Work on Preparatory studies for implementing measures of the Ecodesign Directive 2009/125/EC

ENER Lot 28– Pumps for private and public wastewater and for fluids with high solids content – Task 5: Definition of base-case – Working document

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Task 5: Definition of Base-Case

This task provides an environmental and economic assessment of the average EU pumps for private and public wastewater and for fluids with high solid contents covered in the ENER Lot 28 preparatory study, also known as the "Base-Cases" (BCs). A 'BC' is *"a conscious abstraction of reality"* used to represent the average of a range of similar products on the market. The aim of the assessment is to quantify:

- the environmental impacts of the selected Base-Cases throughout its life
- the economic Life Cycle Costs (LCC)

The assessment includes all stages of the Base-Case's life from the extraction of the materials contained within its components, to the disposal of these materials at the end-of-life. The environmental impacts are determined by a well-established methodology known as Life Cycle Analysis (LCA). In this study a simplified LCA tool is used to calculate the environmental impacts and LCC. The tool, which is called EcoReport, is part of the MEEuP methodology, required by the European Commission for undertaking all preparatory studies under the Ecodesign Directive.[1]

While this study has been completed as comprehensively and accurately as possible, it relies on data which has been extrapolated from literature and information provided by stakeholders. The performance of real-life appliances can vary substantially from the data provided in this report. This is understood and mitigated as much as possible, while handling and calculating the data during the analysis, however rough approximations are ultimately unavoidable. The results of the study nevertheless are valuable as they represent the best indication to date of the environmental impacts of the ENER Lot 28 pumps in the EU.

The description of the Base-Cases is the synthesis of the results of Tasks 1 to 4 of this preparatory study. The environmental and life cycle cost analyses of the selected Base-Cases provide the main results of this study and it serves as the point-of-reference for Task 6 (technical analysis of Best Available Technologies), Task 7 (improvement potential), and Task 8 (policy analysis).

[1] MEEuP – Methodology Study Eco-design of Energy Using Products. Kemna, R. et al. (VHK) for DG ENTR of the European Commission, MEEuP Methodology Final Report, 2005. Accessible at: http://ec.europa.eu/energy/demand/legislation/doc/2005_11_28_finalreport1_en.pdf

5.1 Overview of base-cases

5.1.1 Criteria for defining base-cases

According to the Ecodesign Directive (2009/125/EC), the products subject to future establishment of implementing measures should meet three criteria:

- Significant market share
- Significant environmental impact
- Significant improvement potential

The implementing measures target appliances that are common on the EU market, bear a large environmental burden, and have the potential to improve their environmental performance. An appliance that does not meet any of these three criteria provides little opportunity for policy action, and therefore is not considered as a BC. As previously mentioned, BCs are not necessarily representative of real products. When two products have a similar functionality, bill of materials (BoM), technology and efficiency, they can be represented by a single BC. For further justification of the criteria for selecting Base-Cases, please refer to the MEEuP methodology[2]. It is out of the scope of this study to reflect further upon how and why Base-Cases should be chosen.

Table 5.1 shows the selection of these Base-Cases based on preliminary information gathered from industry stakeholders and technical literature. The total energy consumption of the product stock at EU-27 level is estimated for the year 2011. The specific energy saving potentials estimates have been provided by stakeholders. Seven[3] most appropriate BCs for this study have been selected through discussion with the stakeholders, using the above criteria as guidelines.

Such a high number of BCs is necessary to cover the broad range of ENER Lot 28 water pumps. The main parameters of the selected Base-Cases are presented in Table 5.1 and Table 5.2.

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[2] MEEuP – Methodology Study Eco-design of Energy Using Products, Kemna, R. et. al. (VHK) for DG ENTR of the European Commission, MEEuP Methodology Final Report, 2005, accessible at http://ec.europa.eu/energy/demand/legislation/doc/2005_11_28_finalreport1_en.pdf

[3] Please Note that the last three base cases (BC7-BC 9) might be discarded after the 2nd Stakeholder meeting owing to their exclusion from the scope of ENER Lot 28 study, as previously explained in the Task 1 report. This would eventually bring down the total number of base cases to six.

Table 5.1: Overview of ENER Lot 28 pumps product Base-Cases in 2011

Pump Type		Stock in 2011	Sales in 2011	Hydraulic pmu power*	Operating hours	Energy consumption/ unit	Energy consumption of stock	Share of energy consumption	EPA savings for 2011 stock	Share of savings for 2011 stock	Base-case
		Units	Units	kW	Hours/year	kWh/year	GWh/year	%	GWh	%	
Centrifugal submersible pump	Radial sewage pumps 1 to 10 kW	1 120 000	160 000	4	1 000	3 400	3 808	*12.3%*	510	*23.7%*	BC-1
	Radial sewage pumps >10 to 25 kW	120 000	12 000	15	1 500	19 125	2 295	*7.4%*	256	*11.9%*	
	Radial sewage pumps >25 to 160 kW	70 000	5 000	75	2 000	127 500	8 925	*28.8%*	695	*32.4%*	
	Mixed flow & axial pumps	4 900	700	50	5 000	175 000	858	*2.8%*	99	*4.6%*	BC-2
Centrifugal submersible pump – once a day operation	Shredding, grinding pumps	280 000	50 000	2	30	45	13	*0.04%*	1	*0.04%*	BC-3
	Radial sewage pumps 1 to 10 kW	910 000	130 000	2	30	48	44	*0.1%*	5	*0.2%*	
	Where volute is part of a tank	385 000	55 000	2	30	36	14	*0.04%*	2	*0.1%*	
Centrifugal submersible domestic drainage pump < 40 mm passage		12 250 000	1 500 000	0.3	30	7	88	*0.3%*	13	*0.6%*	BC-4
Submersible dewatering pumps		280 000	40 000	7	2 000	10 500	2 940	*9.5%*	287	*13.3%*	BC-5
Centrifugal dry well pump	Radial sewage pumps 1 to 10 kW	150 000	20 000	6	1 000	5 100	765	*2.5%*	53	*2.4%*	BC-6
	Radial sewage pumps >10 to 25 kW	37 500	5 000	15	1 500	19 125	717	*2.3%*	54	*2.5%*	
	Radial sewage pumps >25 to 160 kW	14 000	1 000	75	2 000	127 500	1 785	*5.8%*	88	*4.1%*	
	Mixed flow & axial pumps	2 000	100	150	250	31 900	64	*0.2%*	1	*0.03%*	-
Slurry Pumps	Light Duty	60 000	1 500	50	2 600	130 000	7 800	*25.2%*	78	*3.6%*	BC-7A
	Heavy Duty	15 000	300	37	2 000	59 200	888	*2.8%*	9	*0.4%*	BC-7B
Total		15 698 400	1 980 600				31 004		2 149	*100%*	

* Calculated as ((Hydraulic pump power * Annual operating hours) +20%) * EU Stock in 2011

Table 5.2: Summary of ENER Lot 28 pumps product Base-Cases[4]

		Stock in 2011	Sales in 2011	Hydraulic pmu power	Operating hours	Energy consumption/ unit	Energy consumption of stock	Share of energy consumption	EPA savings for 2011 stock	Share of savings for 2011 stock
		Units	Units	kW	Hours/year	kWh/year	GWh/year	%	GWh	%
Base Case 1	Centrifugal submersible pump: Radial sewage pumps 1 to 160 kW	1 310 000	177 000	7	1 062	7 972	15 028	*49%*	1 462	*68%*
Base Case 2	Centrifugal submersible pump: Mixed flow & axial pumps	4 900	700	50	5 000	175 000	858	*3%*	99	*5%*
Base Case 3	Centrifugal submersible pump – once a day operation	1 575 000	235 000	2	30	45	70	*0.2%*	8	*0.4%*
Base Case 4	Centrifugal submersible domestic drainage pump < 40 mm passage	12 250 000	1 500 000	0.3	30	7	88	*0.3%*	13	*1%*
Base Case 5	Submersible dewatering pumps	280 000	40 000	7	2 000	10 500	2 940	*10%*	287	*13%*
Base Case 6	Centrifugal dry well pump	201 500	26 000	10	1 135	12 505	3 267	*11%*	194	*9%*
Base Case 7A	Slurry Pumps – Light Duty	60 000	1 500	50	2 600	130 000	7 800	*25%*	78	*4%*
Base Case 7B	Slurry Pumps – Heavy Duty	15 000	300	37	2 000	59 200	800	*3%*	9	*0.4%*
Total		15 696 400	1 980 500				30 939		2 148	*100%*

