the measured efficacy in a 60 W and 40 W GLS-R, which results in a luminous efficacy of 5.35 lm/W. Considering a Lamp Lumen Maintenance Factor (LLMF) of 0.965 for GLS lamps, the **average luminous efficacy of base-case GLS-R is 5.16 lm/W** within an opening angle of 90°.

- **Disposal and Recycling**

For incandescent lamps, 100 % of the product is assumed to be disposed in landfills.

5.1.2 Base-case HL-MV-R-HW (Halogen Lamp – Mains Voltage – Reflector – High Wattage (230 V))

Chapter 4 presented various types of HL-MV-R. The 100 W lamp is chosen for the high wattage base-case, as it corresponds with the high power market average as mentioned in chapter 2.

- **Bill of Material**

The BOM of the base-case HL-MV-R-HW presented in Table 5.2 is based on the data presented in chapter 4.

Table 5.2: Eco-Report material input table for base-case HL-MV-R-HW

Nr	Product name	Date	Author
	Base-Case HL-MV-R-HW		BIO

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Glass	365	7-Misc.	54-Glass for lamps
2				
3	Copper for caps/connector pins	3.5	4-Non-ferro	30-Cu tube/sheet
4				
5	Solderin	0.5	6-Electronics	52-Solder SnAg4Cu0.5
6				

- **Volume and weight of the package volume**

The weight of the base-case HL-MV-R-HW is 369 g and it has a packaged volume of 1.70 dm^3.

- **Annual resource consumption and lamp efficacy**

The electricity consumption of the base-case HL-MV-R-HW is 100 Wh/h, as the total Lamp Wattage Factor (LWFt) is equal to 1 according to chapter 4 (section 4.4.1). The lamp lifetime is 2000 hours with an average use of 450 hours per year (taking into consideration the use in all sectors and not only the domestic one). Therefore, the lifespan of a typical HL-MV-R-HW is 4.44 years.

Based on a measured initial lamp efficacy of 10.8 lm/W and average LLMF of 0.975, the **average luminous efficacy of the base-case HL-MV-R-HW is 10.53 lm/W** within an opening angle of 90°.

- **Disposal and Recycling**

100 % of the HL-MV-R-HW is assumed to be disposed in landfill.

5.1.3 Base-case HL-MV-R-LW (Halogen Lamp – Mains Voltage – Reflector – High Wattage (230 V))

The 50 W lamp is chosen for the low wattage base-case, as it corresponds with the low power market average as mentioned in chapter 2.

- **Bill of Material**

The BOM of the base-case HL-MV-R-LW presented in Table 5.3 is based on the data presented in chapter 4.

Table 5.3: Eco-Report material input table for base-case HL-MV-R-LW

Nr	Product name	Date	Author
	Base-Case HL-MV-R-LW		BIO

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Glass	36	7-Misc.	54-Glass for lamps
2				
3	Copper for caps/connector pins	1.5	4-Non-ferro	30-Cu tube/sheet
4				

- **Volume and weight of the package volume**

The weight of the base-case HL-MV-R-LW is 37.5 g and it has a packaged volume of 0.40 dm^3.

- **Annual resource consumption and lamp efficacy**

The electricity consumption of the base-case HL-MV-R-LW is 50 Wh/h, as the total Lamp Wattage Factor (LWFt) is equal to 1 according to chapter 4 (section 4.4.1). The lamp lifetime is 1500 hours with an average use of 450 hours per year (taking into consideration the use in all sectors and not only the domestic one). Therefore, the lifespan of a typical HL-MV-R-LW is 3.33 years.

Based on a measured initial lamp efficacy of 6.45 lm/W and average LLMF of 0.975, the **average luminous efficacy of the base-case HL-MV-R-LW is 6.29 lm/W** within an opening angle of 90°.

- **Disposal and Recycling**

100 % of the HL-MV-R-HW is assumed to be disposed in landfill.

5.1.4 Base-case HL-LV-R (Halogen Lamp – Low Voltage – Reflector (12 V))

Using the given product market data, 35 W was chosen as the representative power. The BOM and lamp data is taken from measurements of various 50 W lamps. It assumed that a 35 W and a 50 W lamp have the same characteristics, aside from power and lamp efficacy.

- **Bill of Material**

The BOM of HL-LV-R is derived from the products presented in chapter 4 (section 4.1.2) for the low voltage halogen lamp of 50 W (see Table 5.4).

Table 5.4: Eco-Report material input table for base-case HL-LV-R

Nr	Product name	Date	Author
	Base-Case HL-LV-R		BIO

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Glass	29	7-Misc.	54-Glass for lamps
2				
3	Copper for caps	0.3	4-Non-ferro	30-Cu tube/sheet
4				
5	Cement	0.7	7-Misc.	58-Concrete

- **Volume and weight of the package volume**

The weight of the base-case HL-LV-R is 30 g and it has a packaged volume of 0.40 dm^3.

- **Annual resource consumption and lamp efficacy**

The power rating of the base case HL-LV-R is 35 W, however there is a lamp wattage factor (LWFt) of 1.11 (see section 4.4.1). This is due to the inefficiencies in the transformer that steps down the voltage from mains voltage to low voltage. Therefore, the real power consumed is 38.85 W. The lamp lifetime is 3000 hours, with an assumed usage of 500 hours/year (taking into consideration the use in all sectors and not only the domestic one). Thus, the expected lifetime of the lamp is 6 years.

Based on a measured luminous efficacy of 10.34 lm/W and an average LLMF of 0.975, it can be assumed that the **average luminous efficacy of the base-case HL-LV-R is about 10.08 lm/W** within an opening angle of 90°.

- **Disposal and Recycling**

Similar to incandescent lamps, 100% of halogen lamps are assumed to be placed in landfill.

5.2 Base-case Environmental Impact Assessment

5.2.1 Base-case GLS-R

Table 5.5 presents the results of the environmental impact assessment of the base-case GLS-R.

It is clearly visible that for each of the 15 environmental impact indicators, the use phase is the most impacting stage over the whole product life cycle. The total energy consumption for the whole life cycle of the 50 W GLS-R base-case is 580 MJ.

Table 5.5: Environmental assessment results from Eco-Report (base-case GLS-R)

Table . Life Cycle Impact (per unit) of Base-Case GLS-R

Nr	Life cycle Impact per product:								Date	Author	
0	Base-Case GLS-R								0	BIO	
	Life Cycle phases -->		**PRODUCTION**			**DISTRI-**	**USE**	**END-OF-LIFE***			**TOTAL**
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
2	TecPlastics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
3	Ferro	g			**0.0**			0.0	0.0	**0.0**	**0.0**
4	Non-ferro	g			**1.5**			1.5	0.0	**1.5**	**0.0**
5	Coating	g			**0.0**			0.0	0.0	**0.0**	**0.0**
6	Electronics	g			**0.5**			0.4	0.1	**0.5**	**0.0**
7	Misc.	g			**28.0**			28.0	0.0	**28.0**	**0.0**
	Total weight	g			**30.0**			29.9	0.1	**30.0**	**0.0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0.9	0.1	**1.0**	**52.1**	**525.0**	2.1	0.0	**2.0**	**580.1**
9	of which, electricity (in primary MJ)	MJ	0.5	0.0	**0.5**	**0.0**	**525.0**	0.0	0.0	**0.0**	**525.5**
10	Water (process)	ltr	0.3	0.0	**0.3**	**0.0**	**35.0**	0.0	0.0	**0.0**	**35.3**
11	Water (cooling)	ltr	0.0	0.0	**0.0**	**0.0**	**1400.0**	0.0	0.0	**0.0**	**1400.0**
12	Waste, non-haz./ landfill	g	6.4	0.2	**6.6**	**51.6**	**608.8**	36.8	0.0	**36.7**	**703.7**
13	Waste, hazardous/ incinerated	g	0.0	0.0	**0.0**	**1.0**	**12.1**	0.1	0.0	**0.1**	**13.2**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0.0	0.0	**0.1**	**4.6**	**22.9**	0.2	0.0	**0.2**	**27.7**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	0.2	0.0	**0.2**	**12.1**	**135.2**	0.3	0.0	**0.3**	**147.8**
17	Volatile Organic Compounds (VOC)	g	0.0	0.0	**0.0**	**0.1**	**0.2**	0.0	0.0	**0.0**	**0.3**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0.0	0.0	**0.0**	**0.3**	**3.4**	0.3	0.0	**0.3**	**4.0**
19	Heavy Metals	mg Ni eq.	0.0	0.0	**0.0**	**2.6**	**9.0**	0.6	0.0	**0.6**	**12.3**
	PAHs	mg Ni eq.	0.1	0.0	**0.1**	**2.6**	**1.0**	0.0	0.0	**0.0**	**3.8**
20	Particulate Matter (PM, dust)	g	0.0	0.0	**0.0**	**1.7**	**2.9**	2.7	0.0	**2.7**	**7.3**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0.1	0.0	**0.1**	**0.1**	**3.4**	0.2	0.0	**0.2**	**3.7**
22	Eutrophication	g PO4	0.0	0.0	**0.0**	**0.0**	**0.0**	0.0	0.0	**0.0**	**0.0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

Figure 5.1 and Figure 5.2 show the contribution of each of life cycle phases to two main environmental indicators: gross energy requirement (GER) and global warming potential (GWP). The use phase is the highest contributor of these impacts as it represents about 91% of the total energy consumption and about 83% of the GWP over the product's lifetime.

