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Contract N°. Specific contract 185/PP/ENT/IMA/12/1110333 implementing FC ENTR/29/PP/FC Lot 2

Report

Preparatory Studies for Product Group in the Ecodesign Working Plan 2012-2014:
Lot 8- Power Cables
DRAFT Task 5 report

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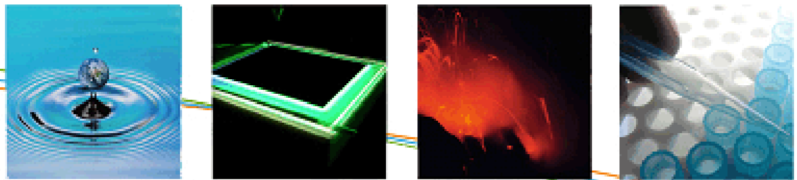

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EXECUTIVE SUMMARY

VITO is performing the preparatory study for the new upcoming eco-design directive for Energy-related Products (ErP) related to power cables, on behalf of the European Commission (more info http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/index_en.htm).

In order to improve the efficient use of resources and reduce the environmental impacts of energy-related products the European Parliament and the Council have adopted Directive 2009/125/EC (recast of Directive 2005/32/EC) establishing a framework for the setting Ecodesign requirements (e.g. energy efficiency) for energy-related products in the residential, tertiary, and industrial sectors. It prevents disparate national legislations on the environmental performance of these products from becoming obstacles to the intra-EU trade and contributes to sustainable development by increasing energy efficiency and the level of protection of the environment, taking into account the whole life cycle cost. This should benefit both businesses and consumers, by enhancing product quality and environmental protection and by facilitating free movement of goods across the EU. It is also possible to introduce binding information requirements for components and sub-assemblies.

The MEErP methodology (Methodology for the Eco-design of Energy-related Products) allows the evaluation of whether and to which extent various energy-related products fulfil the criteria established by the ErP Directive for which implementing measures might be considered. The MEErP model translates product specific information, covering all stages of the life of the product, into environmental impacts (more info http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/methodology/index_en.htm).

The tasks in the MEErP entail:
Task 1 - Scope (definitions, standards and legislation);
Task 2 – Markets (volumes and prices);
Task 3 – Users (product demand side);
Task 4 - Technologies (product supply side, includes both Best Available Technology (BAT) and Best Not Yet Available Technology (BNAT));
Task 5 – Environment & Economics (base case Life Cycle Assessment (LCA) & Life Cycle Costs (LCC));
Task 6 – Design options(improvement potential);
Task 7 – Scenarios (policy, scenario, impact and sensitivity analysis).
Tasks 1 to 4 can be performed in parallel, whereas 5, 6 and 7 are sequential.
Task 0 or a Quick-scan is optional to Task 1 for the case of large or inhomogeneous product groups, where it is recommended to carry out a first product screening. The objective is to re-group or narrow the product scope, as appropriate from an ecodesign point of view, for the subsequent analysis in tasks 2-7.

The preparatory phase of this study is to collect data for input in the MEErP model. An executive Summary of the complete study will be elaborated at completion of the draft final report.

Comment: This report is currently a working progress, as some parts of the study are missing comments and data from the stakeholders, therefore it shall not be viewed as a final report.

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List of Acronyms

α_c	corrected or circuit Load Factor
BAT	Best Available Technology
BC	Base Case
BNAT	Best Not (Yet) Available Technology
BOM	Bill Of Materials
CSA	conductor Cross-Sectional Area
Cu	Copper
EC	European Commission
EOL	End Of Life
Kd	Distribution factor
Kf	Load Form Factor
LCA	(environmental) Life Cycle Assessment
LCC	Life Cycle Costs
LV	Low Voltage
MV	Medium Voltage
Pf	Power Factor
PVC	PolyVinyl Chloride
ρ	conductor resistivity
R	Resistance
TBC	To Be Confirmed
TBD	To Be Defined
VITO	Flemish institute for Technological Research
XLPE	Cross-Linked PolyEthylene

Use of text background colours

Blue: draft text
Yellow: text requires attention to be commented
Green: text changed in the last update

CHAPTER 5 TASK 5: ENVIRONMENT & ECONOMICS

The objective of Task 5 is to define one or two average EU product(s) or to choose a representative product category as the "Base Case" (BC) for the whole of the EU-28. Throughout the rest of the study, most of the environmental and Life Cycle Cost (LCC) analyses will be built on this BC. The BC is a conscious abstraction of reality, necessary for practical reasons (e.g. budget and time). The question if this abstraction leads to inadmissible conclusions for certain market segments will be addressed in the impact- and sensitivity analysis. The description of the BC is the synthesis of the results of Tasks 1 to 4 and the point of reference for tasks 6 (improvement potential) and 7 (impact analysis).

The aim of this section is to assess environmental and economic impacts of the different base cases. The assessment is based on the updated version 3.06 of the EcoReport Tool[1], as provided with the MEErP 2011 methodology.

Remark: Further in this study the word "power cables" will be used as a general term for single core or multi-core LV power cables in buildings, unless otherwise stated.

Summary of Task 5:
TBC

5.1 Product-specific inputs

This section collects all relevant quantitative BC information from previous tasks for the modelling exercise in the rest of Task 5. The input parameters are defined in previous tasks. In these tasks, a parameter may have a low/minimum, average/reference or high/maximum value. For the calculation in Task 5 the average/reference value of each parameter is used as input.

5.1.1 Identification of base cases

According to the MEErP methodology, base cases should reflect average EU products. Different products of similar functionalities, Bill Of Materials (BoM), technologies and efficiency can be compiled into a single BC, thus it does not always represent a real product.

[1] Legal notice of EcoReport tool
This document does not necessarily reflect the view of the European Commission. It was drafted to the best of ability within budget restrictions. VHK and the European Commission do not assume any liability for any material or immaterial damage from using this document or information contained therein.