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[4] Some stakeholders raised concern about merging of a wide range of different products in BC 1 ("Radial sewage pumps" from 1 to 160 kW) and suggested to split it in two Base-Cases: a) 1-25 kW, b) 25 – 160 kW. However, based on our project team's analysis, it was concluded that the current approach for BC 1 (and other BaseCases) is justified and allows to perform a robust policy analysis in Task 8. Some of the main reasons for not splitting the BC 1 are:

- Technical similarities: The pump technologies used for the BC 1, across its power capacity range are quite similar
- No impact on proposed Implementing Measures (IM): the IM proposed in Task 8 are mainly based on Hydraulic efficiency only and as the pump technology (directly related to hydraulic efficiency) for types considered by BC 1 are quite similar, it further justifies to maintain the current classification of Base-Cases. Any slight differences in pump technologies for the BC's (such as impeller type, main application area) should be accounted for in the variation in the C-Values presented as Annex to Task 8 report

5.2 Product specific inputs

In this section a description of the characteristics of the selected Base-Cases and the specific inputs needed for the environmental and economic analysis are presented, as well as the justification of all the assumptions made.

The information used in the environmental and economic analysis of the Base-Cases hereunder is provided by stakeholders and completed with information taken from publicly available literature. Vortex impellers are considered for the Base-Cases presented in this section.

The electricity rates are taken from the MEErP methodology and are a fixed value to be used across all ErP preparatory studies. The discount rate is defined as the interest rate minus the inflation rate. A discount rate of 4% (same for all Base-Cases) was also obtained from MEErP methodology. The discount rate is used for the Life Cycle Cost (LCC) analysis.

For the end of life phase, the same approach as in the ENER Lot 11 is followed. The percentage (by weight) of the product destined to landfill is estimated to be 8%. From the recovered share of plastics, 1% is destined to closed loop recycling, 9% is destined to materials recycling and the rest (90%) to thermal recycling (energy recovery). In order to be used in the EcoReport tool, the reuse, recycling and incineration rates have been recalculated to sum up 100% of the plastic fraction. The recycling rate of the metal and miscellaneous fraction is fixed by the MEEuP at 95%.

Table 5.3: Inputs in the End-of-life phase of BC-1 to BC-7

Disposal: Environmental Costs per kg final product	
Landfill (fraction products not recovered) (%)	*8%*
Re-use, Recycling Benefit	
Plastics: Re-use, Closed Loop Recycling (%)	*1%*
Plastics: Materials Recycling (%)	*9%*
Plastics: Thermal Recycling (%)	*90%*

5.2.1 Centrifugal submersible pumps

5.2.1.1 Inputs in the production and distribution phase

The average quantities of materials used for production and packaging of centrifugal submersible pump base cases are provided in Table 5.4. The biggest share of overall materials used for BC-1 to BC-3 is comprised of "other ferrous metals", while for BC-4 it is "steel" and BC-5 it is "non-ferrous metals".

Table 5.4: Bill of materials of BC-1 to BC-5

	BC-1	BC-2	BC-3	BC-4	BC-5
Hydraulic PMU Power [kW]	6.75	50	2	0.3	7
Product weight [kg]	114	400	45	40	50

	BC-1		BC-2		BC-3		BC-4		BC-5	
Packaging weight [kg]	21		120		17.6		1		1	
Volume of package product [m^3]	0.8		2		0.7		0.5		0.8	
Product Content	**kg**	**%**	**kg**	**%**	**kg**	**%**	**kg**	**%**	**kg**	**%**
Steel	24	20	100	25	9	19	4	15	17	34
Cast Iron	0	0	0	0	0	0	0	0	0	0
Other ferrous metals	75	68	232	58	28	61	0	40	7	14
Non-ferrous metals	13	10	60	15	4	10	2.2	10	22	44
Plastics	1	1	4	1	4	9	1.8	34	1	1
Coatings	0	0	0	0	0	0	0	0	0	0
Electronics	0	0	0	0	0	0	0	0	0	0
Other Materials	1	1	4	1	0.4	1	0.1	1	4	7
Packaging Content	**kg**	**%**	**kg**	**%**	**kg**	**%**	**Kg**	**%**	**kg**	**%**
Plastics	0.2	1	0	0	0.2	4	0	0	0	0
Cardboard	0.6	4	0	0	1.2	22	1.0	100	1.0	100
Paper	0	0	0	0	0	3	0	0	0	0
Other (Wood, etc.)	20	95	120	100	16.2	71	0	0	0	0

5.2.1.2 *Inputs in the use phase*

The annual energy consumption of BC-1 to BC-5 pumps is provided in Table 5.5. On-mode consumption per year refers to the annual energy consumption of different types of pumps corresponding to a base case, weighted per unit of corresponding pump sales in year 2011.

Table 5.5: Inputs in the use phase of BC-1 and BC-5

	BC-1	BC-2	BC-3	BC-4	BC-5
Product life in years	10	10	8	7	10
On-mode: Energy consumption per year (in kWh)	7 972	175 000	45	7	10 500

5.2.1.3 *Economic inputs*

The market data, product price and user expenditure inputs provided in Table 5.6 are based on values collected and already described in the Task 2 report.

Table 5.6: Inputs to economic analysis in EcoReport for BC-1 to BC-5

	BC-1	BC-2	BC-3	BC-4	BC-5
Annual sales 2011	177 000	700	235 000	1 500 000	40 000

	BC-1	BC-2	BC-3	BC-4	BC-5
EU stock 2011	1 310 000	4 900	1 575 000	12 250 000	280 000
Average product purchase price (€)	3 373	15 000	1 617	300	5 000
Installation costs (€)	1 434	3 750	1 130	150	250
Electricity rate (€/kWh)	0.11	0.11	0.11	0.11	0.11
Repair & maintenance costs (incl. VAT) (€/yr)	782	950	162	0	463
Discount rate (incl. VAT)	4%	4%	4%	4%	4%

5.2.2 Centrifugal dry well pumps

5.2.2.1 Inputs in the production and distribution phase

The average quantities of materials used for production and packaging of centrifugal dry well pump base cases are provided in Table 5.7. The biggest share of overall materials used for BC-6 is comprised of "other ferrous metals".

Table 5.7 Bill of materials of BC-6

	BC-6	
Hydraulic PMU Power [kW]	10	
Product weight [kg]	107	
Packaging weight [kg]	22.5	
Volume of package product [m^3]	0.9	
Product Content	**kg**	**%**
Steel	5	5
Cast Iron	0	0
Other ferrous metals	96	90
Non-ferrous metals	0	0
Plastics	1	1
Coatings	0	0
Electronics	0	0
Other Materials	4	4
Packaging Content	**kg**	**%**
Plastics	0.2	1
Cardboard	0.5	3
Paper	0	0
Other (Wood, etc.)	22	96

5.2.2.2 Inputs in the use phase

The annual energy consumption of BC-6 pumps is provided in Table 5.8. On-mode consumption per year refers to the annual energy consumption of different types of pumps corresponding to a base case, weighted per unit of corresponding pump sales in year 2011.

Table 5.8 Inputs in the use phase of BC-6

	BC-6
Product life in years	15
On-mode: Consumption per year (in kWh)	12 505

5.2.2.3 Economic inputs

The market data, product price and user expenditure inputs provided in Table 5.9 are based on values collected and already described in the Task 2 report.