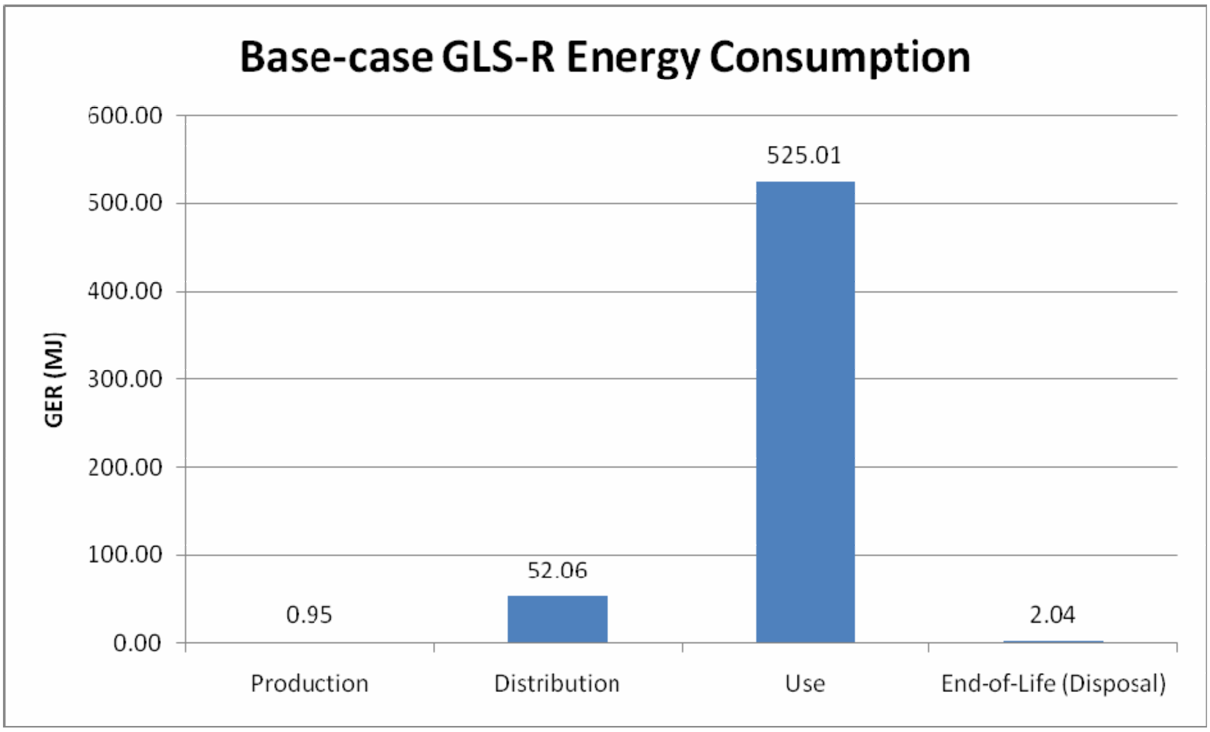

Figure 5.1: Total energy consumption during all life cycle phases

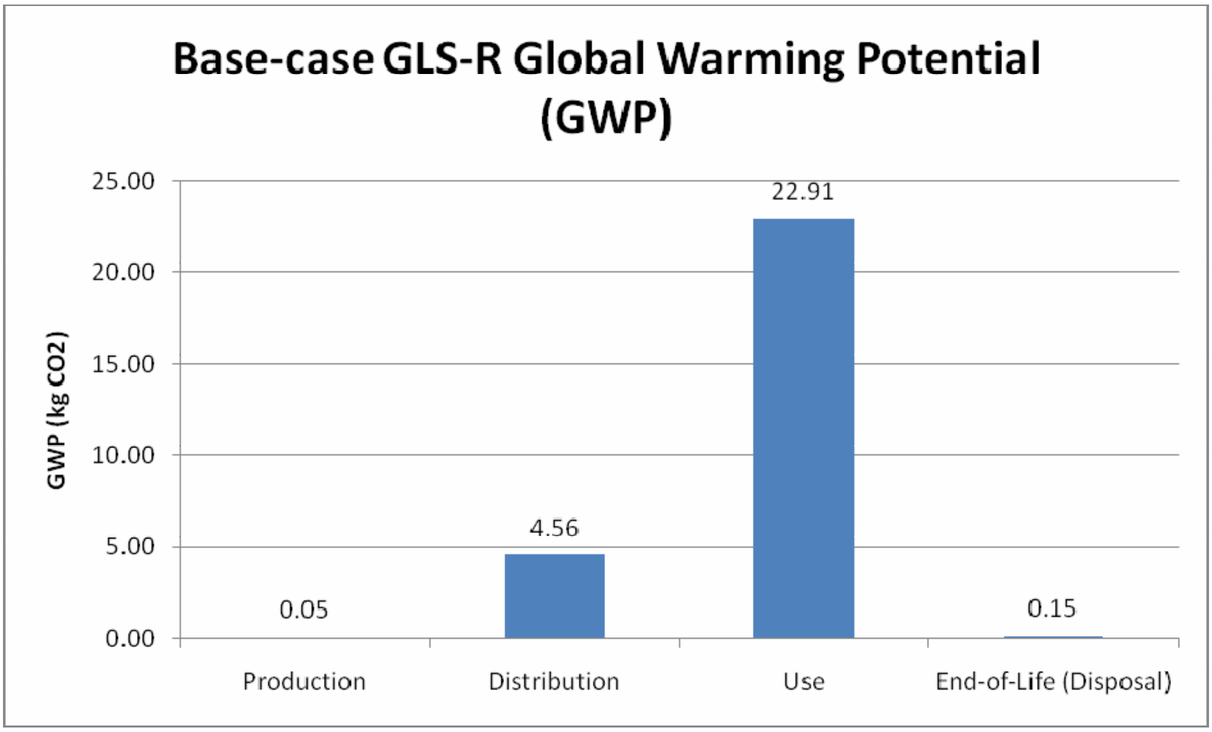

Figure 5.2: Total Global Warming Potential during all life cycle phases

Figure 5.3 presents the contribution of the life cycle phases for each of the 15 environmental impact indicators.

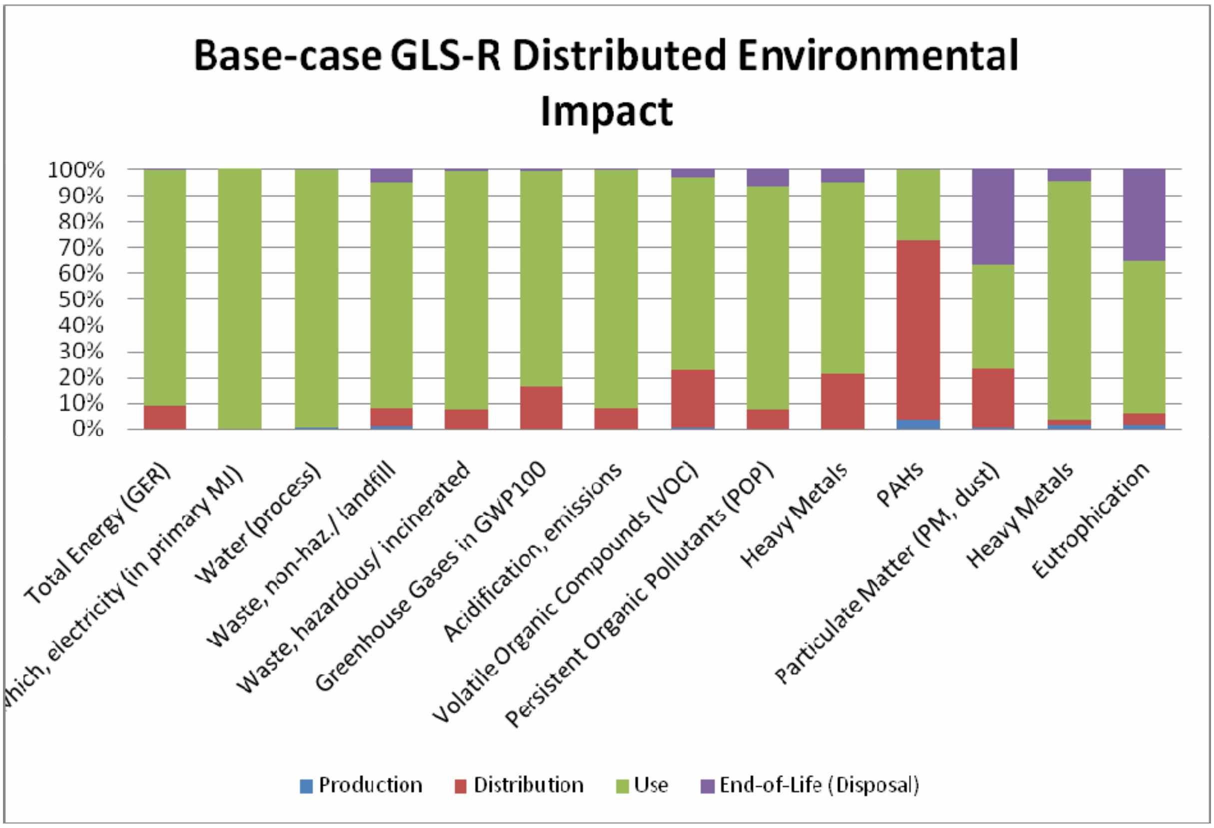

Figure 5.3: Distribution of environmental impacts per life cycle phase

Several observations can be made from this analysis:

- The production phase is negligible for all environmental impact indicators. Its highest contribution is 4% to the emissions of Polycyclic Aromatic Hydrocarbons (PAHs) to air, due to the use of aluminium for the caps of the lamps.
- The distribution phase contributes more than 5% of the life cycle impacts for 11 of the 15 environmental impact indicators. Impacts of this phase are the highest for the emission of PAHs (69%), particulate matter to air (23%), volatile organic compounds (VOC) (22%), and heavy metals (21%). This can be explained by the assumption related to transport in trucks from the retailer's central warehouse to the shop. Nevertheless, although the distribution phase has a high contribution to these indicators, their total values over the life cycle remain low. The Eco-Report tool does not allow specifying means of transport and distances between the production place of the lamp and retailer's central warehouse; only the volume of the product is taken into consideration to assess environmental impacts of the transport. Nevertheless, according to the MEEuP methodology (section 5.3.6, page 96), a mix of means of transport (trucking, rail, sea freight and air freight) with assumptions on distances was used for all base-cases. This assumption could be considered as disadvantageous for lamps mainly produced in Europe (e.g. GLS-R) and advantageous for lamps produced in Asia (e.g. CFLi-R). However, as mentioned previously, the contribution of the distribution phase to the environmental impacts is either low in relative terms compared to other life cycle phases (e.g. for energy consumption or GWP), or low in absolute terms as total values over the whole life cycle are not significant compared to other products (e.g. for PAHs or VOC).

- The contribution of the use phase to environmental impact varies between 27% (for the emissions of PAHs to air) and 100% (for the use of cooling water). For 10 environmental impact indicators, the use phase contributes to more than 80%.
- For incandescent lamps, the whole product is disposed of into landfill and no benefit is possible with recycling. The end-of-life phase is significant for the emissions of particulate matter to air (37%) due to the transport to the landfill, and for eutrophication (36%). However, the eutrophication potential due to the life cycle of an incandescent lamp is very low (less than 0.03 g PO_4) compared to, for example a typical 32" LCD TV (about 15 g PO_4)[3].

Power generation based on coal implies emissions of mercury to air. According to the DG Joint Research Centre, **the generation of 1 kWh emits 0.016 mg of mercury to air**, assuming it is produced from an EU fuel mix of 31 % coal, 21 % gas and oil, and 48 % non-fossils fuels (of which 32% of nuclear)[4]. This assumption will be used for all base-cases.

Therefore, the total electricity consumption of the base-cases GLS-R during the use phase over the product lifetime being 50 kWh (50 Wh during 1000 hours), **0.80 mg of mercury is emitted to air over the whole life cycle** (mercury emissions in other phases than the use phase are assumed to be negligible for this lamp type).

5.2.2 Base-case HL-MV-R-HW

The outcomes of the "life cycle assessment" of the base-case HL-MV-R-HW carried out with the Eco-Report tool are presented in Table 5.6 below.

[3] Source: EuP Preparatory Study on Television (Lot 5) http://www.ecotelevision.org/docs/Lot%205_T5_Final_Report_02-08-2007.pdf

[4] Source: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/Power_grid_mix_UCTE__83c1f02c-f2ef-4ac4-9a57-ac2172c38D15__01.00.001.html

Table 5.6: Environmental assessment results from Eco-Report (base-case HL-MV-R-HW)

Table . Life Cycle Impact (per unit) of Base-Case HL-MV-R-HW

Nr	Life cycle Impact per product:	Date	Author
0	Base-Case HL-MV-R-HW	0	BIO

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
2	TecPlastics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
3	Ferro	g			**0.0**			0.0	0.0	**0.0**	**0.0**
4	Non-ferro	g			**3.5**			3.5	0.0	**3.5**	**0.0**
5	Coating	g			**0.0**			0.0	0.0	**0.0**	**0.0**
6	Electronics	g			**0.5**			0.4	0.1	**0.5**	**0.0**
7	Misc.	g			**365.0**			365.0	0.0	**365.0**	**0.0**
	Total weight	g			**369.0**			368.9	0.1	**369.0**	**0.0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	6.2	0.1	**6.3**	**53.8**	**2100.1**	25.2	0.0	**25.2**	**2185.4**
9	of which, electricity (in primary MJ)	MJ	4.8	0.0	**4.9**	**0.0**	**2100.0**	0.0	0.0	**0.0**	**2104.9**
10	Water (process)	ltr	3.1	0.0	**3.2**	**0.0**	**140.0**	0.0	0.0	**0.0**	**143.2**
11	Water (cooling)	ltr	0.0	0.0	**0.0**	**0.0**	**5600.0**	0.0	0.0	**0.0**	**5600.0**
12	Waste, non-haz./ landfill	g	33.1	0.3	**33.4**	**52.5**	**2435.2**	452.4	0.0	**452.3**	**2973.4**
13	Waste, hazardous/ incinerated	g	0.1	0.0	**0.1**	**1.0**	**48.4**	0.1	0.0	**0.1**	**49.6**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0.3	0.0	**0.3**	**4.7**	**91.6**	1.9	0.0	**1.9**	**98.5**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	1.3	0.0	**1.4**	**12.4**	**540.8**	3.7	0.0	**3.7**	**558.3**
17	Volatile Organic Compounds (VOC)	g	0.0	0.0	**0.0**	**0.1**	**0.8**	0.1	0.0	**0.1**	**1.0**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0.1	0.0	**0.1**	**0.3**	**13.8**	3.1	0.0	**3.1**	**17.2**
19	Heavy Metals	mg Ni eq.	0.2	0.0	**0.2**	**2.7**	**36.0**	7.4	0.0	**7.4**	**46.3**
	PAHs	mg Ni eq.	0.0	0.0	**0.0**	**2.7**	**4.1**	0.0	0.0	**0.0**	**6.9**
20	Particulate Matter (PM, dust)	g	0.0	0.0	**0.0**	**6.1**	**11.6**	32.8	0.0	**32.8**	**50.5**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0.1	0.0	**0.1**	**0.1**	**13.5**	2.1	0.0	**2.1**	**15.9**
22	Eutrophication	g PO4	0.0	0.0	**0.0**	**0.0**	**0.1**	0.1	0.0	**0.1**	**0.2**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

The total energy consumption (GER) and the Global Warming Potential (GWP) of the base-case HL-MV-R-HW are presented in Figure 5.4 and Figure 5.5 for each stage of the entire life cycle of the product. It is clearly visible that the use phase is predominant for both environmental indicators. The use phase represents about 96% of the total energy required by a typical HL-MV-R-HW 100 W over its whole life cycle and about 93% of its global warming potential.