For the identification of the base cases, three application types (power cable for use in lighting circuit, power cable for use in distribution circuit and power cable for use in dedicated circuit) and two different application sectors (services sector and industry sector) have been chosen.
The most appropriate base cases have been selected in accordance with the analysis presented in Tasks 2, 3 and 4 concerning the analysis of market and environmental and technical elements associated to products used across the EU. As introduced in Task 4, ***five base cases*** have been identified to assess the environmental and economic impacts over the life cycle:

- Base case 1: A typical power cable for use in typical lighting circuit in the services sector;
- Base case 2: A typical power cable for use in typical distribution circuit in the services sector (see Figure 5-1);
- Base case 3: A typical power cable for use in typical distribution circuit in the industry sector (see Figure 5-2);
- Base case 4: A typical power cable for use in typical dedicated circuit in the services sector (see Figure 5-1);
- Base case 5: A typical power cable for use in typical dedicated circuit in the industry sector (see Figure 5-2);

The characteristics of each BC are summarised in Table 5-1. These characteristics are relevant because they have an impact on the energy consumption and the BoM. The bases cases are explained more in detail in the next paragraphs.

Table 5-1: base case identification

	Unit	Bases cases definiton				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector
Application circuit		Lighting circuit	Distribution circuit	Distribution circuit	Dedicated circuit	Dedicated circuit
Transformer/Consumer	kVA	2.3	400	1250	43	108
Voltage	V	230	400	400	400	400
Load current Ib	A	10	577	1804	62	156
Cores		3	5	4	5	5
CSA	mm²	1.5	120	300	10	35
Installation Method (IEC 60364-5-52)		E	E	E	E	E
Current Carying Capacity cable (IEC 60364-5-52 / Table B52.12)	A	26	346	621	75	158
Cables in parallel //		1	2	4	1	1
Current-Carrying Capacity - total	A	26	692	2484	75	158
Reduction Factor (IEC 60364-5-52 / Table B52.17)		1	0.88	0.8	1	1
Current-Carrying Capacity cable - total - reducted	A	26	609	1987	75	158
Icircuit= Ir (circuit breaker setting)	A	10	577	1804	62	156
Single phase or 3-phase		1	3	3	3	3
Imax per cable		10	289	451	62	156
Circuit length	m	38.00	34.00	72.00	34.00	72.00

Remarks:

- Installation Method E means cables arranged in a single layer on a perforated horizontal or vertical cable tray system (IEC 60364-5-52).
- Cable sizing is done according to the circuit breaker setting (Ir) and not according to the circuit breaker rating (In). For instance in base case 2 a 630 A (=In) circuit breaker will be used with Ir set at 609A.

Base Case 1: Services Sector - Lighting circuit

A 3G1.5 mm² power cable is commonly used in lighting circuits in EU 28 countries. A circuit breaker of 10 A (or 16 A) can be used to protect the cable against overload and short circuit. The maximum power which can be transmitted over the cable is (230V*10A=) 2.3 kVA.

Base Case 2: Services Sector – Distribution circuit

This base case includes the main distribution circuit - this means the LV power cable and protective device - between the 400 kVA MV/LV power transformer and the main LV distribution board (see Figure 5-1). In services sector smaller transformers are used compared to the industry. A 400 kVA transformer[2] is assumed as a common used transformer in services sector.
Two parallel cables of each 5G120 mm² are needed to transport the maximum power from the 400 kVA transformer to the main distribution board at the given circuit length.

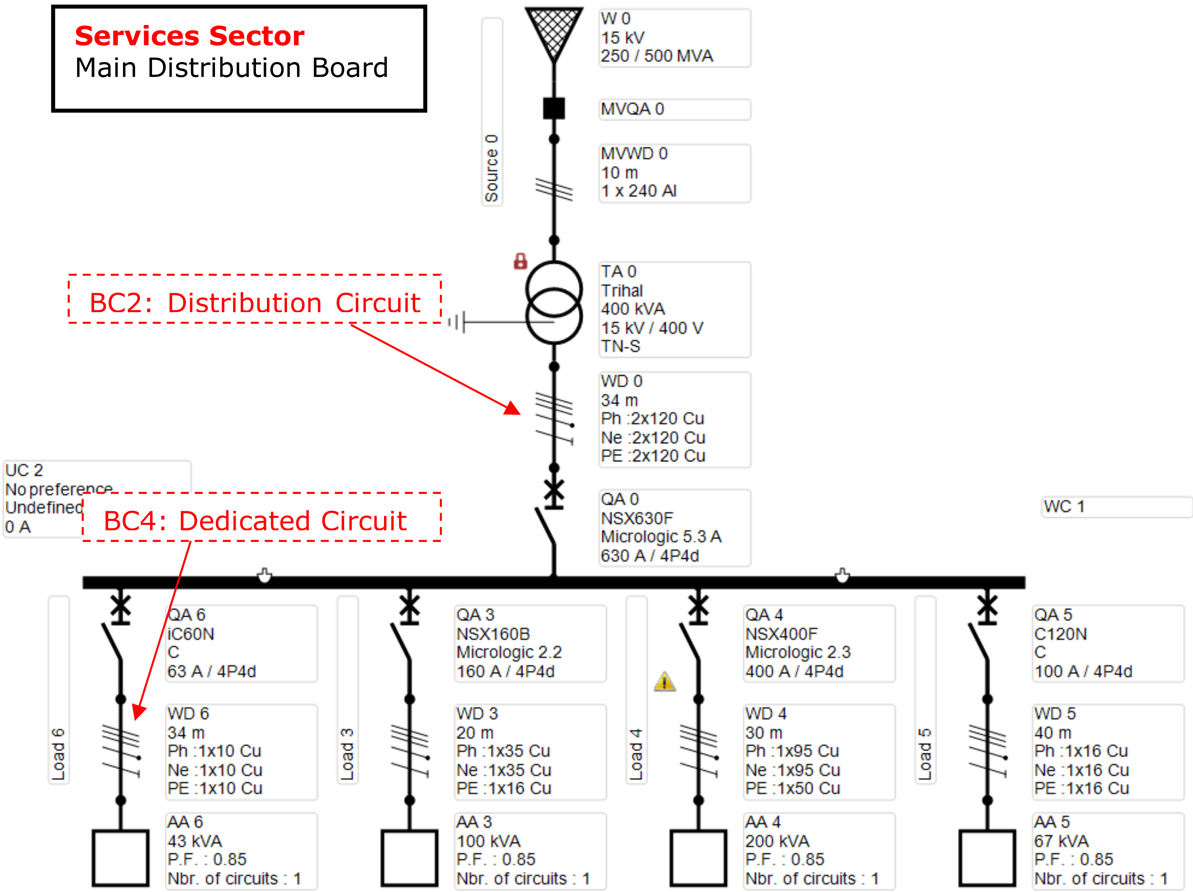

Figure 5-1 Services Sector- Base Cases 2 & 4

Base Case 3: Industry sector – Distribution Circuit

In general, transformers with a higher power rate are used in industry sector compared to the services sector. A 1250 kVA transformer is used in this BC as a common used transformer in industry[2].
The distribution circuit contains the main distribution circuit - this means the LV power cable and protective device - between the 1250 kVA MV/LV power transformer and the main LV distribution board (see Figure 5-2).