Table 5.9 Inputs to economic analysis in EcoReport for BC-6

	BC-6
Annual sales 2011	26 000
EU stock 2011	201 500
Average product purchase price (€)	3 433
Installation costs (€)	1 563
Electricity rate (€/kWh)	0.11
Repair & maintenance costs (incl. VAT) (€/yr)	807
Discount rate (incl. VAT)	4%

5.2.3 Slurry pumps

5.2.3.1 Inputs in the production and distribution phase

The average quantities of materials used for production and packaging of slurry pump for light and heavy duty base cases are provided in Table 5.10.

Table 5.10 Bill of materials of BC-7A and BC-7B

	BC-7A		BC-7B	
Hydraulic PMU Power [kW]	50		37	
Product weight [kg]	600		700	
Packaging weight [kg]	120		120	
Spare parts weight [kg]	665		5165	
Volume of package product [m^3]	4		4	
Product Content	**kg**	**%**	**kg**	**%**
Steel	135	23	133	19
Cast Iron	0	0	0	0
Other ferrous metals	417	70	567	81
Non-ferrous metals	0	0	0	0

	BC-7A		BC-7B	
Plastics	0	0	0	0
Coatings	0	0	0	0
Electronics	0	0	0	0
Other Materials	48	8	0	0
Spare parts content	**kg**	**%**		
Steel	15.3	2	0	0
Cast Iron	0	0	0	0
Other ferrous metals	200	30	5165	100
Non-ferrous metals	0	0	0	0
Plastics	0	0	0	0
Coatings	0	0	0	0
Electronics	0	0	0	0
Other Materials	450	68	0	0
Packaging Content	**kg**	**%**	**kg**	**%**
Plastics	0	0	0	0
Cardboard	0	0	0	0
Paper	0	0	0	0
Other (Wood, etc.)	120	100	120	100

5.2.3.2 *Inputs in the use phase*

The annual energy consumption of BC-7A and BC-7B pumps is provided in Table 5.11. On-mode consumption per year refers to the annual energy consumption of slurry pumps.

Table 5.11 Inputs in the use phase of BC-7A and BC-7B

	BC-7A	BC-7B
Product life in years	25	25
On-mode: Consumption per year (in kWh)	130 000	59 200

5.2.3.3 *Economic inputs*

The market data, product price and user expenditure inputs provided in Table 5.12 are based on values collected and already described in the Task 2 report.

Table 5.12 Inputs to economic analysis in EcoReport for BC-7A and BC-7B

	BC-7A	BC-7B
Annual sales 2011	1 500	300
EU stock 2011	60 000	15 000
Average product purchase price (€)	20 000	20 000
Installation costs (€)	5 000	5 000
Electricity rate (€/kWh)	0.11	0.11
Repair & maintenance costs (incl. VAT) (€/yr)	1 275	1 275

	BC-7A	BC-7B
Discount rate (incl. VAT)	*4%*	*4%*

5.3 Base-case environmental impacts

This section provides the environmental impacts of the Base-Cases throughout all the life cycle stages. These results were calculated using the EcoReport tool of the MEEuP methodology and based on the inputs presented in the previous section. The MEEuP methodology tracks 17 environmental impact categories, classified in three main categories:

- Resources and waste
  - Total energy (GER - gross energy requirement)
  - Electricity (in primary MJ)
  - Water (process)
  - Water (cooling)
  - Waste, non hazardous/landfill
  - Waste, hazardous/incinerated
- Emissions (air)
  - Greenhouse gases in GWP100
  - Ozone depletion, emissions
  - Acidification, emissions
  - Volatile organic compounds (VOC)
  - Persistent organic pollutants (POP)
  - Heavy metals into air
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Particulate matter (PM, dust)
- Emissions (water)
  - Heavy metals into water
  - Eutrophication
  - Persistent organic pollutants (POP)

The analysis presented in sub-sections below allows the most significant environmental impacts to be determined. It will also be used as a reference when analysing the improvement potential of design options in Task 6.

5.3.1 BC-1: Centrifugal submersible radial sewage pump 1-160 kW

The Table 5.13 presents the contribution of each life cycle stage to the overall environmental impacts of centrifugal submersible radial sewage pump 1-160 kW.

Table 5.13: Life cycle impact (per unit) of BC-1: Centrifugal submersible radial sewage pump 1-160 kW

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							debit	credit		
Total Energy (GER)	MJ	3 531	643	4 174	940	837 076	819	363	456	842 646
of which, electricity (in primary MJ)	MJ	134	384	518	2	837 039	0	1	-1	837 559
Water (process)	ltr	255	6	260	0	55 805	0	0	0	56 065
Water (cooling)	ltr	316	178	494	0	2 232 095	0	3	-3	2 232 587
Waste, non-haz./ landfill	g	199 750	2 187	201 937	414	972 513	13 204	2	13 202	1 188 066
Waste, hazardous/ incinerated	g	14	0	14	8	19 288	1 226	0	1 226	20 536
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	235	36	271	57	36 530	61	27	34	36 893
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO2 eq.	2 504	155	2 659	172	215 563	120	34	87	218 480
Volatile Organic Compounds (VOC)	g	13	0	13	17	315	3	0	3	348
Persistent Organic Pollutants (POP)	ng i-Teq	1 319	13	1 332	2	5 500	91	0	91	6 925
Heavy Metals	mg Ni eq.	603	31	633	21	14 367	238	0	238	15 259
PAHs	mg Ni eq.	152	0	152	38	1 650	0	0	0	1 840
Particulate Matter (PM, dust)	g	1 159	24	1 183	2 735	4 616	1 066	1	1 065	9 599
Emissions (Water)										
Heavy Metals	mg Hg/20	237	0	237	1	5 399	68	0	68	5 705
Eutrophication	g PO4	6	0	7	0	26	4	0	4	36
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

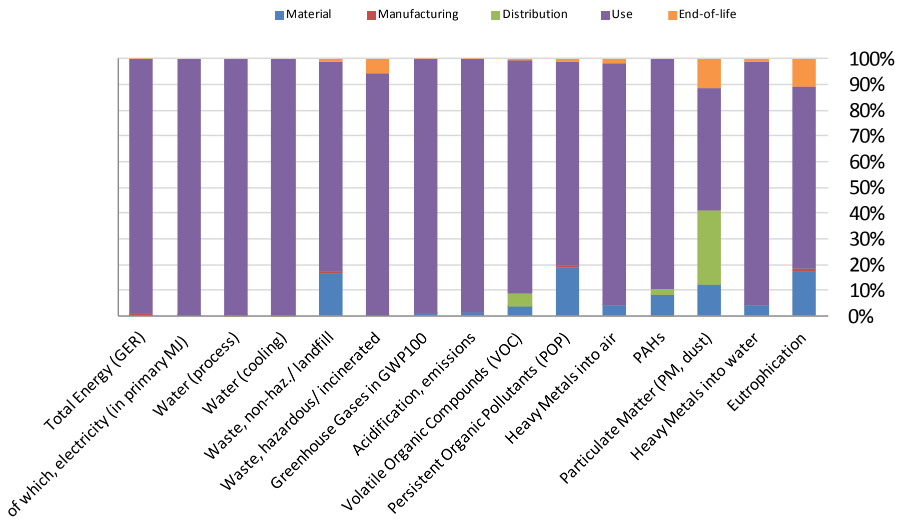

Figure 5-1: Distribution of the BC-1's environmental impacts by life cycle phase

The use phase is clearly the main predominant phase contributing to the environmental impacts of a centrifugal submersible radial sewage pump 1-160 kW. The following 15 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:

- Total energy (GER) 99.3%
- Electricity (in primary MJ) 99.9%
- Water (process) 99.5%
- Water (cooling) 100%
- Waste, non hazardous/landfill 81.9%
- Waste, hazardous/incinerated 93.9%
- Greenhouse gases in GWP100 99.0%
- Acidification, emissions 98.7%
- VOC 90.7%
- POP 79.4%
- Heavy metals into air 94.2%
- PAHs 89.7%
- Particulate matter (PM, dust) 48.1%
- Heavy metals into water 94.6%
- Eutrophication 71.0%

Results of the EcoReport modelling indicates that the end-of-life phase has minor contributions to hazardous/incinerated waste generation, particulate matter and eutrophication. The highest contribution of the material acquisition phase is 19.1% to POP. The distribution phase has a contribution of 28.5% to particulate matter and the contribution of the manufacturing phase is less than 1% of the overall environment impacts.