The distribution phase (assumed transport by trucks) is most significant for the emission of PAHs to air (40%) and does not exceed 15% for the other environmental impacts.

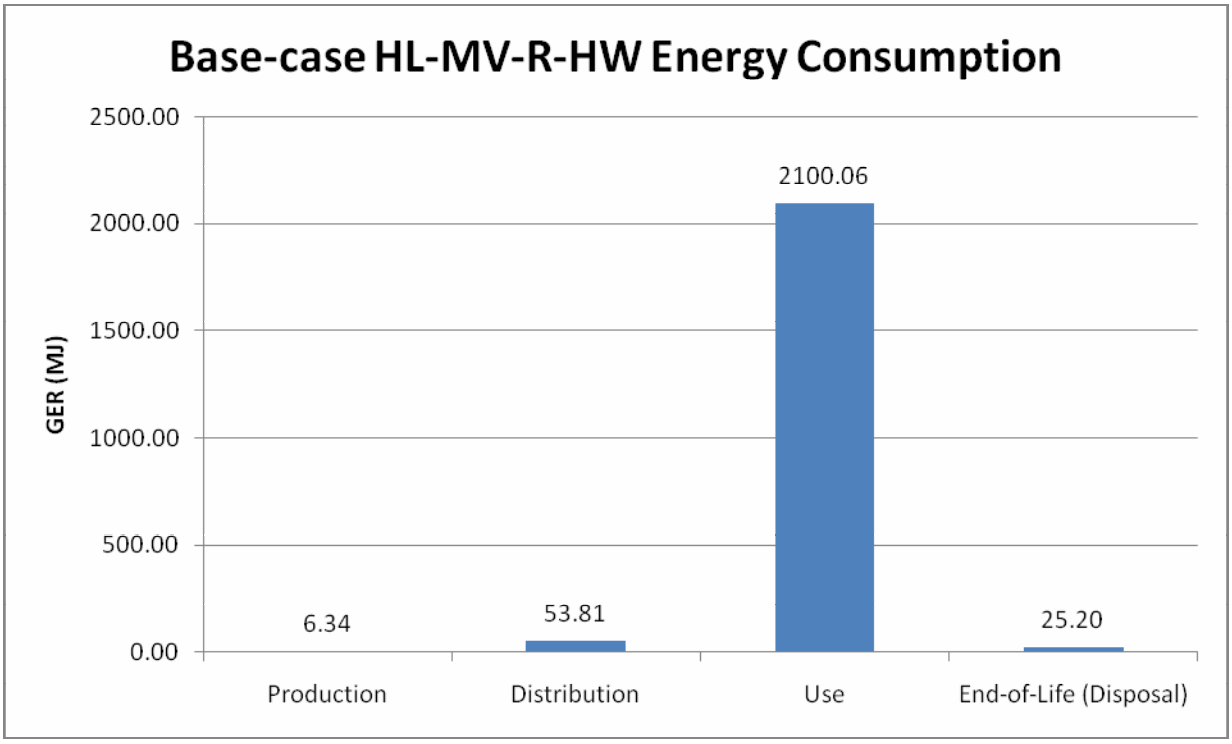

Figure 5.4: Total energy consumption during all life cycle phases

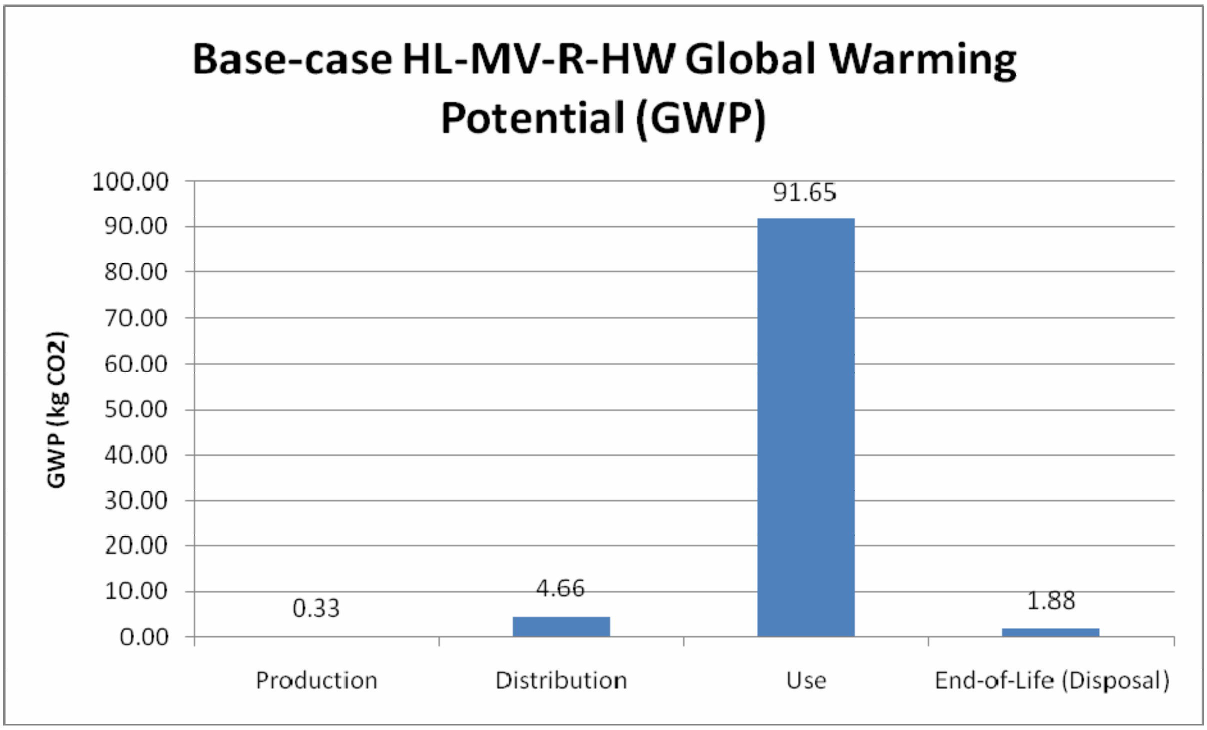

Figure 5.5: Total Global Warming Potential during all life cycle phases

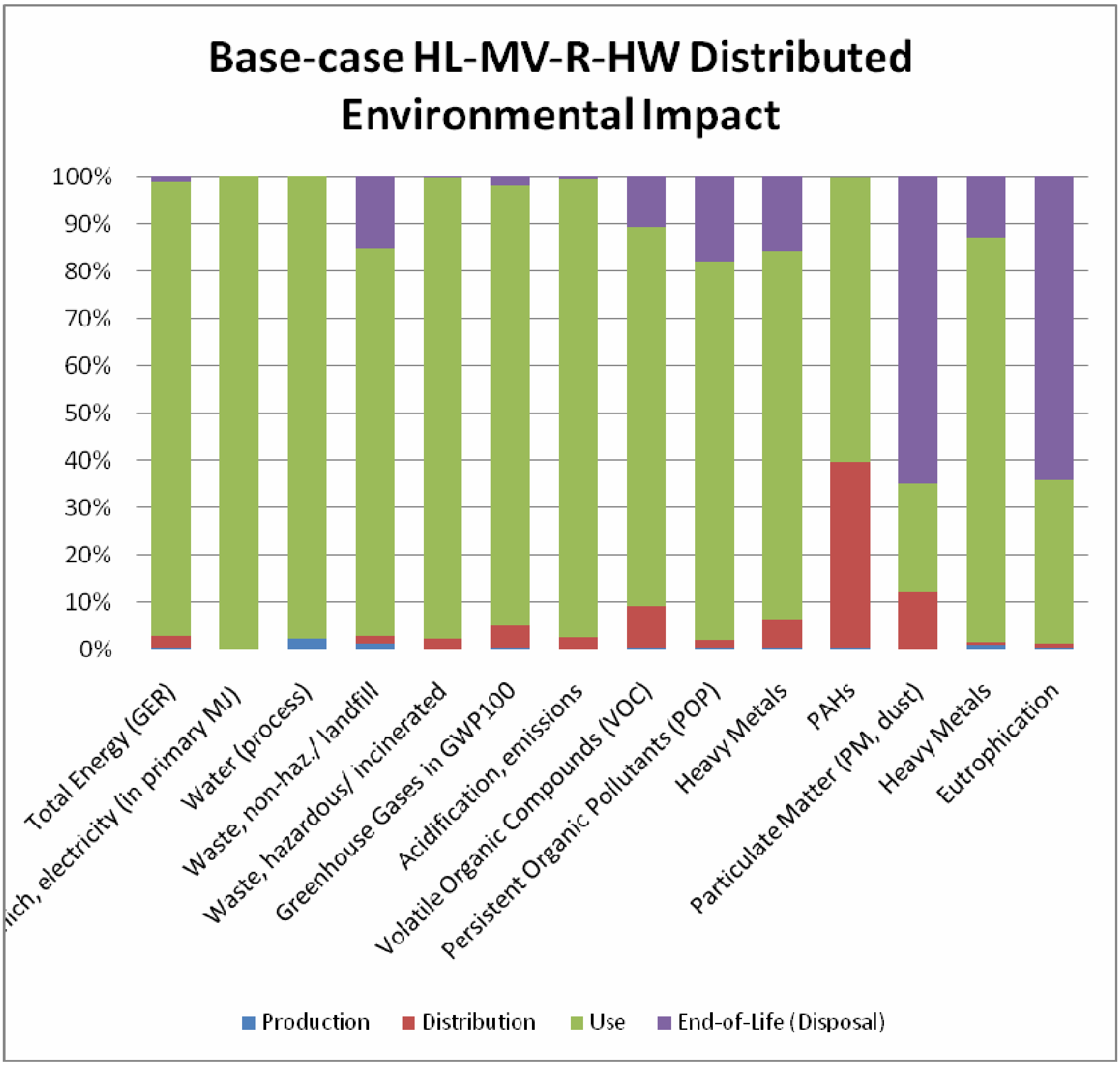

Figure 5.6: Distribution of environmental impacts per life cycle phase

Over its entire life cycle (2000 hours), the base-case HL-MV-R-HW (100 W) emits 3.2 mg of mercury to air, due to electricity generation. Mercury emissions in other phases than the use phase are assumed to be negligible for this lamp type.

5.2.3 Base-case HL-MV-R-LW

The results of the Eco-Report for base-case HL-MV-R-LW are presented in Table 5.7 below.