Four parallel cables of each 4 x 300 mm² are needed to transport the maximum power from the 1250 kVA transformer to the main distribution board at the given circuit length.

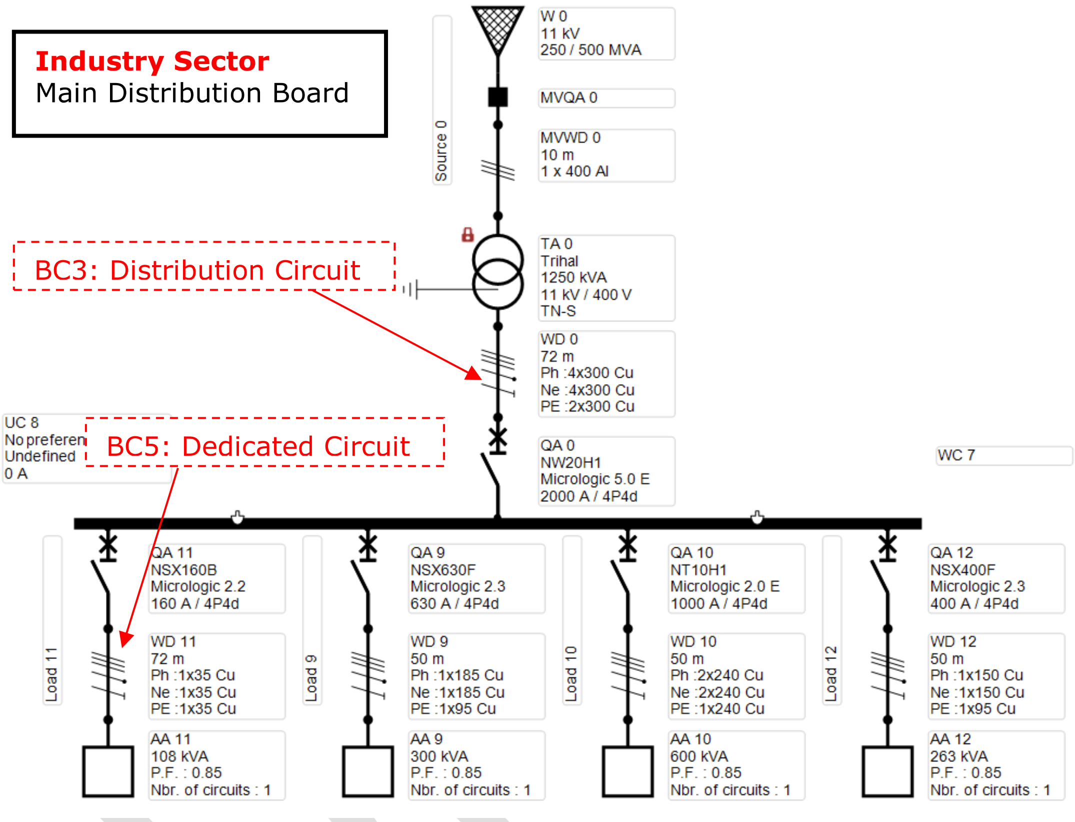

Figure 5-2 Industry Sector – Base Cases 3 & 5

Base Case 4: Services sector – Dedicated Circuit

A dedicated circuit forms the connection between a main- or sub-distribution board and a dedicated consumer (see Figure 5-1). A 5G10 mm² cable is selected for the services sector as a dedicated circuit cable. For the given cable length and cable section a load of 43 kVA can be connected to the 63 A circuit breaker in the distribution board.

Base Case 5: Industry Sector – Dedicated Circuit

[2] EU DG ENTR- Lot 2: Distribution and power transformers: http://www.eceee.org/ecodesign/products/distribution_power_transformers/Final_report_Feb2011

A 5G35 mm² cable is selected for the industry sector as a dedicated circuit cable. For the given cable length and cable section a load of 108 kVA can be connected to the 160 A circuit breaker in the distribution board (Figure 5-2).

5.1.2 Manufacturing of the product: Bill Of Materials

The manufacturing phase includes the extraction and processing of the required materials and the following steps necessary to produce and assembly one product. The MEErP 2011 EcoReport tool contains a list of materials and processes for which materials and energy indicators are provided (see for instance the "Material Code in EcoReport tool" reported in Table 5-8).

A frequently used LV power cable with the following specifications is selected as the reference cable:

- Conductor:
    - Material: Cu
    - Flexibility: Class 1 and 2
- Insulation material: XLPE (Cross-Linked Polyethylene)
- Sheath material: PVC (Polyvinyl Chloride)
- Voltage rating: 0.6/1 kV
- Single- and multicore
- Armoured: No
- Standard: IEC 60502-1

The BoM of this preparatory study has been selected according to information included in Task 2 and Task 4. An overview of the BoM per BC is shown in Table 5-2.

Table 5-2: bill of material per base case

Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector
Application circuit		Lighting circuit	Distribution circuit	Distribution circuit	Dedicated circuit	Dedicated circuit
BoM per meter cable						
CSA	**mm²**	1.50	120.00	300.00	10.00	35.00
Cu	g/m	40.01	5,334.00	10,668.00	444.50	1,555.75
XLPE	g/m	12.88	238.41	448.07	43.97	99.92
PVC	g/m	66.57	478.79	820.05	129.78	210.34
Filler material	g/m	40.54	1,300.81	1,933.88	141.25	390.98
Total weight material	g/m	160.00	7,352.00	13,870.00	759.50	2,257.00
BoM per base case						
Cu	g	1,520.19	362,712.00	3,072,384.00	15,113.00	112,014.00
XLPE	g	489.62	16,211.82	129,043.88	1,495.02	7,194.35
PVC	g	2,529.63	32,557.38	236,173.68	4,412.49	15,144.74
Filler material	g	1,540.57	88,454.79	556,958.44	4,802.48	28,150.91
Total weight material	kg	6.08	499.94	3,994.56	25.82	162.50

5.1.3 Distribution phase: volume of packaged product

This phase includes the distribution of the packaged product. The volume of the packaged product (power cable) depends on the length of cable. For a certain cable section, the appropriate drum is selected. If multiple drum sizes (drum numbers) are available, the average drum size has been selected. The volume of this drum is then multiplied by length of cable of the BC (= circuit length x number of parallel cables) divided by the maximum length of cable on this drum. Drum characteristics are listed in Task 4. The calculation is shown in Table 5-3. An estimated spacing correction factor of 15% has been chosen for the extra space between drums during transport needed for handling. The EcoReport input is shown in Table 5-4.