5.3.2 BC-2: Centrifugal submersible mixed flow & axial pump

The Table 5.14 presents the contribution of each life cycle stage to the overall environmental impacts of centrifugal submersible mixed flow and axial pumps.

Table 5.14: Life cycle impact (per unit) of BC-2: centrifugal submersible mixed flow & axial pump

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							debit	credit		
Total Energy (GER)	MJ	15 387	2 441	17 828	2 273	18 375 178	3 087	1 937	1 150	18 396 429
of which, electricity (in primary MJ)	MJ	590	1 458	2 048	6	18 375 020	0	2	-2	18 377 072
Water (process)	ltr	1 195	22	1 217	0	1 225 012	0	1	-1	1 226 228
Water (cooling)	ltr	973	676	1 649	0	49 000 016	0	8	-8	49 001 657
Waste, non-haz./ landfill	g	875 500	8 361	883 861	959	21 313 608	51 000	6	50 994	22 249 423
Waste, hazardous/ incinerated	g	52	0	53	19	423 414	3 600	1	3 599	427 085
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO_2 eq.	950	136	1 086	135	801 886	230	143	87	803 194
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO_2 eq.	11 241	588	11 829	412	4 731 681	453	180	272	4 744 194
Volatile Organic Compounds (VOC)	g	45	1	45	41	6 921	12	2	10	7 018
Persistent Organic Pollutants (POP)	ng i-Teq	5 118	54	5 172	5	120 492	351	0	351	126 020
Heavy Metals	mg Ni eq.	2 540	126	2 666	49	315 272	897	0	897	318 885
PAHs	mg Ni eq.	708	0	708	91	36 206	0	0	0	37 004
Particulate Matter (PM, dust)	g	3 736	90	3 826	6 836	101 101	4 018	3	4 014	115 778
Emissions (Water)										
Heavy Metals	mg Hg/20	956	0	956	2	118 486	257	0	257	119 700
Eutrophication	g PO_4	28	1	29	0	565	15	0	15	609
Persistent Organic Pollutants (POP)	ng i-Teq					956				

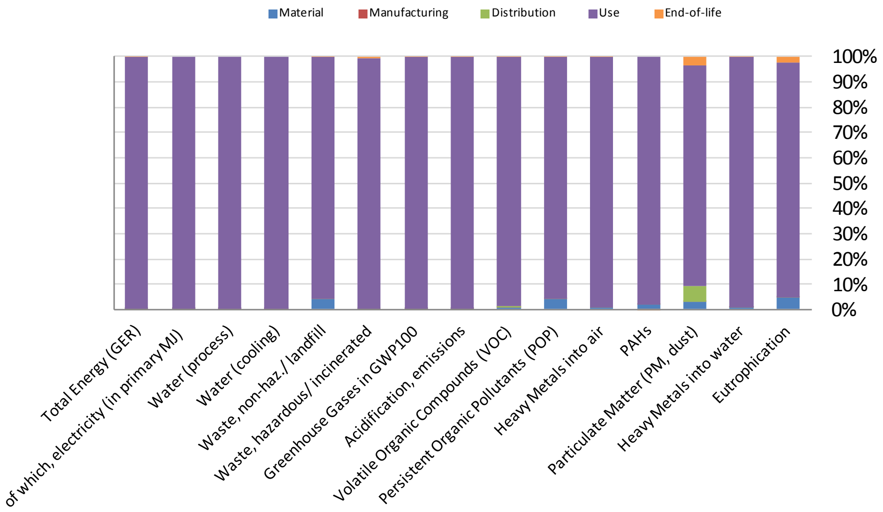

Figure 5-2: Distribution of the BC-2's environmental impacts by life cycle phase

From the analysis, the use phase is clearly the main predominant phase contributing to the environmental impacts of a centrifugal submersible mixed flow and axial pump. The following 15 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:

Total energy (GER)	99.9%
Electricity (in primary MJ)	100%
Water (process)	99.9%
Water (cooling)	100%
Waste, non hazardous/landfill	95.8%
Waste, hazardous/incinerated	99.1%
Greenhouse gases in GWP100	99.8%
Acidification, emissions	99.7%
VOC	98.6%
POP	95.6%
Heavy metals into air	98.9%
PAHs	97.8%
Particulate matter (PM, dust)	87.3%
Heavy metals into water	99.0%
Eutrophication	92.8%

Results of the EcoReport modelling indicates that material acquisition phase has some minor contributions to generation of non-hazardous/landfill waste, POP, particulate matter and Eutrophication. The distribution phase and end-of-life phase contribute 5.9% and 3.5% respectively to particulate matter emission to air. The contribution of the manufacturing phase is less than 1% of the overall environment impacts.

5.3.3 BC-3: Centrifugal submersible once a day operation pump

The Table 5.15 presents the contribution of each life cycle stage to the overall environmental impacts of centrifugal submersible once a day operation pumps.

Table 5.15: Life cycle impact (per unit) of BC-3: centrifugal submersible once a day operation pump

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							debit	credit		
Total Energy (GER)	MJ	1 794	362	2 156	829	3 767	570	451	120	6 872
of which, electricity (in primary MJ)	MJ	101	217	318	2	3 749	0	1	-1	4 067
Water (process)	ltr	177	3	180	0	252	0	1	-1	431
Water (cooling)	ltr	218	101	319	0	9 991	0	8	-8	10 303
Waste, non-haz./ landfill	g	71 179	1 196	72 375	369	5 066	6 131	6	6 126	83 937
Waste, hazardous/ incinerated	g	23	0	23	7	87	3 362	1	3 361	3 478
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	97	20	118	50	165	43	33	10	342
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO2 eq.	913	87	1 000	152	974	84	41	43	2 169
Volatile Organic Compounds (VOC)	g	5	0	5	14	1	2	1	1	23
Persistent Organic Pollutants (POP)	ng i-Teq	473	5	478	2	29	42	0	42	551
Heavy Metals	mg Ni eq.	215	11	226	19	67	161	0	161	472
PAHs	mg Ni eq.	54	0	54	33	8	0	0	0	96
Particulate Matter (PM, dust)	g	433	13	446	2 393	25	741	1	740	3 605
Emissions (Water)										
Heavy Metals	mg Hg/20	85	0	85	1	25	47	0	47	158
Eutrophication	g PO4	3	0	4	0	0	3	0	3	6
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

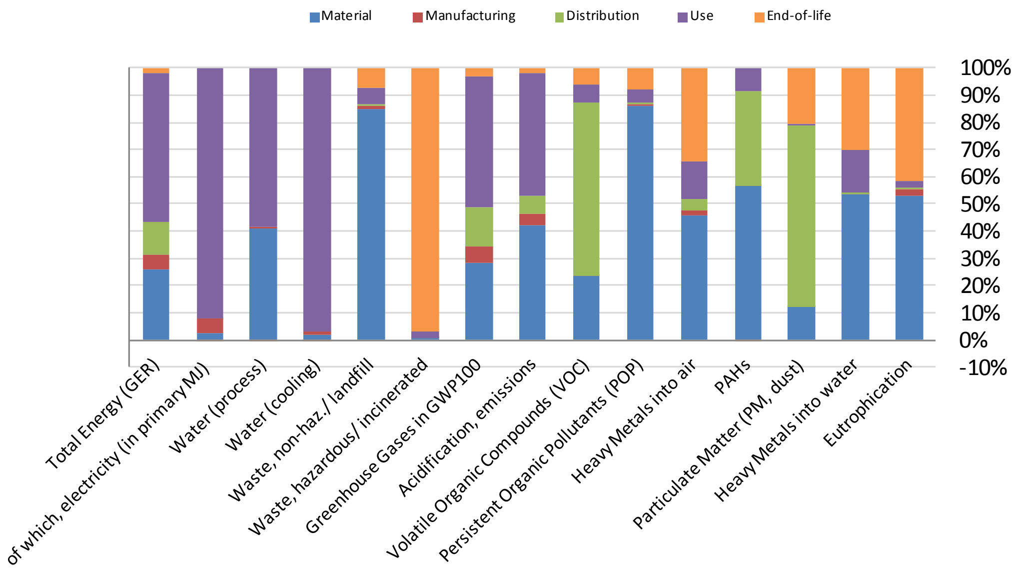

Figure 5-3: Distribution of the BC-3's environmental impacts by life cycle phase

The material acquisition phase, use phase and end-of-life phase are clearly the three predominant phases contributing to the environmental impacts of a centrifugal submersible once a day operation pump.