Table 5.7: Environmental assessment results from Eco-Report (base-case HL-MV-R)

Table . Life Cycle Impact (per unit) of Base-Case HL-MV-R-LW

Nr	Life cycle Impact per product:	Date	Author
0	Base-Case HL-MV-R-LW	0	BIO

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			0.0			0.0	0.0	0.0	0.0
2	TecPlastics	g			0.0			0.0	0.0	0.0	0.0
3	Ferro	g			0.0			0.0	0.0	0.0	0.0
4	Non-ferro	g			1.5			1.5	0.0	1.5	0.0
5	Coating	g			0.0			0.0	0.0	0.0	0.0
6	Electronics	g			0.0			0.0	0.0	0.0	0.0
7	Misc.	g			36.0			36.0	0.0	36.0	0.0
	Total weight	g			37.5			37.5	0.0	37.5	0.0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0.7	0.0	0.7	52.0	787.5	2.6	0.0	2.6	842.8
9	of which, electricity (in primary MJ)	MJ	0.5	0.0	0.5	0.0	787.5	0.0	0.0	0.0	788.0
10	Water (process)	ltr	0.3	0.0	0.3	0.0	52.5	0.0	0.0	0.0	52.8
11	Water (cooling)	ltr	0.0	0.0	0.0	0.0	2100.0	0.0	0.0	0.0	2100.0
12	Waste, non-haz./ landfill	g	12.5	0.1	12.6	51.6	913.2	46.0	0.0	46.0	1023.4
13	Waste, hazardous/ incinerated	g	0.0	0.0	0.0	1.0	18.1	0.0	0.0	0.0	19.2
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0.0	0.0	0.0	4.6	34.4	0.2	0.0	0.2	39.1
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	0.2	0.0	0.2	12.1	202.8	0.4	0.0	0.4	215.5
17	Volatile Organic Compounds (VOC)	g	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.4
18	Persistent Organic Pollutants (POP)	ng i-Teq	0.0	0.0	0.0	0.3	5.2	0.3	0.0	0.3	5.8
19	Heavy Metals	mg Ni eq.	0.1	0.0	0.1	2.6	13.5	0.8	0.0	0.8	17.0
	PAHs	mg Ni eq.	0.0	0.0	0.0	2.6	1.6	0.0	0.0	0.0	4.2
20	Particulate Matter (PM, dust)	g	0.0	0.0	0.0	1.6	4.3	3.3	0.0	3.3	9.3
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0.1	0.0	0.1	0.1	5.1	0.2	0.0	0.2	5.4
22	Eutrophication	g PO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

The energy consumption and global warming potential are shown in Figure 5.7 and Figure 5.8, respectively. As with the other base-cases, the use phase has the greatest impact on both energy consumption (93% of total) and global warming potential (88% of total).

The use phase dominates the other environmental impacts as well, as shown in Figure 5.9. The distribution phase contributes a significant amount of PAHs with about 62%.

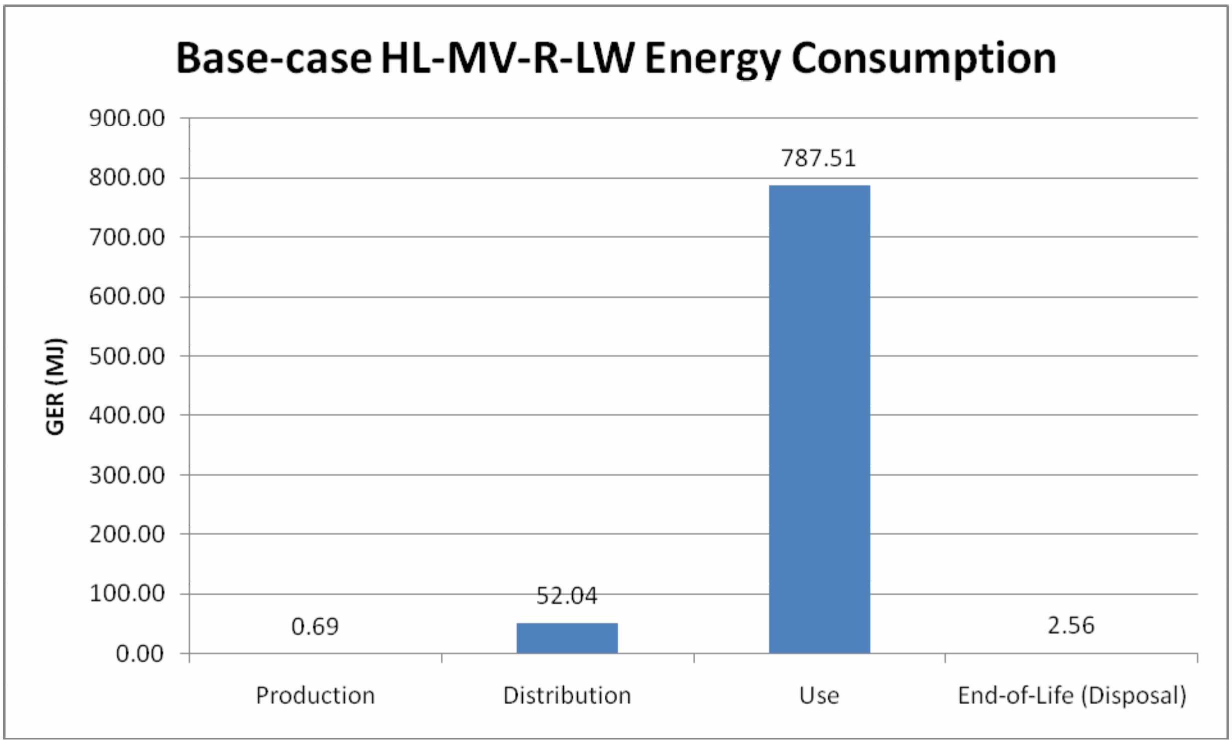

Figure 5.7: Total energy consumption during all life cycle phases

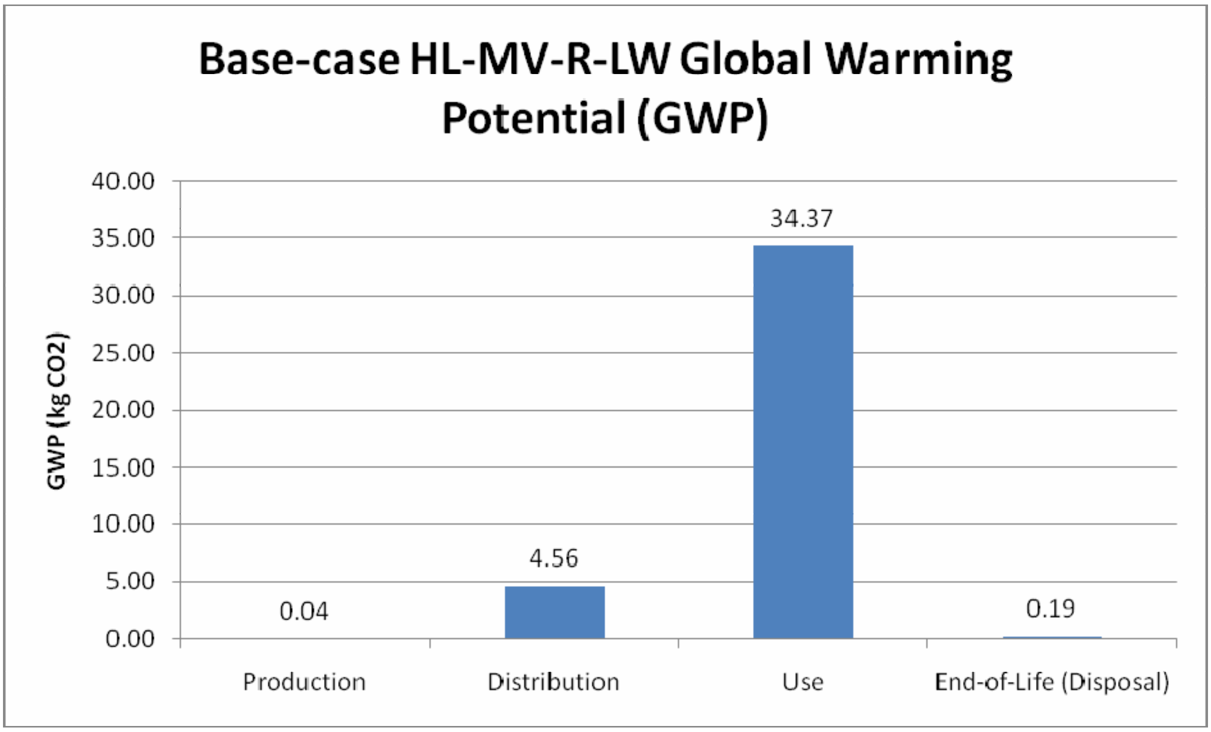

Figure 5.8: Total Global Warming Potential during all life cycle phases

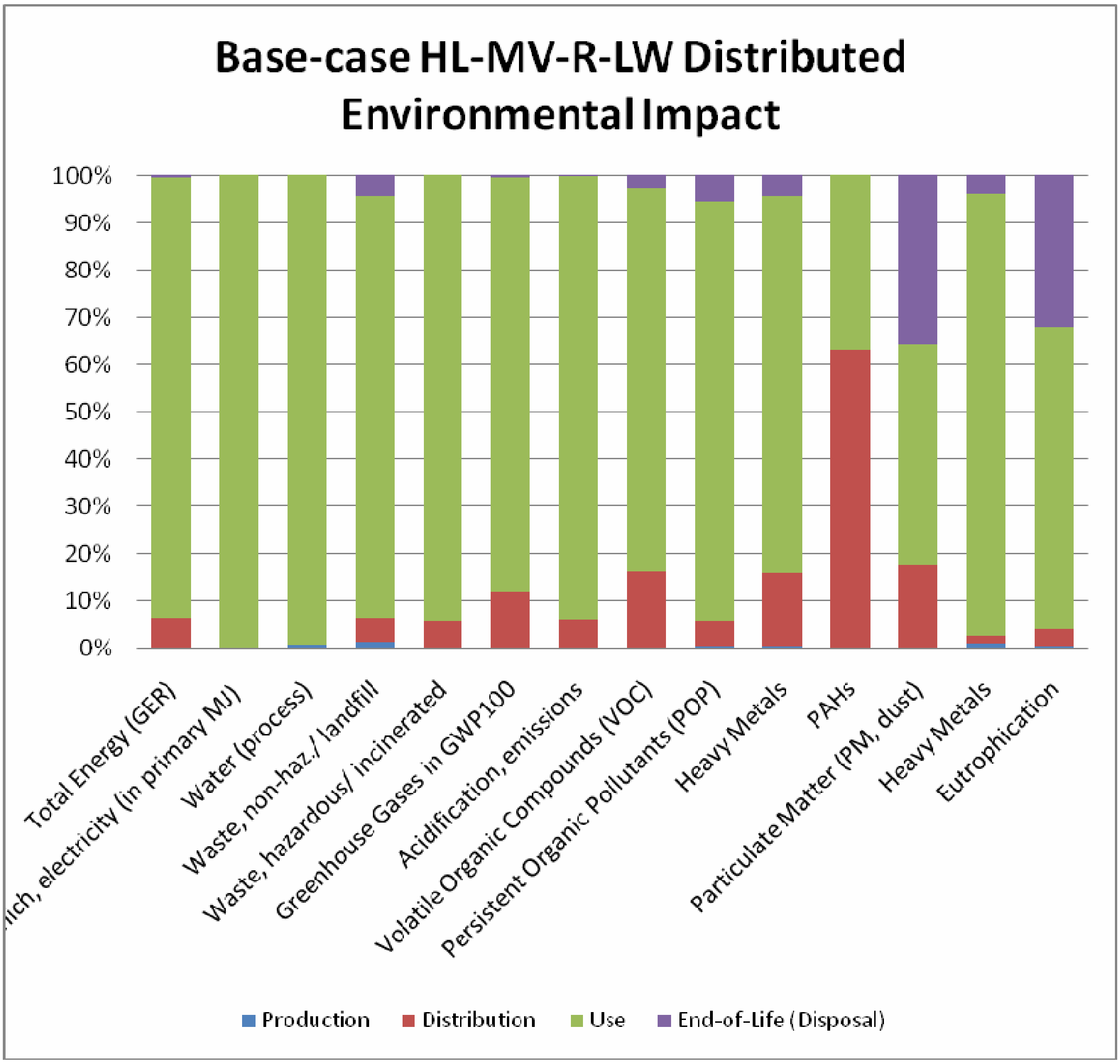

Figure 5.9: Distribution of environmental impacts per life cycle phase

Over its entire life cycle (1500 hours), the base-case HL-MV-R-LW (50 W) emits 1.2 mg of mercury to air, due to electricity generation. Mercury emissions in other phases than the use phase are assumed to be negligible for this lamp type.