Table 5-3: calculation of volume of packaged base case per meter cable

	Unit	BC1	BC2	BC3	BC4	BC5
Cable outer diameter	mm	9.65	44.76	61.82	17.10	26.56
Drum Size		10	22	22	14	18
Max. cable length	m	2810	842.00	443.00	2448.00	1926.00
Drum Volume (formula	m³	0.70	6.04	9.04	1.80	4.04
Drum spacing	m³	0.11	0.91	1.36	0.27	0.61
Correction factor (spacing)	%	15%	15%	15%	15%	15%
Drum Corrected Volume	m³	0.81	6.95	10.40	2.07	4.65
Drum Weight	kg	50.00	450.00	595.00	125.00	290.00
Drum corrected volume / meter cable	m³/m	0.00029	0.00825	0.02348	0.00085	0.00241
Drum Weigth / meter cable	g/m	17.8	534.4	1343.1	51.1	150.6

Table 5-4: EcoReport input: volume of packaged base case

	Unit	**Bases cases definiton**				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector
Application circuit		Lighting circuit	Distribution circuit	Distribution circuit	Dedicated circuit	Dedicated circuit
Volume package						
Volume package per meter cable	m3	0.000286477	0.008249843	0.023475576	0.000847092	0.002414355
Volume package per base case	m3	0.01089	0.56099	6.76097	0.02880	0.17383

5.1.4 Use phase

The use phase considers the amount of energy resources demanded during the lifetime of power cables. In this study, the amount of energy loss due to the resistance of the power cable is regarded as the energy consumption of the power cable. The calculated result of the energy consumption value per BC and the input parameters for this calculation are listed in Table 5-5. Average consumption of energy per BC has been calculated based on parameters, models and formulas described in Task 2 and Task 3.

Table 5-5: energy consumption per base case

Parameter	Unit	Base cases				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector
Application circuit		Lighting circuit	Distribution circuit	Distribution circuit	Dedicated circuit	Dedicated circuit
Loaded cores		2	6	12	3	3
Cables in parallel		1	2	4	1	1
Conductor material		Cu	Cu	Cu	Cu	Cu
Imax per cable	A	10	289	451	62	156
CSA	mm²	1.5	120	300	10	35
Length of circuit	m	38	34	72	34	72
ρ_t	Ω.mm²/m	0.0167	0.0167	0.0167	0.0167	0.0167
R (formula 3.2) per wire	Ω	0.423	0.005	0.004	0.057	0.034
Kd		0.38	1.00	1.00	1.00	1.00
Kf		1.27	1.21	1.02	1.21	1.01
αc		0.24	0.41	0.57	0.41	0.61
Pf		1.00	0.80	0.80	0.80	0.80
Annual energy loss (formula 3.5) per loaded core	kVAh	13.42	841.42	2441.35	466.74	2762.15
Annual energy loss (formula 3.5) per BC	kVAh	26.85	5048.54	29296.26	1400.21	8286.46
Annual energy transported (formula 3.6) per BC	kWh	6,233.33	1,383,543.21	5,121,229.66	148,730.89	465,153.33
Energy loss ratio (formula 3.7)		0.43%	0.36%	0.57%	0.94%	1.78%

5.1.5 End of Life (EoL)

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials and this is modelled in EcoReport tool as credits (avoided impacts), i.e. negative impacts. Defaults values of the EcoReport have been used for recycling rates of the materials, except for ferro and non-ferro materials. For instance, default values for the recycling rate of metals and plastics are 94% and 29%, respectively. These recycling rates are considered comparable with the outcomes of the previous tasks and thus suitable for the current environmental analysis. Only the re-use of metals is set to 0% instead of 1% and recycling of metals is set to 95% instead of 94% (see section 3.3 in Task 3).

5.1.6 Life Cycle Cost Inputs

Average market data and consumer expenditure data have been estimated in Task 2. These have been summarized in Table 5-6 and form the data input for carrying out the economic assessment of the base cases. As mentioned in Task 3 there are no repair and maintenance costs for installed power cables.

Table 5-6: LCC input parameter per base case

	Unit	Bases cases definiton				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector
Application circuit		Lighting circuit	Distribution circuit	Distribution circuit	Dedicated circuit	Dedicated circuit
LCC data						
Year		2010	2010	2010	2010	2010
Electricity rate	€/kWh	0.11	0.11	0.11	0.11	0.11
Product price for 1 meter cable	€	0.82	58.23	116.45	6.11	18.10
Bace case product price	€	31.16	3959.30	33537.60	207.74	1303.20
Base case installation cost	€	39.54	205.80	744.18	85.83	288.78
Product life	Year	14.12	14.12	14.12	14.12	14.12
Product service life	Year	13.42	13.42	13.42	13.42	13.42

5.2 Base case environmental impact assessment (using EcoReport)

In this section, the EcoReport tool 2011 version 3.06 is used to calculate the outputs per environmental indicator and "cradle-to-grave" stages of a product life.
A summary of all input parameters values used in the EcoReport tool is listed in Table 5-7. For parameters not mentioned in Table 5-7 the default parameters of the EcoReport tool are used.