- The following 5 out of the 17 impacts related to the appliance's life cycle occur mostly during the material acquisition phase:
  - Waste, non hazardous/landfill 84.8%
  - POP 85.8%
  - PAHs 56.8%
  - Heavy metals into water 53.7%
  - Eutrophication 52.7%
- The following 4 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:
  - Total energy (GER) 54.8%
  - Electricity (in primary MJ) 92.2%
  - Water (process) 58.4%
  - Water (cooling) 97.0%

End-of-life phase also has a contribution of 96.7% to hazardous/ incinerated waste. The distribution phase contributes 66.4% to the particulate matter emissions to air.

5.3.4 BC-4: Centrifugal submersible domestic drainage pump < 40 mm passage

The Table 5.16 presents the contribution of each life cycle stage to the overall environmental impacts of centrifugal submersible domestic drainage pump <40mm passage.

Table 5.16: Life cycle impact (per unit) of BC-4: centrifugal submersible domestic drainage pump < 40 mm passage

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							**debit**	**credit**		
Total Energy (GER)	MJ	522	143	665	607	521	162	114	48	1 841
of which, electricity (in primary MJ)	MJ	30	86	115	1	516	0	1	-1	632
Water (process)	ltr	14	1	15	0	34	0	0	0	49
Water (cooling)	ltr	57	40	97	0	1 373	0	4	-4	1 466
Waste, non-haz./ landfill	g	30 019	475	30 494	278	901	883	3	881	32 555
Waste, hazardous/ incinerated	g	11	0	11	6	12	1 656	0	1 656	1 684
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO_2 eq.	27	8	35	37	23	12	8	4	99
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO_2 eq.	399	34	433	112	137	24	10	14	696
Volatile Organic Compounds (VOC)	g	1	0	1	10	0	0	0	0	12
Persistent Organic Pollutants (POP)	ng i-Teq	142	2	144	2	5	6	0	6	156
Heavy Metals	mg Ni eq.	78	5	83	14	10	44	0	44	151
PAHs	mg Ni eq.	27	0	27	25	1	0	0	0	53
Particulate Matter (PM, dust)	g	20	5	25	1 709	3	210	0	210	1 947
Emissions (Water)										
Heavy Metals	mg Hg/20	28	0	28	0	4	13	0	13	46
Eutrophication	g PO_4	1	0	1	0	0	1	0	1	1
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

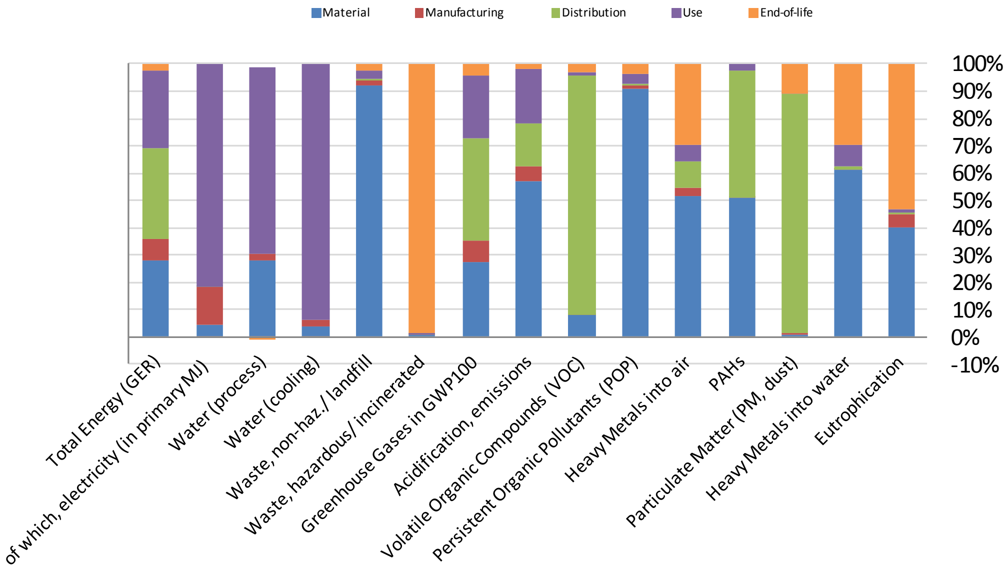

Figure 5-4: Distribution of the BC-4's environmental impacts by life cycle phase

The material acquisition phase, distribution and use phase are clearly the three predominant phases contributing to the environmental impacts of a centrifugal submersible domestic drainage pump <40mm passage.

- The following 5 out of the 17 impacts related to the appliance's life cycle occur mostly during the material acquisition phase:
  - Waste, non hazardous/landfill 92.2%
  - Acidification, emissions 57.3.6%
  - POP 90.7.2%
  - Heavy Metal into water 61.6%
  - Heavy Metal into air 51.6%
- The following 4 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:
  - Total Energy (GER) 28.3%
  - Electricity (in primary MJ) 81.6%
  - Water (process) 70.0%
  - Greenhouse Gases 23.0%

The distribution phase also has a contribution of 87.4% to VOC and the end-of-life phase contributes 54.1% to Eutrophication.

5.3.5 BC-5: Submersible dewatering pump

The Table 5.17 presents the contribution of each life cycle stage to the overall environmental impacts of submersible dewatering pumps.

Table 5.17: Life cycle impact (per unit) of BC-5: Submersible dewatering pump

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							**debit**	**credit**		
Total Energy (GER)	MJ	2 934	375	3 309	940	1 102 533	307	35	272	1 107 054
of which, electricity (in primary MJ)	MJ	91	224	315	2	1 102 503	0	0	0	1 102 820
Water (process)	ltr	44	3	48	0	73 500	0	0	0	73 548
Water (cooling)	ltr	41	104	145	0	2 940 001	0	1	-1	2 940 145
Waste, non-haz./ landfill	g	260 257	1 295	261 553	414	1 280 902	4 955	1	4 954	1 547 823
Waste, hazardous/ incinerated	g	12	0	13	8	25 405	450	0	450	25 876
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	180	21	201	57	48 114	23	2	20	48 392
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	3 678	90	3 768	172	283 931	45	3	42	287 913
Volatile Organic Compounds (VOC)	g	4	0	4	17	415	1	0	1	437
Persistent Organic Pollutants (POP)	ng i-Teq	896	9	905	2	7 235	34	0	34	8 177
Heavy Metals	mg Ni eq.	706	21	727	21	18 922	89	0	89	19 759
PAHs	mg Ni eq.	257	0	257	38	2 175	0	0	0	2 469
Particulate Matter (PM, dust)	g	223	14	236	2 735	6 066	399	0	399	9 436
Emissions (Water)										
Heavy Metals	mg Hg/20	209	0	209	1	7 111	26	0	26	7 346
Eutrophication	g PO4	3	0	3	0	34	1	0	1	39
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