5.2.4 Base-case HL-LV-R

Table 5.8 presents the outcomes of the "life cycle assessment" of the base-case HL-LV-R using the Eco-Report tool.

Table 5.8: Environmental assessment results from Eco-Report (base-case HL-LV-R)

Table . Life Cycle Impact (per unit) of Base-Case HL-LV-R

Nr	Life cycle Impact per product:	Date	Author
0	Base-Case HL-LV-R	0	BIO

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
2	TecPlastics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
3	Ferro	g			**0.0**			0.0	0.0	**0.0**	**0.0**
4	Non-ferro	g			**0.3**			0.3	0.0	**0.3**	**0.0**
5	Coating	g			**0.0**			0.0	0.0	**0.0**	**0.0**
6	Electronics	g			**0.0**			0.0	0.0	**0.0**	**0.0**
7	Misc.	g			**29.7**			29.7	0.0	**29.7**	**0.0**
	Total weight	g			**30.0**			30.0	0.0	**30.0**	**0.0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0.5	0.0	**0.5**	**52.0**	**1223.8**	2.0	0.0	**2.0**	**1278.4**
9	of which, electricity (in primary MJ)	MJ	0.4	0.0	**0.4**	**0.0**	**1223.8**	0.0	0.0	**0.0**	**1224.2**
10	Water (process)	ltr	0.2	0.0	**0.2**	**0.0**	**81.6**	0.0	0.0	**0.0**	**81.8**
11	Water (cooling)	ltr	0.0	0.0	**0.0**	**0.0**	**3263.4**	0.0	0.0	**0.0**	**3263.4**
12	Waste, non-haz./ landfill	g	2.8	0.0	**2.8**	**51.6**	**1418.9**	36.8	0.0	**36.8**	**1510.1**
13	Waste, hazardous/ incinerated	g	0.0	0.0	**0.0**	**1.0**	**28.2**	0.0	0.0	**0.0**	**29.2**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0.0	0.0	**0.0**	**4.6**	**53.4**	0.2	0.0	**0.2**	**58.1**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	0.1	0.0	**0.1**	**12.1**	**315.1**	0.3	0.0	**0.3**	**327.6**
17	Volatile Organic Compounds (VOC)	g	0.0	0.0	**0.0**	**0.1**	**0.5**	0.0	0.0	**0.0**	**0.5**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0.0	0.0	**0.0**	**0.3**	**8.0**	0.3	0.0	**0.3**	**8.6**
19	Heavy Metals	mg Ni eq.	0.0	0.0	**0.0**	**2.6**	**21.0**	0.6	0.0	**0.6**	**24.2**
	PAHs	mg Ni eq.	0.0	0.0	**0.0**	**2.6**	**2.4**	0.0	0.0	**0.0**	**5.0**
20	Particulate Matter (PM, dust)	g	0.0	0.0	**0.0**	**1.6**	**6.7**	2.7	0.0	**2.7**	**11.0**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0.0	0.0	**0.0**	**0.1**	**7.9**	0.2	0.0	**0.2**	**8.2**
22	Eutrophication	g PO4	0.0	0.0	**0.0**	**0.0**	**0.0**	0.0	0.0	**0.0**	**0.0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

Figure 5.10 and Figure 5.11 highlight the importance of the use phase for two main environmental impact indicators (total energy consumption and global warming potential). Also, Figure 5.12 shows the relative importance of the use phase compared to the other often negligible phases. The use phase represents about 96% of the total energy required by a typical HL-LV-R 35 W over its whole life cycle (GER), and about 92% of its global warming potential (GWP).

Regarding the distribution phase, its contribution to the environmental impacts does not surpass 14% except for the emission of PAHs to air (52%), which is, as for incandescent lamps, due to the assumed transport by trucks.

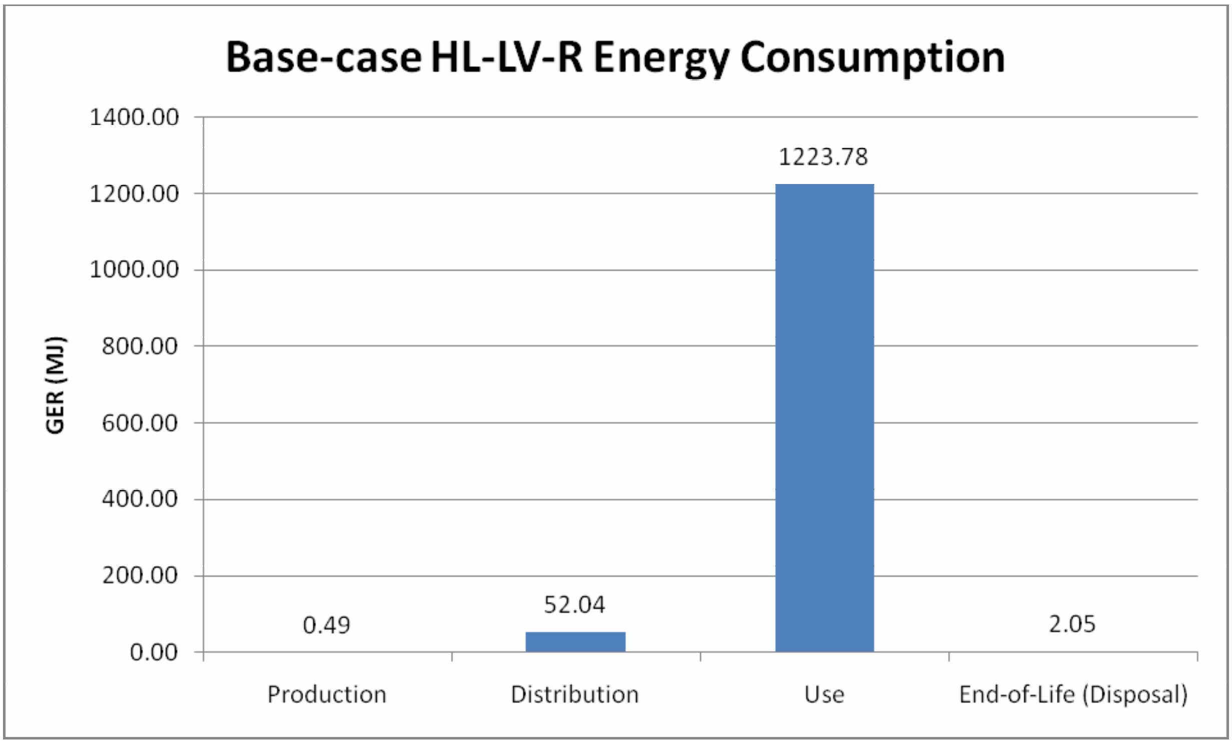

Figure 5.10: Total energy consumption during all life cycle phases

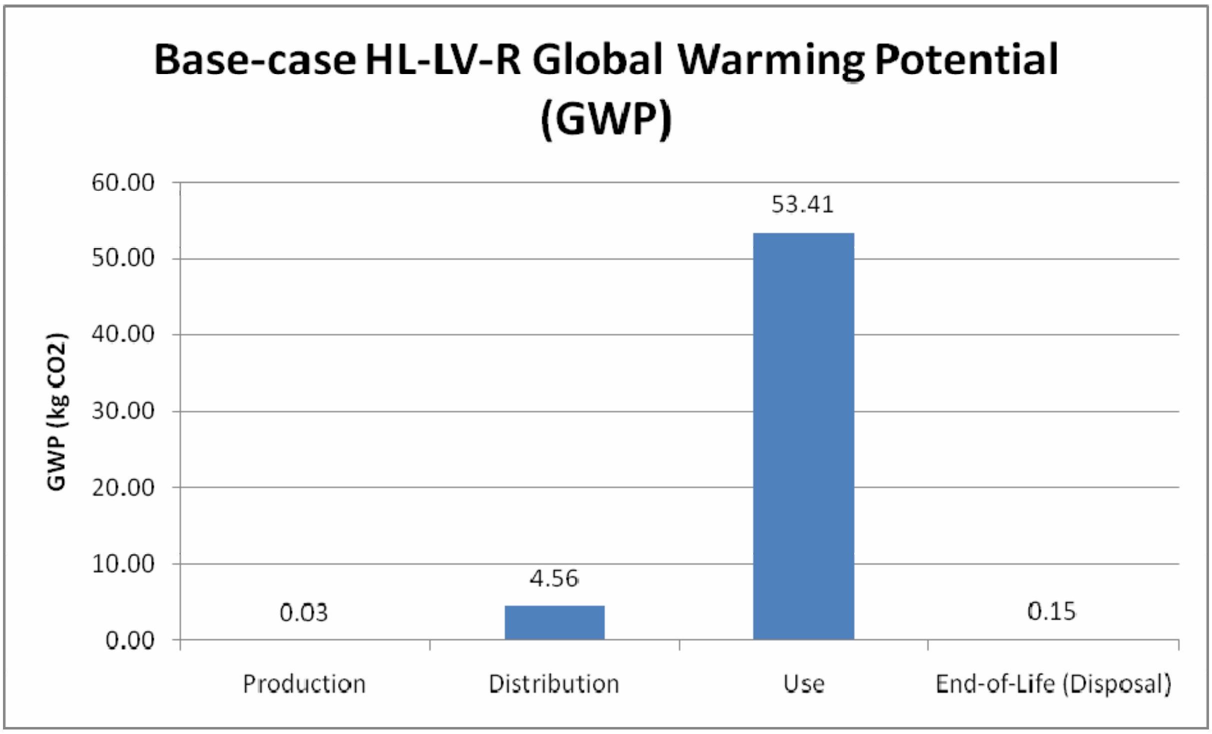

Figure 5.11: Total Global Warming Potential during all life cycle phases

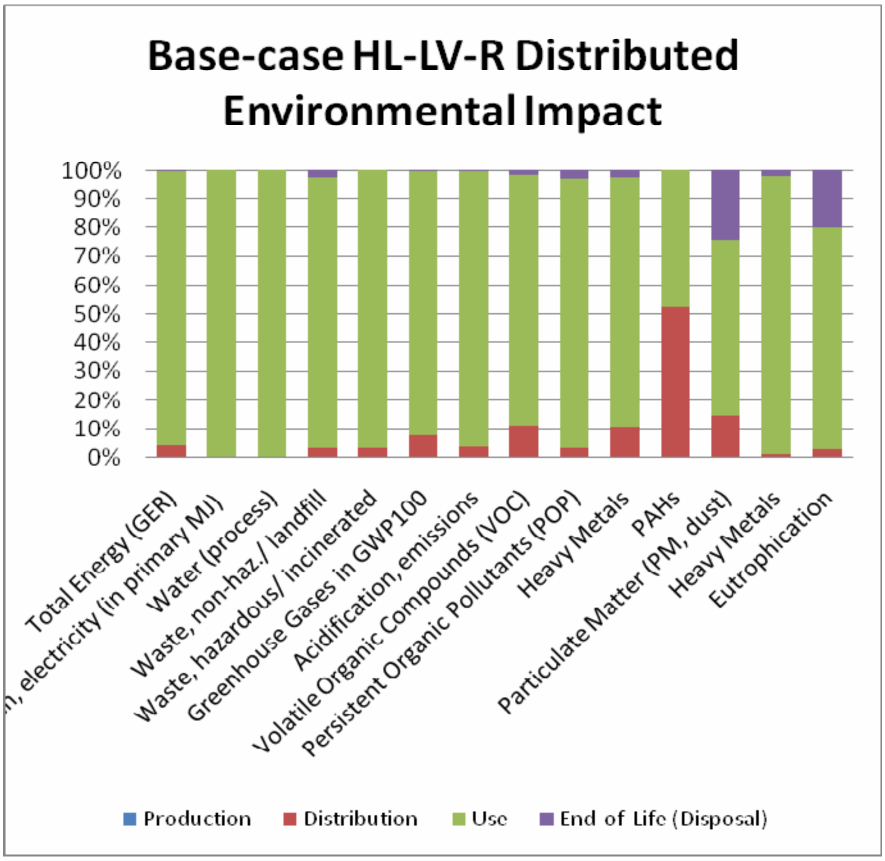

Figure 5.12: Distribution of environmental impacts per life cycle phase

As expected, the three previous figures confirm that the use phase is predominant with at least 80% of the environmental impacts (except for the emissions of PAHs and of Particulate Matter).