Table 5-7: EcoReport tool input parameters per base case

	Unit	Base cases: ecoreport input				
Base case id		BC1	BC2	BC3	BC4	BC5
CSA	mm²	1.5	120	300	10	35
Cu	g/m	1520.19	362712.00	3072384.00	15113.00	112014.00
XLPE	g/m	489.62	16211.82	129043.88	1495.02	7194.35
PVC	g/m	2529.63	32557.38	236173.68	4412.49	15144.74
Annual energy loss (formula 3.5) per BC	kVAh	26.85	5048.54	29296.26	1400.21	8286.46
Volume	m3	0.01	0.56	6.76	0.03	0.17
Product life	Year	14.12	14.12	14.12	14.12	14.12
Bace case product price	€	31.16	3959.30	33537.60	207.74	1303.20
Annual sales (base case units)	mln. Units	32.86	0.42	0.04	1.76	1.44
EU Stock (base case units)	mln. Units	464.07	5.98	0.51	24.85	20.27
Base case installation cost	€	39.54	205.80	744.18	85.83	288.78
Electricity rate	€/kWh	0.11	0.11	0.11	0.11	0.11
Filler material	g	1540.57	88454.79	556958.44	4802.48	28150.91
EoL mass fraction to re-use, non-Ferro material	%	0%	0%	0%	0%	0%
Product service life	Year	13.42	13.42	13.42	13.42	13.42

5.2.1 Base case 1: lighting circuit in services sector

The environmental impacts related to the use of one BC1 circuit per year, calculated by means of the EcoReport tool, are shown in Table 5-8.

Table 5-8: Environmental impacts related to the use of one BC1 circuit per year

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**340**		**3**	189	154	0	**0**
2	TecPlastics	g			**0**		**0**	0	0	0	**0**
3	Ferro	g			**0**		**0**	0	0	0	**0**
4	Non-ferro	g			**113**		**1**	6	109	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**0**		**0**	0	0	0	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**0**	0	0	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**453**		**5**	194	263	0	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	24	14	**38**	**9**	**242**	0	-6		**283**
12	of which, electricity (in primary MJ)	MJ	0	8	**9**	**0**	**242**	0	0		**250**
13	Water (process)	ltr	21	0	**21**	**0**	**0**	0	-2		**20**
14	Water (cooling)	ltr	1	4	5	0	11	0	0		**16**
15	Waste, non-haz./ landfill	g	3	43	**46**	**8**	**125**	0	-1		**179**
16	Waste, hazardous/ incinerated	g	0	0	**0**	**0**	**4**	0	0		**4**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	1	1	**2**	**1**	**10**	0	0		**13**
18	Acidification, emissions	g SO2 eq.	34	3	**37**	**2**	**46**	0	-13		**73**
19	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**5**	0	0		**5**
20	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	**0**	**0**	**1**	0	0		**1**
21	Heavy Metals	mg Ni eq.	6	0	**6**	**0**	**3**	0	-2		**7**
22	PAHs	mg Ni eq.	1	0	**1**	**0**	**1**	0	0		**1**
23	Particulate Matter (PM, dust)	g	0	1	**1**	**3**	**1**	0	0		**5**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	11	0	**11**	**0**	**1**	0	-4		**8**
25	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0		**0**

5.2.2 Base case 2: distribution circuit in services sector

The environmental impacts related to the use of one BC2 circuit per year, calculated by means of the EcoReport tool, are shown in Table 5-9.

Table 5-9: Environmental impacts related to the use of one BC2 circuit per year

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**9,715**		**97**	5,397	4,416	0	**0**
2	TecPlastics	g			**0**		**0**	0	0	0	**0**
3	Ferro	g			**0**		**0**	0	0	0	**0**
4	Non-ferro	g			**25,680**		**257**	1,297	24,640	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**0**		**0**	0	0	0	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**0**	0	0	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**35,395**		**354**	6,694	29,056	0	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	3,304	397	**3,701**	**55**	**45,470**	22	-1,162		**48,086**
12	of which, electricity (in primary MJ)	MJ	11	239	**250**	**0**	**45,437**	0	-1		**45,686**
13	Water (process)	ltr	597	4	**600**	**0**	**6**	0	-47		**559**
14	Water (cooling)	ltr	36	113	148	0	2,020	0	-3		**2,165**
15	Waste, non-haz./ landfill	g	357	1,244	**1,600**	**31**	**23,419**	7	-122		**24,935**
16	Waste, hazardous/ incinerated	g	12	0	**12**	**1**	**717**	0	-3		**727**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	179	22	**201**	**4**	**1,941**	0	-62		**2,084**
18	Acidification, emissions	g SO2 eq.	7,523	95	**7,617**	**11**	**8,658**	4	-2,852		**13,438**
19	Volatile Organic Compounds (VOC)	g	0	0	**0**	**1**	**1,015**	0	0		**1,016**
20	Persistent Organic Pollutants (POP)	ng i-Teq	96	0	**96**	**0**	**107**	0	-37		**167**
21	Heavy Metals	mg Ni eq.	1,414	0	**1,414**	**2**	**474**	1	-537		**1,353**
22	PAHs	mg Ni eq.	139	0	**139**	**2**	**107**	0	-53		**195**
23	Particulate Matter (PM, dust)	g	74	15	**89**	**136**	**182**	0	-28		**379**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	2,416	0	**2,416**	**0**	**220**	1	-918		**1,719**
25	Eutrophication	g PO4	4	0	**4**	**0**	**9**	0	-2		**11**

5.2.3 Base case 3: distribution circuit in industry sector

The environmental impacts related to the use of one BC3 circuit per year, calculated by means of the EcoReport tool, are shown in Table 5-10.

Table 5-10: Environmental impacts related to the use of one BC3 circuit per year

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**65,290**		**653**	36,269	29,674	0	**0**
2	TecPlastics	g			**0**		**0**	0	0	0	**0**
3	Ferro	g			**0**		**0**	0	0	0	**0**
4	Non-ferro	g			**217,525**		**2,175**	10,985	208,715	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**0**		**0**	0	0	0	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**0**	0	0	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**282,815**		**2,828**	47,254	238,389	0	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	27,512	2,667	**30,179**	**582**	**263,941**	167	-9,803		**285,066**
12	of which, electricity (in primary MJ)	MJ	90	1,606	**1,695**	**1**	**263,667**	0	-7		**265,357**
13	Water (process)	ltr	3,917	24	**3,941**	**0**	**39**	0	-307		**3,673**
14	Water (cooling)	ltr	283	757	1,041	0	11,721	0	-22		**12,740**
15	Waste, non-haz./ landfill	g	2,998	8,357	**11,356**	**294**	**135,906**	56	-1,034		**146,578**
16	Waste, hazardous/ incinerated	g	102	0	**102**	**6**	**4,161**	0	-24		**4,245**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	1,482	148	**1,630**	**37**	**11,270**	1	-523		**12,414**
18	Acidification, emissions	g SO2 eq.	63,689	638	**64,327**	**114**	**50,441**	32	-24,157		**90,756**
19	Volatile Organic Compounds (VOC)	g	4	0	**4**	**10**	**5,889**	0	-1		**5,901**
20	Persistent Organic Pollutants (POP)	ng i-Teq	814	0	**814**	**2**	**623**	0	-309		**1,130**
21	Heavy Metals	mg Ni eq.	11,977	0	**11,977**	**15**	**2,786**	12	-4,551		**10,238**
22	PAHs	mg Ni eq.	1,173	1	**1,174**	**21**	**627**	0	-445		**1,378**
23	Particulate Matter (PM, dust)	g	626	98	**724**	**1,637**	**1,061**	3	-235		**3,189**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	20,468	0	**20,468**	**0**	**1,340**	6	-7,778		**14,036**
25	Eutrophication	g PO4	34	2	**36**	**0**	**50**	1	-13		**74**