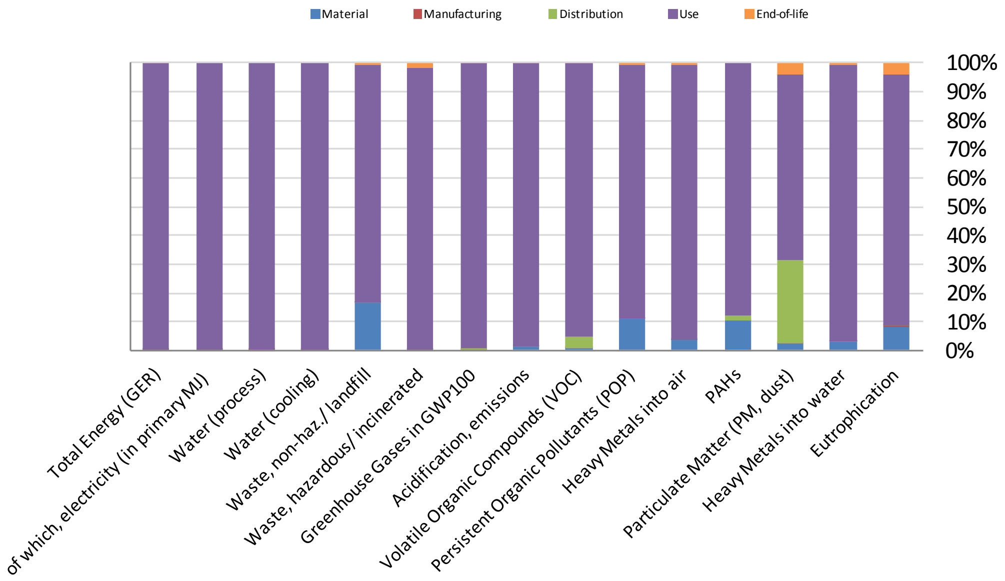

Figure 5-5: Distribution of the BC-5's environmental impacts by life cycle phase

The use phase is clearly the predominant phase contributing to the environmental impacts of a submersible dewatering pump. The following 15 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:

- Total energy (GER) 99.6%
- Electricity (in primary MJ) 100%
- Water (process) 99.9%
- Water (cooling) 100%
- Waste, non hazardous/landfill 82.8%
- Waste, hazardous/incinerated 98.2%
- Greenhouse gases in GWP100 99.4%
- Acidification, emissions 98.6%
- VOC 94.9%
- POP 88.5%
- Heavy metals into air 95.8%
- PAHs 88.1%
- Particulate matter (PM, dust) 64.3%
- Heavy metals into water 96.8%
- Eutrophication 87.8%

Results of the EcoReport modelling indicate that material acquisition phase has some minor contributions to generation of non-hazardous/landfill waste, POP, PAHs and eutrophication. While the end-of-life phase mostly impacts particulate matter and Eutrophication. On the other hand, the manufacturing phase contributes less than 1% of the overall environment impacts. The highest contribution from distribution phase is particulate matter emissions (29%).

5.3.6 BC-6: Centrifugal dry well pump

The Table 5.18 presents the contribution of each life cycle stage to the overall environmental impacts of centrifugal dry well pumps.

Table 5.18: Life cycle impact (per unit) of BC-6: Centrifugal Dry Well Pump

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							debit	credit		
Total Energy (GER)	MJ	1 932	346	2 277	1 051	1 969 540	783	384	399	1 973 268
of which, electricity (in primary MJ)	MJ	137	208	345	3	1 969 521	0	0	0	1 969 868
Water (process)	ltr	323	3	326	0	131 304	0	0	0	131 630
Water (cooling)	ltr	390	97	487	0	5 252 051	0	3	-3	5 252 536
Waste, non-haz./ landfill	g	40 753	1 121	41 874	460	2 283 962	12 675	2	12 673	2 338 969
Waste, hazardous/ incinerated	g	9	0	9	9	45 384	1 122	0	1 121	46 523
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	138	19	157	63	85 950	58	28	30	86 201
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	394	83	477	192	507 155	115	36	79	507 904
Volatile Organic Compounds (VOC)	g	12	0	12	19	742	3	0	3	775
Persistent Organic Pollutants (POP)	ng i-Teq	716	3	719	3	12 917	87	0	87	13 725
Heavy Metals	mg Ni eq.	211	7	218	23	33 792	227	0	227	34 260
PAHs	mg Ni eq.	2	0	2	42	3 880	0	0	0	3 924
Particulate Matter (PM, dust)	g	1 361	13	1 374	3 077	10 846	1 018	1	1 018	16 314
Emissions (Water)										
Heavy Metals	mg Hg/20	107	0	107	1	12 700	65	0	65	12 872
Eutrophication	g PO4	5	0	5	0	61	4	0	4	69
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

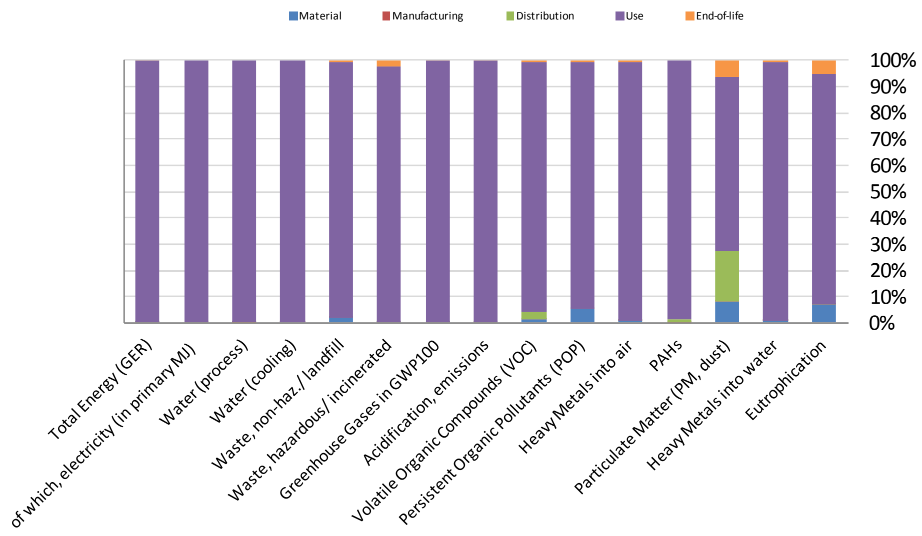

Figure 5-6: Distribution of the BC-6's environmental impacts by life cycle phase

The use phase is clearly the predominant phase contributing to the environmental impacts of a centrifugal dry well pump. The following 15 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:

- Total energy (GER) 99.8%
- Electricity (in primary MJ) 100%
- Water (process) 99.8%
- Water (cooling) 100%
- Waste, non hazardous/landfill 97.6%
- Waste, hazardous/incinerated 97.6%
- Greenhouse gases in GWP100 99.7%
- Acidification, emissions 99.9%
- VOC 95.7%
- POP 94.1%
- Heavy metals into air 98.6%
- PAHs 98.9%
- Particulate matter (PM, dust) 66.5%
- Heavy metals into water 98.7%
- Eutrophication 87.4%

Results of the EcoReport modelling indicates that material acquisition phase has some minor contributions to POP, particulate matter and eutrophication. The contribution of the manufacturing phase is less than 1% of the overall environment impacts. The highest contribution from distribution phase and end-of-life phase is particulate matter with 18.9% and 6.2% respectively.