Over its entire life cycle (3000 hours), the base-case HL-LV-R (real power consumption 38.85 W) emits 1.86 mg of mercury to air, due to electricity generation. Mercury emissions in other phases than the use phase are assumed to be negligible for this lamp type.

5.3 Base-case Life Cycle Costs

Economic data used for the calculation of the Life Cycle Costs (LCC) were elaborated in chapters 2 and 4. Table 5.9 presents the summary of the LCC input data and results for the 4 base-cases. Electricity tariff, discount rate, and overall improvement ratio are common inputs for all base-cases, of which the parameter "overall improvement ratio" equal to 1 reflects the fact that there have not been improvements related to energy efficiency of the average European lamp types in the recent years (i.e. the average products in 2004/2005 and in 2007 are quite similar in terms of energy efficiency).

Table 5.9: Inputs and outcomes of the calculation of the LCC

	GLS-R	***HL-MV-R-HW***	***HL-MV-R-LW***	***HL-LV-R***
Lamp lifespan (years)	2	4.44	3.33	6
Lamp wattage (W)	50	100	50	35
Average functional lumen output within opening angle of 90° (lm)	258.14	1053.98	314.50	391.60
Electricity tariff (€/kWh)	0.1528			
Discount rate	1.8%			
Overall improvement ratio	1.00			
Product price	1.30 €	13.50	3.60 €	2.40 €
Electricity	7.41 €	29.12	11.03 €	16.74 €
Life Cycle Cost	**8.71 €**	**42.62**	**14.63 €**	**19.14 €**

One has to keep in mind that lifespan, lamp wattage and lumen output vary for different lamp types, thus a straightforward comparison with the outcomes of Table 5.9 has to be made with caution. The comparison of the LCC of the 4 base-cases is provided in section 5.5.

5.4 EU Totals for all sectors

This section provides the environmental assessment of the base-cases at the EU-27 level using stock and market data from chapter 2, considering their use in all sectors. The reference year for the EU totals is 2007 for environmental impacts. The term 'EU' is synonymous to 'EU-27'. The total impacts cover:

- The life cycle environmental impact of the new products designed in 2007 (this relates to a period of 2007 up to 2007 + product life) (i.e. impacts of the sales).
- The annual (2007) impact of production, use and (estimated) disposal of the product group, assuming post-RoHS and post-WEEE conditions and the total LCC (i.e. impact and LCC of the stock).

■ Market data for all sectors

In order to carry out the environmental and economic assessment with the Eco-Report tool of the base-cases at the EU-27 level for all sectors, it is required to have sales data, stock data as well as annual burning hours. They are presented in Table 5.10.

Table 5.10: Market and technical data for all sectors in 2007

	GLS-R	HL-MV-R-HW	HL-MV-R-LW	HL-LV-R
Stock DLS (mln)	292	107	121	584.9
Sales DLS (mln)	126.1	59	84	153
Average wattage (W)	50	100	50	35
Lifetime (h)	1000	2000	1500	3000
Annual burning hours (h)	400	450	450	500

- **Environmental impacts of the stock in 2007 for all sectors**

Table 5.11 shows the total environmental impact of all products in operation in EU-27 in 2007, assuming that all the products have the same impacts as the base-case of their category. These figures come from the Eco-Report tool by multiplying the individual environmental impacts of a base-case with the stock of this base-case in 2007 for all sectors.

Table 5.11: Environmental impacts of the EU stock in 2007 for all sectors

		GLS-R	***HL-MV-R-HW***	***HL-MV-R-LW***	***HL-LV-R***	***TOTAL***
main environmental indicators	**unit**	**Value**	**value**	**value**	**value**	**value**
Total Energy (GER)	PJ	68.262	55.655	33.206	127.643	**216.504**
of which, electricity	TWh	5.846	4.851	2.722	11.367	**18.940**
Water (process)	mln.m3	4.122	3.561	1.929	7.991	**13.481**
Waste, non-haz./ landfill*	kton	83.073	90.277	42.397	152.271	**284.946**
Waste, hazardous/ incinerated*	kton	1.558	1.241	0.745	2.907	**4.893**
Emissions (Air)						
Greenhouse Gases in GWP100	mt CO2eq.	3.276	2.613	1.649	5.930	**10.193**
Acidifying agents (AP)	kt SO2eq.	17.384	14.068	8.419	32.631	**55.118**
Volatile Org. Compounds (VOC)	kt	0.032	0.030	0.017	0.055	**0.102**
Persistent Org. Pollutants (POP)	g i-Teq.	0.472	0.536	0.240	0.866	**1.642**
Heavy Metals (HM)	ton Ni eq.	1.462	1.470	0.780	2.544	**4.794**
PAHs	ton Ni eq.	0.472	0.259	0.279	0.639	**1.177**
Particulate Matter (PM, dust)	kt	0.889	2.561	0.576	1.313	**4.450**
Emissions (Water)						
Heavy Metals (HM)	ton Hg/20	0.433	0.462	0.214	0.809	**1.485**
Eutrophication (EP)	kt PO4	0.003	0.009	0.002	0.005	**0.016**

Summary of environmental impacts of base-cases as a percentage of total impact for these lamp types, are presented in Figure 5.13. As the figure shows, low voltage halogen lamps have the greatest impacts within the sector. However, it is very important to note that these lamps also constitute 53% of all lamps in the sector in terms of quantity. The figures stay relatively constant, varying from 41 – 46% of all impacts except particulate matter, which is resulting mostly from the use phase of HL-MV-R-HW.

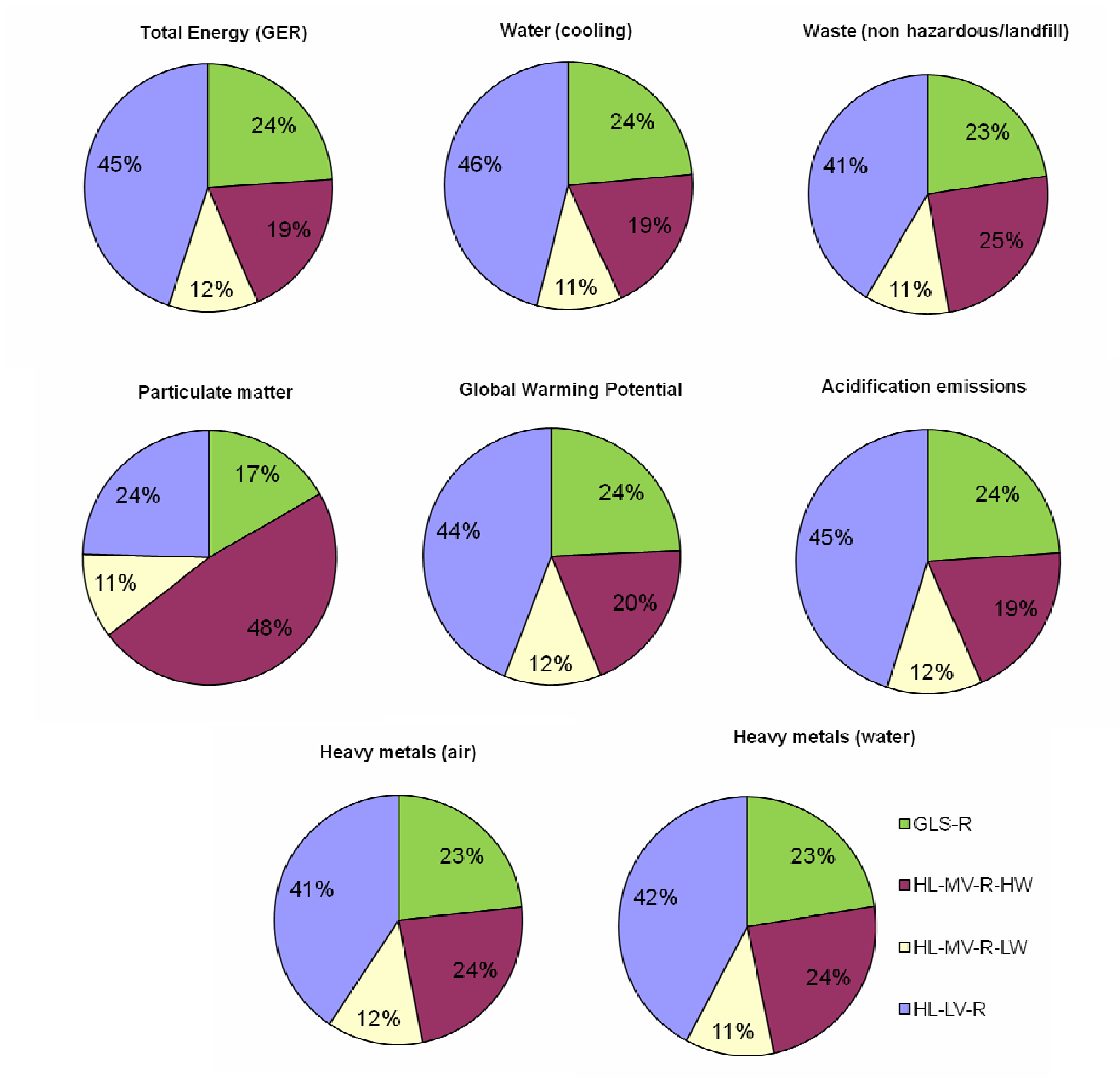

Figure 5.13: Base-cases' share of the environmental impacts of the 2007 stock for all sectors

Table 5.12 summarises the total electricity consumption (during the use phase) of each base-case, assuming that the whole stock is composed of base-cases. Therefore, the total electricity consumption in 2007 of directional lighting sources which are in the scope of this study and used in all sectors is about 24.785 TWh. This represents about 0.88% of the EU-27 total electricity consumption[5].

[5]Source Eurostat: EU-27 electricity consumption in 2006 = 242 million toe = 2,815 TWh

Table 5.12: Total electricity consumption for the year 2007 for all sectors

Base-case	EU 27 stock electricity consumption in 2007 for all sectors (TWh)	Share of the total electricity consumption of the 3 lamp types
Base-case GLS-R	5.846	23.58%
Base-case HL-MV-R-HW	4.851	19.57%
Base-case HL-MV-R-LW	2.722	10.98%
Base-case HL-LV-R	11.367	45.86%
TOTAL	**24.785**	**100.00%**

- **Total consumer expenditure in 2007**

Regarding the total consumer expenditure in 2007 related to the 4 base-cases, about 69.9% of the 5.41 billion Euros is due to electricity costs. The distribution per base-case is given in Figure 5.14, and details on consumer expenditure are presented in Table 5.13.