5.2.4 Base case 4: dedicated circuit in services sector

The environmental impacts related to the use of one BC4 circuit per year, calculated by means of the EcoReport tool, are shown in Table 5-11.

Table 5-11: Environmental impacts related to the use of one BC4 circuit per year

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Materials	**unit**									
1	Bulk Plastics	g			**758**		**8**	421	345	0	**0**
2	TecPlastics	g			**0**		**0**	0	0	0	**0**
3	Ferro	g			**0**		**0**	0	0	0	**0**
4	Non-ferro	g			**1,070**		**11**	54	1,027	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**0**		**0**	0	0	0	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**0**	0	0	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**1,828**		**18**	475	1,371	0	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	150	31	**181**	**10**	**12,603**	1	-49		**12,746**
12	of which, electricity (in primary MJ)	MJ	1	19	**20**	**0**	**12,602**	0	0		**12,622**
13	Water (process)	ltr	46	0	**46**	**0**	**0**	0	-4		**43**
14	Water (cooling)	ltr	3	9	12	0	560	0	0		**572**
15	Waste, non-haz./ landfill	g	17	97	**114**	**9**	**6,494**	0	-5		**6,612**
16	Waste, hazardous/ incinerated	g	1	0	**1**	**0**	**199**	0	0		**200**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	8	2	**10**	**1**	**538**	0	-3		**546**
18	Acidification, emissions	g SO2 eq.	314	7	**322**	**2**	**2,384**	0	-119		**2,589**
19	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**281**	0	0		**282**
20	Persistent Organic Pollutants (POP)	ng i-Teq	4	0	**4**	**0**	**29**	0	-2		**32**
21	Heavy Metals	mg Ni eq.	59	0	**59**	**0**	**128**	0	-22		**165**
22	PAHs	mg Ni eq.	6	0	**6**	**0**	**29**	0	-2		**33**
23	Particulate Matter (PM, dust)	g	3	1	**4**	**7**	**50**	0	-1		**61**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	101	0	**101**	**0**	**55**	0	-38		**118**
25	Eutrophication	g PO4	0	0	**0**	**0**	**2**	0	0		**3**

5.2.5 Base case 5: dedicated circuit in industry sector

The environmental impacts related to the use of one BC5 circuit per year, calculated by means of the EcoReport tool, are shown in Table 5-12.

Table 5-12: Environmental impacts related to the use of one BC5 circuit per year

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**3,575**		**36**	1,986	1,625	0	**0**
2	TecPlastics	g			**0**		**0**	0	0	0	**0**
3	Ferro	g			**0**		**0**	0	0	0	**0**
4	Non-ferro	g			**7,931**		**79**	400	7,609	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**0**		**0**	0	0	0	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**0**	0	0	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**11,505**		**115**	2,386	9,234	0	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	1,043	146	**1,189**	**23**	**74,589**	8	-361		**75,447**
12	of which, electricity (in primary MJ)	MJ	5	88	**93**	**0**	**74,578**	0	0		**74,671**
13	Water (process)	ltr	214	1	**215**	**0**	**2**	0	-17		**201**
14	Water (cooling)	ltr	16	41	57	0	3,315	0	-1		**3,371**
15	Waste, non-haz./ landfill	g	116	458	**574**	**15**	**38,434**	3	-38		**38,987**
16	Waste, hazardous/ incinerated	g	5	0	**5**	**0**	**1,177**	0	-1		**1,181**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	56	8	**65**	**2**	**3,184**	0	-19		**3,231**
18	Acidification, emissions	g SO2 eq.	2,325	35	**2,360**	**5**	**14,110**	1	-881		**15,595**
19	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**1,666**	0	0		**1,666**
20	Persistent Organic Pollutants (POP)	ng i-Teq	30	0	**30**	**0**	**174**	0	-11		**193**
21	Heavy Metals	mg Ni eq.	437	0	**437**	**1**	**758**	0	-166		**1,030**
22	PAHs	mg Ni eq.	43	0	**43**	**1**	**174**	0	-16		**202**
23	Particulate Matter (PM, dust)	g	23	5	**28**	**42**	**299**	0	-9		**361**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	746	0	**746**	**0**	**328**	0	-284		**791**
25	Eutrophication	g PO4	1	0	**1**	**0**	**14**	0	0		**15**

5.3 Base case Life Cycle Cost for consumer

This section includes a calculation of the LCC for consumers using the new LCC equations available in the MEErP methodology including the escalation rate.

LCC have been calculated using the EcoReport tool based upon the economic input parameters shown in Table 5-6. The results of this calculation are shown in Table 5-13 referred to the lifetime considered for each of the base cases. Product price, installation costs and energy (electricity) costs during the whole life cycle have been considered.

Table 5-13: Life Cycle Costs for consumer per base case

	Unit	Bases cases definiton				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services	Services	Industry	Services	Industry
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated
Product price	€	€ 31.16	€ 3,959.30	€ 33,537.60	€ 207.74	€ 1,303.20
Installation/ acquisition costs (if any)	€	€ 39.54	€ 205.80	€ 744.18	€ 85.83	€ 288.78
Electricity	€	€ 39.62	€ 7,843.77	€ 45,516.79	€ 2,175.47	€ 12,874.45
Total	€	€ 110.32	€ 12,008.87	€ 79,798.57	€ 2,469.04	€ 14,466.43
Product price	%	28%	33%	42%	8%	9%
Installation/ acquisition costs (if any)	%	36%	2%	1%	3%	2%
Electricity	%	36%	65%	57%	88%	89%
Total	%	100%	100%	100%	100%	100%

5.4 Base case Life Cycle Costs for society

This section includes a calculation of the LCC for society as described in the MEErP methodology , following the extended LCC equations with CO_2 stock price, societal damage of certain emissions, etc.