5.3.7 BC-7A: Slurry pump – Light Duty

The Table 5.19 will present the contribution of each life cycle stage to the overall environmental impacts of slurry pumps with Light Duty

Table 5.19: Life cycle impact (per unit) of BC-7A: Slurry pump – Light Duty

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							debit	credit		
Total Energy (GER)	MJ	22 499	3 674	26 173	4 494	34 125 262	7 502	1 705	5 797	34 161 725
of which, electricity (in primary MJ)	MJ	7 016	2 195	9 211	11	34 125 092	0	0	0	34 134 315
Water (process)	ltr	5 831	32	5 864	0	2 275 059	0	0	0	2 280 922
Water (cooling)	ltr	2 243	1 018	3 261	0	91 000 033	0	0	0	91 003 293
Waste, non-haz./ landfill	g	461 032	12 568	473 600	1 866	39 570 737	134 606	0	134 606	40 180 809
Waste, hazardous/ incinerated	g	138	0	138	37	786 342	0	0	0	786 517
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	1 560	205	1 765	266	1 489 214	560	127	433	1 491 677
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO2 eq.	4 688	884	5 572	812	8 787 243	1 098	159	939	8 794 566
Volatile Organic Compounds (VOC)	g	94	1	95	83	12 853	31	2	29	13 060
Persistent Organic Pollutants (POP)	ng i-Teq	7 565	80	7 645	11	223 752	926	0	926	232 333
Heavy Metals	mg Ni eq.	1 831	187	2 018	95	585 476	2 196	0	2 196	589 785
PAHs	mg Ni eq.	19	0	19	179	67 227	0	0	0	67 424
Particulate Matter (PM, dust)	g	9 012	136	9 148	13 673	187 779	9 767	3	9 764	220 364
Emissions (Water)										
Heavy Metals	mg Hg/20	1 103	0	1 103	3	220 039	623	0	623	221 769
Eutrophication	g PO4	36	2	38	0	1 050	36	0	36	1 123
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

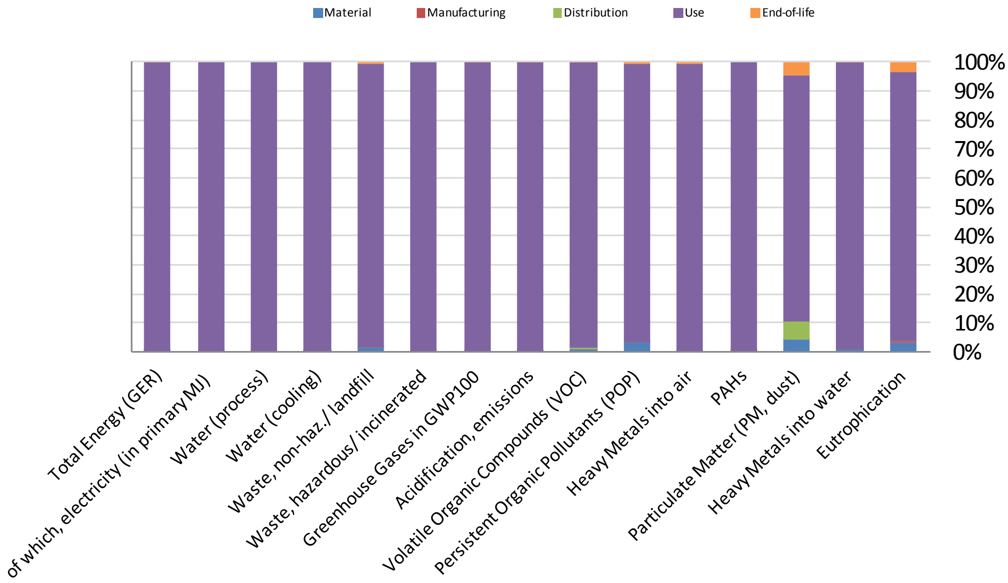

Figure 5-7: Distribution of the BC-7A's environmental impacts by life cycle phase

The use phase is clearly the predominant phase contributing to the environmental impacts of a centrifugal dry well pump. The following 15 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:

- Total energy (GER) 99.9%
- Electricity (in primary MJ) 100%
- Water (process) 99.7%
- Water (cooling) 100%
- Waste, non hazardous/landfill 98.5%
- Waste, hazardous/incinerated 100.0%
- Greenhouse gases in GWP100 99.8%
- Acidification, emissions 99.9%
- VOC 98.4%
- POP 96.3%
- Heavy metals into air 99.3%
- PAHs 99.7%
- Particulate matter (PM, dust) 85.2%
- Heavy metals into water 99.2%
- Eutrophication 93.4%

Results of the EcoReport modelling indicates that material acquisition phase has some minor contributions to POP, particulate matter and eutrophication. The contribution of the manufacturing phase is less than 1% of the overall environment impacts. The highest contribution from distribution phase and end-of-life phase is particulate matter with 6.2% and 4.4% respectively.

5.3.8 BC-7B: Slurry pump – Heavy Duty

The Table 5.19 will present the contribution of each life cycle stage to the overall environmental impacts of slurry pumps with Heavy Duty

Table 5.20: Life cycle impact (per unit) of BC-7B: Slurry pump – Heavy Duty

Life Cycle phases -->		Production			Distribution	Use	End of Life			Total
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							**debit**	**credit**		
Total Energy (GER)	MJ	64 621	14 550	79 171	4 494	15 540 792	32 396	1 432	30 963	15 655 421
of which, electricity (in primary MJ)	MJ	1 308	8 744	10 052	11	15 540 101	0	0	0	15 550 164
Water (process)	ltr	8 222	131	8 353	0	1 036 084	0	0	0	1 044 436
Water (cooling)	ltr	20 767	4 109	24 876	0	41 440 249	0	0	0	41 465 124
Waste, non-haz./ landfill	g	2 024 548	46 540	2 071 088	1 866	18 038 459	581 285	0	581 285	20 692 698
Waste, hazardous/ incinerated	g	6	0	6	37	358 087	0	0	0	358 130
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	6 458	808	7 266	266	678 230	2 418	107	2 311	688 073
Ozone Depletion, emissions	mg R-11 eq.					negligible				
Acidification, emissions	g SO2 eq.	19 457	3 486	22 942	812	4 001 779	4 742	134	4 608	4 030 141
Volatile Organic Compounds (VOC)	g	688	2	689	83	5 860	134	2	132	6 764
Persistent Organic Pollutants (POP)	ng i-Teq	37 503	72	37 575	11	102 234	3 999	0	3 999	143 818
Heavy Metals	mg Ni eq.	11 728	168	11 895	95	266 727	9 483	0	9 483	288 200
PAHs	mg Ni eq.	84	0	85	179	30 615	0	0	0	30 878
Particulate Matter (PM, dust)	g	79 796	537	80 334	13 673	86 273	42 178	2	42 176	222 455
Emissions (Water)										
Heavy Metals	mg Hg/20	5 629	0	5 629	3	100 254	2 692	0	2 692	108 578
Eutrophication	g PO4	168	8	176	0	480	154	0	154	809
Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

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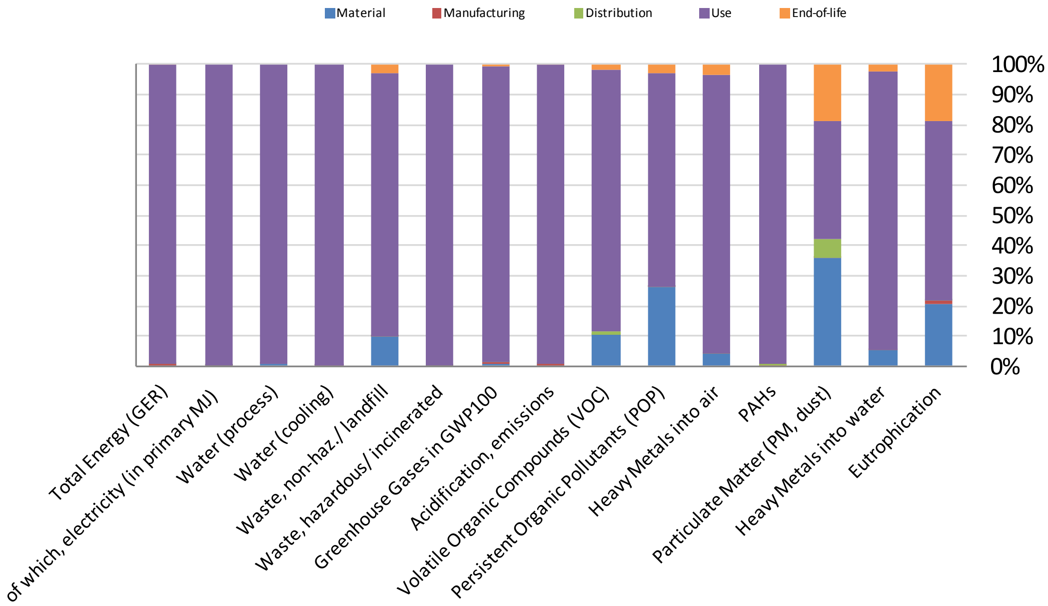

Figure 5-8: Distribution of the BC-7B's environmental impacts by life cycle phase

The use phase is clearly the predominant phase contributing to the environmental impacts of a centrifugal dry well pump. The following 15 out of the 17 impacts related to the appliance's life cycle occur mostly during the use phase:

Total energy (GER)	99.3%
Electricity (in primary MJ)	99.9%
Water (process)	99.2%
Water (cooling)	99.9%
Waste, non hazardous/landfill	87.2%
Waste, hazardous/incinerated	100.0%
Greenhouse gases in GWP100	98.6%
Acidification, emissions	99.3%
VOC	86.6%
POP	71.1%
Heavy metals into air	92.5%
PAHs	99.1%
Particulate matter (PM, dust)	38.8%
Heavy metals into water	92.3%
Eutrophication	59.2%

Results of the EcoReport modelling indicates that material acquisition phase has some contributions to POP, particulate matter and eutrophication with 26.1%, 35.9% and 20.7% respectively. The contribution of the manufacturing phase is less than 1% of the overall environment impacts. The highest contribution from distribution phase and end-of-life phase is particulate matter with 6.1% and 19% respectively.