Table 5.13: Comparison of total consumer expenditure (EU-27) in 2007 for all sectors

	GLS-R	HL-MV-R-HW	HL-MV-R-LW	HL-LV-R	TOTAL
Lumen output per lamp (lm)	258.14	1053.98	314.50	391.60	n/a
EU 27 sales (mln unit)	126.1	59	84	153	422
Share of the EU 27 sales	29.87%	13.98%	19.90%	36.25%	100.00%
Product price (mln €)	163.9	796.5	302.4	367.2	1630.0
Electricity (mln €)	892.4	737.1	415.3	1736.0	3780.7
Total (mln €)	**1056.3**	**1533.6**	**717.7**	**2103.2**	**5410.8**

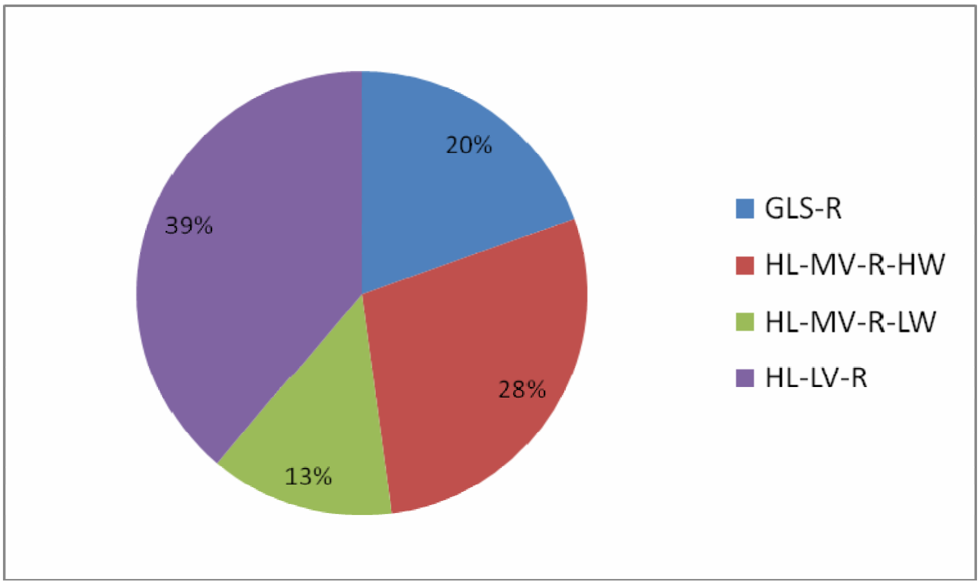

Figure 5.14: Base-cases' share of the total consumer expenditure in 2007 for all sectors

Total consumer expenditure in 2007 related to low-voltage halogen lamps represents 39% of the total, with the next highest being HL-MV-R-HW with 28%. Total consumer expenditure includes product and electricity costs over the product lifetime.

5.5 “Comparison” of the base-cases

As the luminous efficacy of the 4 base-cases defined in this chapter differs, as well as the lifetime, it is interesting and relevant to compare their environmental impacts as well as their life cycle cost taking into account this difference. Therefore, Table 5.14, Table 5.15 and Table 5.16 present data per lumen and per hour. In Table 5.14, for each environmental indicator, variations with reference to the base-case GLS-R are also given.

Table 5.14: Environmental impacts per lumen and per hour

main environmental indicators	unit	GLS-R value per lumen per hour	HL-MV-R-HW value per lumen per hour	HL-MV-R-LW value per lumen per hour	HL-LV-R value per lumen per hour
Total Energy (GER)	J	**2247.06**	**1036.74**	**1786.54**	**1088.15**
	variation with GLS-R	***0.00%***	***-53.86%***	***-20.49%***	***-51.57%***
of which, electricity	J	**2035.59**	**998.54**	**1670.35**	**1042.01**
	variation with GLS-R	***0.00%***	***-50.95%***	***-17.94%***	***-48.81%***
Water (process)	µltr	**136.63**	**67.92**	**83.96**	**69.66**
	variation with GLS-R	***0.00%***	***-50.29%***	***-38.55%***	***-49.02%***
Waste, non-haz./ landfill*	µg	**2726.00**	**1410.56**	**2169.40**	**1285.45**
	variation with GLS-R	***0.00%***	***-48.26%***	***-20.42%***	***-52.84%***
Waste, hazardous/ incinerated*	µg	**51.31**	**23.55**	**40.66**	**24.88**
	variation with GLS-R	***0.00%***	***-54.10%***	***-20.75%***	***-51.50%***
Emissions (Air)					
Greenhouse Gases in GWP100	mg CO2 eq.	**107.20**	**46.73**	**82.99**	**49.49**
	variation with GLS-R	***0.00%***	***-56.40%***	***-22.58%***	***-53.83%***
Acidifying agents (AP)	µg SO2 eq.	**572.67**	**264.83**	**456.74**	**278.88**
	variation with GLS-R	***0.00%***	***-53.76%***	***-20.24%***	***-51.30%***
Volatile Org. Compounds (VOC)	ng	**1035.22**	**466.88**	**776.85**	**449.97**
	variation with GLS-R	***0.00%***	***-54.90%***	***-24.96%***	***-56.53%***
Persistent Org. Pollutants (POP)	10^{-3} pg i-Teq	**15.49**	**8.18**	**12.28**	**7.30**
	variation with GLS-R	***0.00%***	***-47.20%***	***-20.76%***	***-52.91%***
Heavy Metals (HM)	ng Ni eq.	**47.49**	**21.96**	**35.94**	**20.64**
	variation with GLS-R	***0.00%***	***-53.77%***	***-24.32%***	***-56.55%***
PAHs	ng Ni eq.	**14.79**	**3.25**	**8.89**	**4.30**
	variation with GLS-R	***0.00%***	***-78.03%***	***-39.86%***	***-70.94%***
Particulate Matter (PM, dust)	µg	**28.13**	**23.95**	**19.71**	**9.39**
	variation with GLS-R	***0.00%***	***-14.85%***	***-29.94%***	***-66.63%***
Emissions (Water)					
Heavy Metals (HM)	ng Hg/20	**14.27**	**7.52**	**33.61**	**6.94**
	variation with GLS-R	***0.00%***	***-47.27%***	***135.61%***	***-51.35%***
Eutrophication (EP)	ng PO4	**106.76**	**88.42**	**395.09**	**41.51**
	variation with GLS-R	***0.00%***	***-17.18%***	***270.07%***	***-61.12%***

Table 5.14 highlights that a typical incandescent lamp represents generally highest environmental impacts over its life cycle compared to the others lamp types. This can be explained by two factors:

- the use phase is the most significant stage of the life cycle for any type of lamp, and

- the base-case GLS-R has the lowest lumen efficacy (5.16 lm/W).

It should be noted the HL-MV-R-LW has increase of 135% of heavy metals into water and 270% eutrophication over the base-case GLS-R.

Also interesting is that on a per lumen per hour basis, the HL-MV-R-HW has the least environmental impact of all options of -78.03% from the GLS-R. This is despite the results shown in Figure 5.13.

As the lamps HL-MW-R-HW and HL-LV-R have a much higher luminous efficacy than the other two base cases (10.53 lm/W and 10.08 lm/W respectively), the environmental impacts are significantly lower.

For two main environmental impact indicators (GER and GWP), Figure 5.15 and Figure 5.16 show the results per lumen per hour for the 4 base-cases with reference to the base-case GLS-R. As expected, incandescent lamps, being the least energy efficient, have the highest magnitude of impacts.

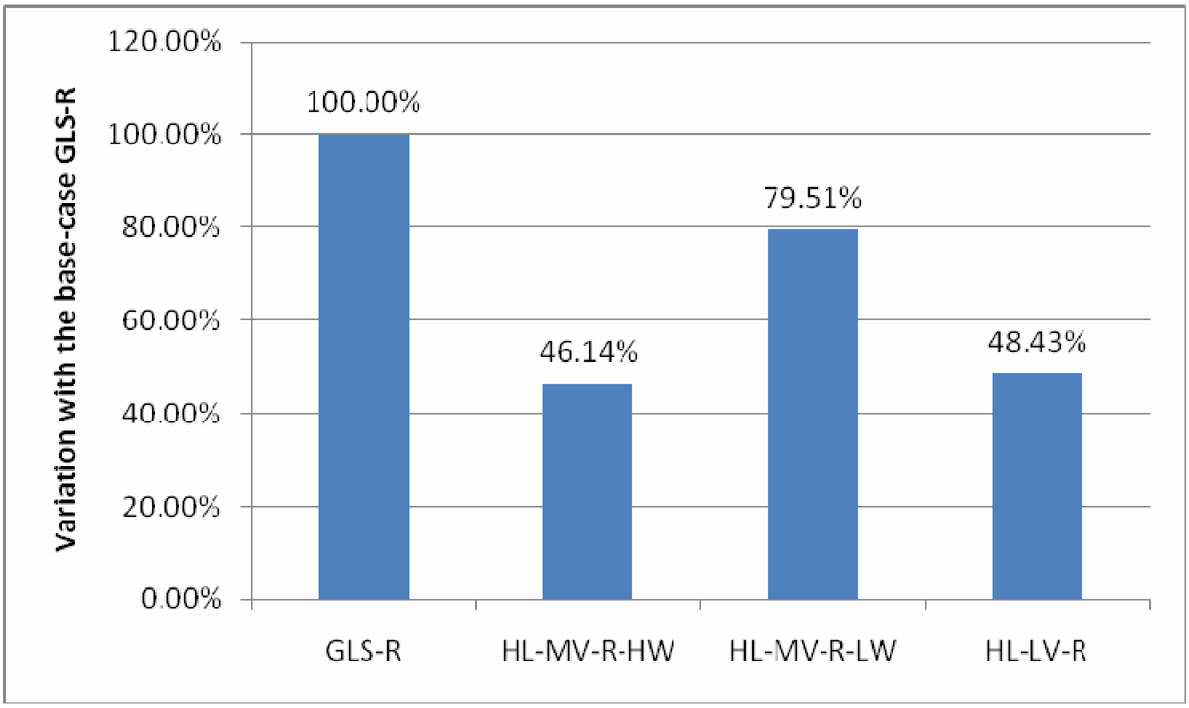

Figure 5.15: Comparison of the base-cases for the GER indicator

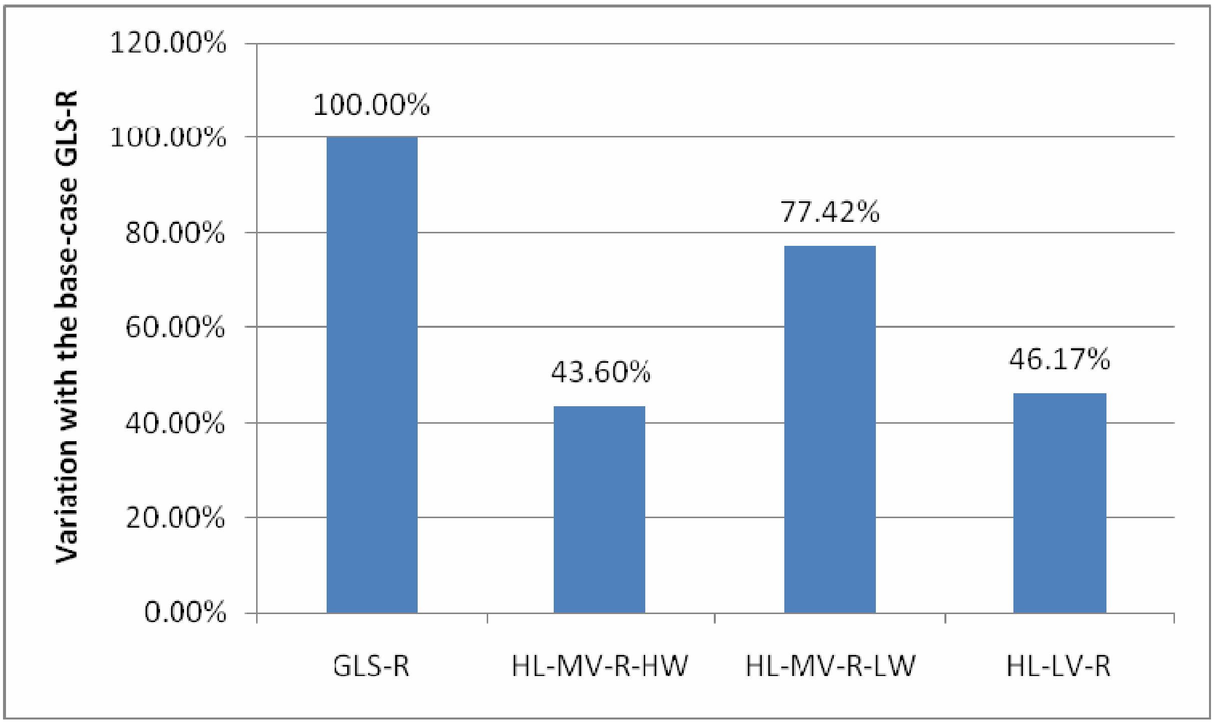

Figure 5.16: Comparison of the base-cases for the GWP indicator

Regarding mercury emissions, Table 5.15 compares values per lumen per hour for the 3 base-cases.