LCC for society have been calculated using the EcoReport tool. The results of this calculation are shown in Table 5-14 referred to the lifetime considered for each of the base cases.

Table 5-14: Life Cycle Costs for society per base case

	Unit	Bases cases definiton				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services	Services	Industry	Services	Industry
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated
Product price	€	€ 31.16	€ 3,959.30	€ 33,537.60	€ 207.74	€ 1,303.20
Installation/ acquisition costs (if any)	€	€ 39.54	€ 205.80	€ 744.18	€ 85.83	€ 288.78
Electricity	€	€ 39.62	€ 7,843.77	€ 45,516.79	€ 2,175.47	€ 12,874.45
External damages total, of which	€	€ 14.80	€ 2,853.02	€ 20,314.59	€ 466.55	€ 2,839.66
- production PPext	€	€ 14.80	€ 2,853.02	€ 20,314.59	€ 466.55	€ 2,839.66
- lifetime operating expense N*OEext	€	€ 7.46	€ 1,478.00	€ 8,602.24	€ 407.66	€ 2,413.13
- end-of-life OELext	€	€ 1.54	€ 363.61	€ 3,079.09	€ 15.17	€ 112.33
Total	€	€ 125.12	€ 14,861.89	€ 100,113.15	€ 2,935.60	€ 17,306.09
Product price	%	25%	27%	33%	7%	8%
Installation/ acquisition costs (if any)	%	32%	1%	1%	3%	2%
Electricity	%	32%	53%	45%	74%	74%
External damages total, of which	%	12%	19%	20%	16%	16%
Total	%	100%	100%	100%	100%	100%

5.5 EU totals

Following the MEErP 2011 methodology, EU Totals have been calculated using the EcoReport tool in which environmental impacts and LCC outcomes have been aggregated according to stock and market data estimated in Task 2.

5.5.1 Stock specific inputs

Table 5-15 shows the stock input parameters per BC. The five base cases are assumed to represent the installed stock in the EU-28.

Table 5-15: Stock input parameters per base case

	Unit	Bases cases definiton				
Base case id		BC1	BC2	BC3	BC4	BC5
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector
Application circuit		Lighting circuit	Distribution circuit	Distribution circuit	Dedicated circuit	Dedicated circuit
Stock and sales data (fixed total stock)						
Year		2010	2010	2010	2010	2010
EU Stock per base case cable (Cu weight)	kg	7.05E+08	2.17E+09	1.55E+09	3.76E+08	2.27E+09
EU Stock (units of 1 cable)	m	1.76E+10	4.07E+08	1.46E+08	8.45E+08	1.46E+09
EU Stock (base case units)	mln. Units	464.07	5.98	0.51	24.85	20.27
Annual sales (base case units)	mln. Units	32.86	0.42	0.04	1.76	1.44

5.5.2 Environmental impact at EU-28

The total annual impacts from the EU stock of products are presented in Table 5-16.

Table 5-16: EU-28 total annual environmental impacts from the installed stock

	Unit	Bases cases definiton					
Base case id		BC1	BC2	BC3	BC4	BC5	Total
Sector		Services sector	Services sector	Industry sector	Services sector	Industry sector	
Application circuit		Lighting circuit	Distribution circui	Distribution circuit	Dedicated circuit	Dedicated circuit	
Materials							
Plastics	Mt	0.151	0.059	0.033	0.019	0.073	0.34
Ferrous metals	Mt	0.000	0.000	0.000	0.000	0.000	0.00
Non-ferrous metals	Mt	0.050	0.155	0.111	0.027	0.162	0.51
Other resources & waste							
Total Energy (GER)	PJ	132.94	294.36	149.10	317.99	1536.52	2,430.91
of which, electricity	TWh	12.89	30.36	14.92	34.86	168.18	261.19
Water (process)*	mln.m3	9.46	3.63	2.01	1.15	4.41	20.66
Waste, non-haz./ landfill*	Mt	0.08	0.15	0.07	0.16	0.79	1.26
Waste, hazardous/ incinerated*	kton	0.00	0.00	0.00	0.00	0.02	0.04
Emissions (Air)							
Greenhouse Gases in GWP100	mt CO2eq.	6.05	12.83	6.54	13.64	65.88	104.95
Acidifying agents (AP)	kt SO2eq.	38.61	97.39	58.12	67.29	333.95	595.36
Volatile Org. Compounds (VOC)	kt	2.52	6.08	2.99	7.00	33.77	52.35
Persistent Org. Pollutants (POP)	g i-Teq.	0.47	1.22	0.73	0.83	4.14	7.39
Heavy Metals (HM)	ton Ni eq.	4.10	11.30	7.48	4.66	24.24	51.77
PAHs	ton Ni eq.	0.65	1.48	0.92	0.88	4.42	8.35
Particulate Matter (PM, dust)	kt	2.07	2.43	1.73	1.53	7.48	15.25
Emissions (Water)							
Heavy Metals (HM)	ton Hg/20	5.24	15.76	11.03	3.88	21.79	57.70
Eutrophication (EP)	kt PO4	0.03	0.08	0.04	0.06	0.31	0.53

Note: a total of 261.19 TWh for electricity is too high: see 5.6.

5.5.3 Economic assessment at EU-28

Table 5-17 shows the total annual expenditure in EU due to the stock of products currently installed in the EU-28.

Table 5-17: Total annual expenditure in the EU-28 per base case

	Unit	**Bases cases definiton**					**Total**
Base case id		BC1	BC2	BC3	BC4	BC5	
Sector		Services	Services	Industry	Services	Industry	
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated	
Product price	mln. €	1023.79	1676.22	1201.30	365.55	1870.31	6137.18
Installation/ acquisition costs (if any)	mln. €	1299.11	87.13	26.66	151.04	414.45	1978.38
Electricity	mln. €	1370.37	3320.76	1630.39	3828.08	18476.95	28626.56
Total	mln. €	3693.28	5084.11	2858.35	4344.67	20761.71	36742.12
Product price	%	17%	27%	20%	6%	30%	100%
Installation/ acquisition costs (if any)	%	66%	4%	1%	8%	21%	100%
Electricity	%	5%	12%	6%	13%	65%	100%
Total	%	10%	14%	8%	12%	57%	100%

5.6 Cross checks on EU-28 impact

To verify the outcomes of the calculation some cross checks were added.

There are two possible methods with different starting assumptions for the calculation:

1. Fixed total stock/annual sales (figures in Task 2) -> EU-28 annual transported active energy is calculated
2. Fixed EU-28 energy consumption -> total stock/annual sales is calculated

In case of the first method the amount of energy transported per BC multiplied by the number of BC units must be lower than the amount of electricity consumed in the EU-28 services and industry sector.

In case of the second method the calculated annual replacement sales multiplied by the product life (= stock) should be about the same as the stock/annual sales figures mentioned in Task 2.

Table 5-19 shows the results when using the second method (fixed energy consumption).

Table 5-18: EU-28 totals check: first method

	Unit	Bases cases definiton					Total over all BC
Base case id		BC1	BC2	BC3	BC4	BC5	
Sector		Services	Services	Industry	Services	Industry	
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated	
Method 1: fixed stock	**kg**						**7.08E+09**
Energy distribution factor	%	10%	100%	100%	85%	85%	
EU Stock (base case units)	mln. Units	464.07	5.98	0.51	24.85	20.27	
Number of buildings per sector (Task 2 Table 2-9)	mln Units	11.41	11.41	2.58	11.41	2.58	
Annual energy loss (formula 3.5) per BC	kVAh	26.85	5048.54	29296.26	1400.21	8286.46	
Annual energy transported (formula 3.6) per BC	kWh	6,233	1,383,543	5,121,230	148,731	465,153	
Checks							
Annual energy loss Eu-28 (=BC loss * #BC units)	TWh	12.46	30.19	14.82	34.80	167.97	260.24
Annual energy transported Eu-28 (=BC annual energy transport * #BC units)	TWh	2,893	8,273	2,591	3,697	9,429	
Annual energy transported Eu-28 corrected with energy distribution factor	TWh	28,927	8,273	2,591	4,349	11,093	
Number of BC units (circuits) per building		40.7	0.5	0.2	2.2	7.9	

Table 5-19: EU-28 totals check: second method

	Unit	Bases cases definiton					Total over all BC
Base case id		BC1	BC2	BC3	BC4	BC5	
Sector		Services	Services	Industry	Services	Industry	
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated	
Method 2: fixed EU-28 energy consumption	TWh		904	1030			1934
Energy distribution factor	%	10%	100%	100%	85%	85%	
Number of buildings per sector (Task 2 Table 2-9)	mln Units	11.41	11.41	2.58	11.41	2.58	
Annual energy transported (formula 3.6) per BC	kWh	6,233	1,383,543	5,121,230	148,731	465,153	
EU28 energy consumption (distributed via energy distribution factor)	TWh	90.41	904.12	1029.62	768.50	875.17	
Checks							
BC stock (= EU-28 energy consumption / energy transported per BC)	mln Units	14.50	0.65	0.20	5.17	1.88	22.41
BC stock (weight)	kg	2.20E+07	2.37E+08	6.18E+08	7.81E+07	2.11E+08	**1.17E+09**
Number of BC units (circuits) per building		1.3	0.1	0.1	0.5	0.7	

The EU-28 totals mentioned in the previous sections are based upon a fixed Cu stock for the reference year as provided in the Working Plan. Table 5-18 shows the results when comparing the amount of energy transported with the total electricity consumption in Europe.

One notices the outcome is too high, potential reasons:

- the assumed stock/annual sales is too high;
- the load and load form factor are too high;
- the length of the circuits is too low;
- base case selection is not representative;
- a combination of the above mentioned reasons.

As an experiment Table 5-20 respectively Table 5-21 shows the results for the first respectively the second method, when the length of the circuits is multiplied by 3 and the load factor is divided by 3.

Table 5-20: EU-28 totals check: first method, corrected

	Unit	Bases cases definiton					Total over all BC
Base case id		BC1	BC2	BC3	BC4	BC5	
Sector		Services	Services	Industry	Services	Industry	
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated	
Method 1: fixed stock	**kg**						**7.08E+09**
Energy distribution factor	%	10%	100%	100%	85%	85%	
EU Stock (base case units)	mln. Units	154.69	1.99	0.17	8.28	6.76	
Number of buildings per sector (Task 2 Table 2-9)	mln Units	11.41	11.41	2.58	11.41	2.58	
Annual energy loss (formula 3.5) per BC	kVAh	8.77	1649.36	9571.09	457.45	2707.19	
Annual energy transported (formula 3.6) per BC	kWh	2,057	456,569	1,690,006	49,081	153,501	
Checks							
Annual energy loss Eu-28 (=BC loss * #BC units)	TWh	1.36	3.29	1.61	3.79	18.29	28.34
Annual energy transported Eu-28 (=BC annual energy transport * #BC units)	TWh	318	910	285	407	1,037	
Annual energy transported Eu-28 corrected with energy distribution factor	TWh	3,182	910	285	478	1,220	
Number of BC units (circuits) per building		13.6	0.2	0.1	0.7	2.6	

Table 5-21: EU-28 totals check: second method, corrected

	Unit	Bases cases definiton					Total over all BC
Base case id		BC1	BC2	BC3	BC4	BC5	
Sector		Services	Services	Industry	Services	Industry	
Application circuit		Lighting	Distribution	Distribution	Dedicated	Dedicated	
Method 2: fixed EU-28 energy consumption	TWh		904	1030			1934
Energy distribution factor	%	10%	100%	100%	85%	85%	
Number of buildings per sector (Task 2 Table 2-9)	mln Units	11.41	11.41	2.58	11.41	2.58	
Annual energy transported (formula 3.6) per BC	kWh	2,057	456,569	1,690,006	49,081	153,501	
EU28 energy consumption (distributed via energy distribution factor)	TWh	90.41	904.12	1029.62	768.50	875.17	
Checks							
BC stock (= EU-28 energy consumption / energy transported per BC)	mln Units	43.95	1.98	0.61	15.66	5.70	67.90
BC stock (weight)	kg	2.00E+08	2.15E+09	5.62E+09	7.10E+08	1.92E+09	**1.06E+10**
Number of BC units (circuits) per building		3.9	0.2	0.2	1.4	2.2	