Table 5.15: Mercury emissions to air for each base-case per lumen and per hour

	GLS-R	HL-MV-R-HW	HL-MV-R-LW	HL-LV-R
Product life time (hours)	1000	2000	1500	3000
Lumen output per lamp (lm)	258.14	1053.98	314.50	391.60
Mercury emitted to air for the production of 1 kWh (mg)	0.016			
Mercury emitted during the use phase (mg)	0.80	3.20	1.20	1.86
Mercury emitted during the end-of-life (mg)	0	0	0	0
Mercury emitted over lifetime per lumen per hour (ng)	3.10	0.76	2.54	1.59
Difference with the base-case GLS-R	0.00%	-51.02%	-17.92%	-48.78%

As it is assumed that none of the base-cases contain mercury, mercury emissions are only a result from the energy consumed during the use phase. Therefore, as the HL-MV-R-HW has the highest luminous efficacy, it also has the lowest mercury emissions per lumen per hour as well. As shown in Figure 5.17, the base-case HL-MV-R-HW is slightly better than HL-LV-R when focusing on mercury emissions.

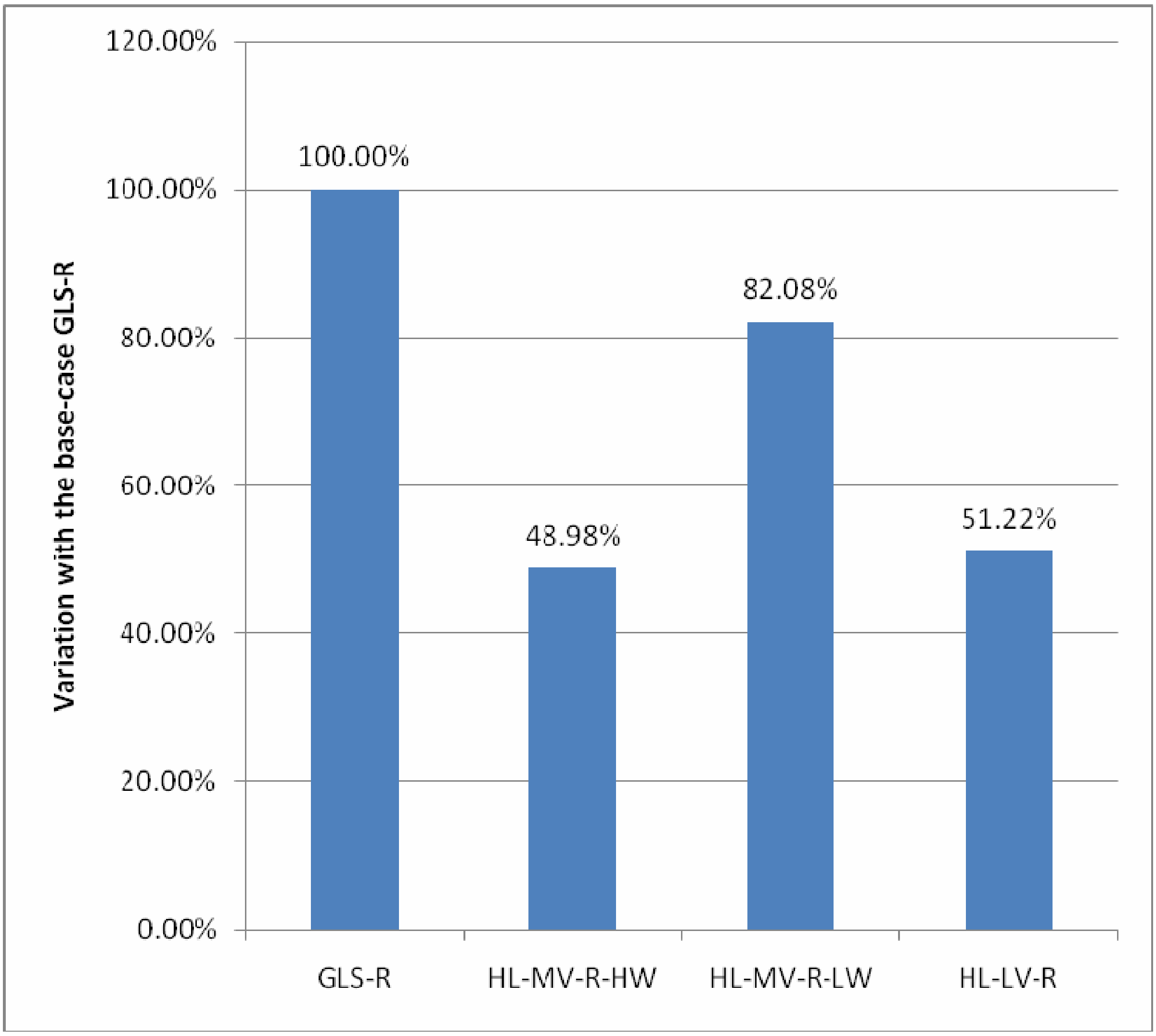

Figure 5.17: Comparison of the base-cases for mercury emissions over lifetime

The life cycle cost per lumen and per hour for each base-case is highlighted in Figure 5.18. It is clearly visible that the use of the base-case GLS-R implies the highest cost over lifetime (product price + electricity cost): 33.72×10^{-6} €/lm/h. This is due to its high cost in electricity per lumen per hour (28.69×10^{-6} €/lm/h). On the contrary, the base-case HL-LV-R presents a significant reduction compared to the base-case GLS-R (-51.7%) due to its low product price and low electricity consumption.

Table 5.16: Economic data per lumen and per hour

	GLS-R	HL-MV-R-HW	HL-MV-R-LW	HL-LV-R
Product life time (hours)	1000	2000	1500	3000
Lumen output per lamp (lm)	258.14	1053.98	314.50	391.60
Product price per lumen per hour (10^{-6} €)	5.04	6.40	7.63	2.04
Electricity per lumen per hour (10^{-6} €)	28.69	13.81	23.37	14.25
LCC per lumen per hour (10^{-6} €)	**33.72**	**20.22**	**31.01**	**16.29**
Difference with the LCC of the base-case GLS-F	0.00%	-40.05%	-8.06%	-51.69%

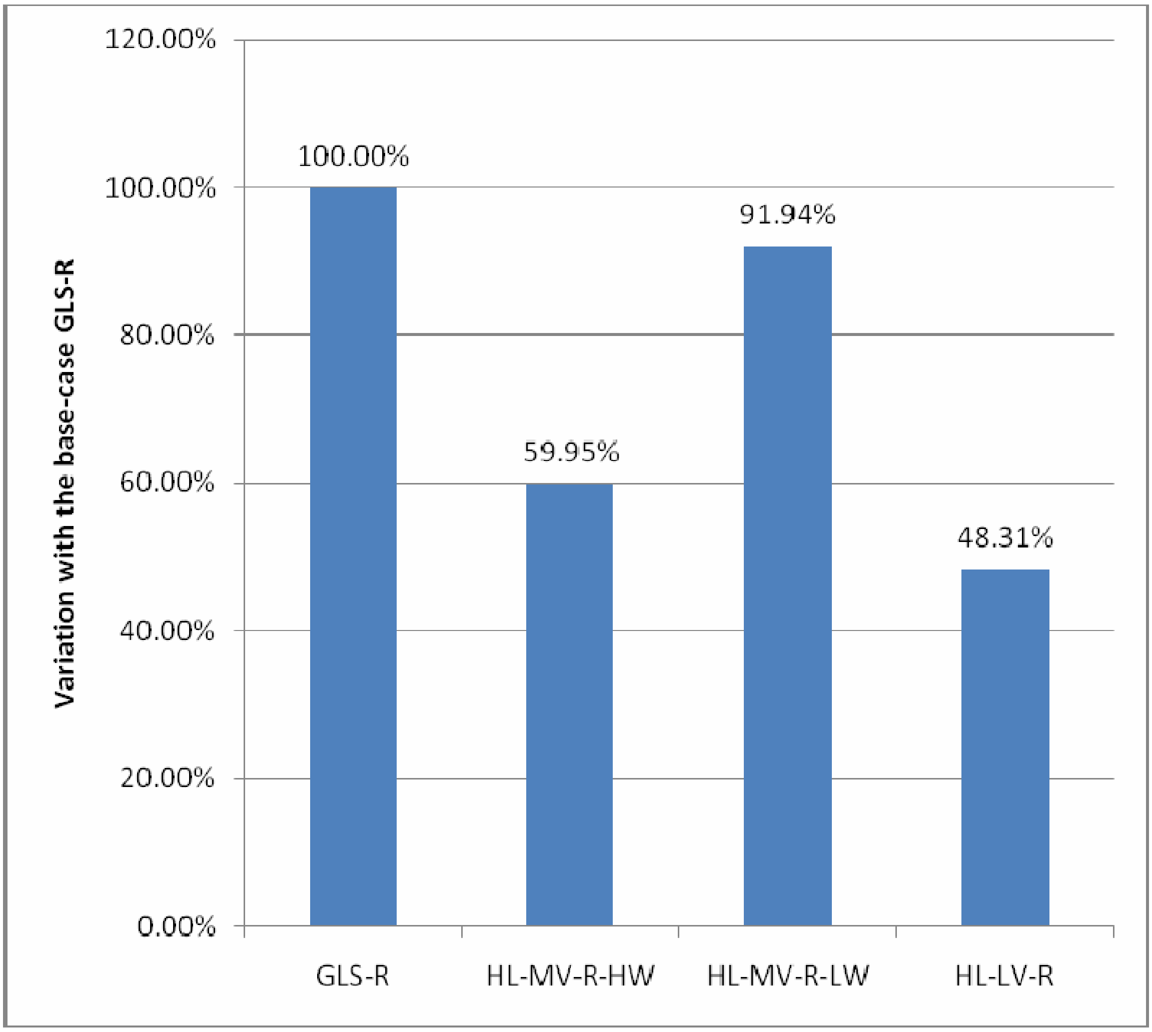

Figure 5.18: Comparison of the base-cases Life Cycle Cost per lumen and per hour

The economical analysis of the 4 base-cases shows that the HL-LV-R is the “best choice” in terms of LCC.

5.6 Conclusions

The environmental impact assessment carried out with the Eco-Report tool for each base-case shows that the use phase is, not surprisingly, the most significant stage of the life cycle in terms of energy and resource consumption as well as for environmental impacts. Therefore, the analysis of the improvement potential in chapter 7 will primarily focus on technologies that reduce the electricity consumption, for instance by increasing the lamp efficacy. Regarding environmental impacts, the HL-MV-R-HW and HL-LV-R are the best lamp choices and incandescent lamps the worst choice among the base-cases examined in this chapter. Further improvement options will be examined in chapter 6.

Regarding the Life Cycle Cost of the 4 base-cases, compared per lumen and per hour, the base-case HL-LV-R appears as the least-cost alternative among the 4 base-cases due to its low electricity consumption and low purchase price.

Chapter 6 will examine other DLS lamp types considered as best available technology, such as CFLi-R, LED, and halogen with xenon or infrared coating. It is important to note that the lamps presented in chapter 5 were only base-cases, and chapter 6 will study other lamp types in an attempt to improve upon the base-cases.

6 IMPROVEMENT POTENTIAL

For more info see website www.eup4light.net.

7 SCENARIO- POLICY- IMPACT- AND SENSITIVITY ANALYSIS

For more info see website www.eup4light.net.

8 REFERENCES

9 ABBREVIATIONS AND ACRONYMS

10 ANNEXES