5.4 Base-case life cycle costs

This section presents the results of the Life Cycle Cost (LCC) analysis of the Base-Cases using the EcoReport tool. In this analysis, all the consumer expenditures throughout the life of the product are considered which include:

- Average purchase cost of the Bases-Cases of the Base-Cases (in Euro)
- Average installation costs, if any (in Euro)
- Average repair and maintenance costs, if any (in Euro)
- Average electricity rates (Euro Cent/kWh)
- Average lifetime of the Base-Case (in years)
- Average annual energy consumption including on-mode, standby and off-mode (in kWh)

This analysis will serve to compare the total expenditure of the different design options identified for each Base-Case.

The life cycle costs are calculated as follows:

$$LCC = PP + PWF * OE$$

Where PP is the purchase and installation price, OE is the operating expense and PWF is the present worth factor, calculated as follows:

$$PWF = \frac{1 - \frac{1}{(1+r)^N}}{r}$$

Where N is the product life in years and r is the discount rate.

Table 5.21: EcoReport outcomes of the LCC calculations for all the Base cases

	BC-1		BC-2		BC-3		BC-4		BC-5		BC-6		BC-7A		BC-7B	
	[€]	%	[€]	%	[€]	%	[€]	%	[€]	%	[€]	%	[€]	%	[€]	%
Product price	3 373	*18%*	15 000	*8%*	1 617	*42%*	300	66%	5 000	*28%*	3 433	*12%*	20 000	*7%*	20 000	*14%*
Installation/ acquisition costs (if any)	1 434	*8%*	3 750	*2%*	1 133	*29%*	150	33%	250	*1%*	1 563	*5%*	5 000	*2%*	5 000	*3%*
Electricity	7 112	*39%*	156 135	*86%*	33	*1%*	5	1%	9 368	*51%*	15 294	*52%*	223 396	*83%*	101 731	*69%*
Repair & maintenance costs	6 347	*35%*	7 705	*4%*	1 094	*28%*	0	0%	3 751	*20%*	8 970	*31%*	19 918	*8%*	19 918	*14%*
Total	**18 266**	***100%***	**182 590**	***100%***	**3 877**	***100%***	**455**	**100%**	**18 369**	***100%***	**29 258**	***100%***	**268 314**	***100%***	**127 528**	***100%***

There are similarities between BC-1, BC-2, BC-5, BC-6, BC-7A and BC-7B concerning the life cycle cost. The cost of energy consumption in use phase is the main life cycle cost for these base cases (more than 50% of LCC). The gains in energy efficiency of these pumps may therefore significantly reduce the LCC. For BC-3 and BC-4, the product price has the major contribution to the LCC. These pumps have lower annual operation hours, thus the amount of energy consumed by them is not as significant as the other group of pumps.

5.5 EU Totals

In this section the environmental impact data and the Life Cycle Cost data are aggregated at the EU-27 level using stock and market data from Task 2. It is assumed that the entire installed stock in the EU-27 in 2011 is represented by the Base-Cases.

5.5.1 Life-cycle environmental impact at EU-27 level

The aggregated results of the environmental impact per year of the EU stock of products are presented in Table 5.22. The total primary energy consumption per year of the stock of each of the 8 Base-Cases in 2011 in the EU-27 varies significantly depending on the BC, between 1 PJ and 111 PJ.

BC-1 has the highest contribution to the overall environmental impacts at the EU level. BC 1 represents more than 50% of both the overall energy consumption and the overall greenhouse gas emissions. This is due to the large number of centrifugal submersible radial sewage pumps for 1 to 160 kW installed in EU and the annual energy consumption of the pumps is high.

Table 5.22: EU-27 total impact of the installed stock (2011) of the Base-Cases

Life Cycle phases -->		BC-1	BC-2	BC-3	BC-4	BC-5	BC-6	BC-7A	BC-7B	TOTAL
Other Resources & Waste										
Total Energy (GER)	PJ	111	9	1	3	31	27	82	9	273
of which, electricity (in primary MJ)	PJ	110	9	1	1	31	26	82	9	269
Water (process)	mln. m3	7	1	0.1	0.1	2	2	5	1	18
Water (cooling)	mln. m3	292	24	2	3	82	71	218	25	717
Waste, non-haz./ landfill	kt	166	11	20	49	47	35	96	12	434
Waste, hazardous/ incinerated	kt	3	0.2	1	3	1	1	2	0.2	10
Emissions (Air)										
Greenhouse Gases in GWP100	mt CO2 eq.	5	0.4	0.1	0.2	1	1	4	0.4	12
Ozone Depletion, emissions	t R-11 eq.	negligible								
Acidification, emissions	kt SO2 eq.	29	2.3	0.5	1.1	8	7	21	2,4	71
Volatile Organic Compounds (VOC)	kt	0.05	0.003	0.01	0.02	0.01	0.01	0	0.004	0.1
Persistent Organic Pollutants (POP)	g i-Teq	1	0.1	0.1	0.2	0.2	0.2	1	0.1	2
Heavy Metals	ton Ni eq.	2	0.2	0.1	0.2	1	0.5	1	0.2	5
PAHs	ton Ni eq.	0.2	0.02	0.02	0.1	0.1	0.1	0.2	0.02	1
Particulate Matter (PM, dust)	kt	1	0.1	0.8	2.9	0.3	1	0.5	0.1	7
Emissions (Water)										
Heavy Metals	ton Hg/20	1	0.1	0.04	0.1	0.2	0.2	1	0.06	2
Eutrophication	kt PO4	0.01	0.0003	0.001	0.002	0.001	0.001	0.003	0.0004	0.01
Persistent Organic Pollutants (POP)	g i-Teq	negligible								

5.5.2 Life-cycle costs at EU-27 level

The aggregated results of the annual consumer expenditure per Base-Case in the EU-27 based on the year 2011 are presented in Table 5.23. This represents the total expenditure at EU level per year, assuming that the Base-Cases represent the entire installed stock in the EU-27.

The product price, electricity cost and repair and maintenance are the predominant aspects of the total annual consumer expenditure at the EU-27 with 25%, 40% and 24% respectively. These results also indicate that the assessment of the energy efficiency of these pumps is essential.

Table 5.23: EU-27 total annual consumer expenditure (2011)

	BC-1	BC-2	BC-3	BC-4	BC-5	BC-6	BC-7A	BC-7B	TOTAL EU-27	Share of the annual consumer expenditure by item
Product price (€)	597	11	380	450	200	89	30	6	**1 763**	*25%*
Installation/ acquisition costs (if any) (€)	254	3	266	225	10	41	8	2	**809**	*11%*
Electricity (€)	1 149	94	8	9	323	277	858	98	**2 816**	*40%*
Repair & maintenance costs (€)	1 025	5	256	0	130	163	77	19	**1 675**	*24%*
Total (€)	**3 025**	**113**	**910**	**684**	**663**	**570**	**973**	**125**	**7 063**	***100%***
Share of the annual consumer expenditure by BC	43%	2%	13%	9%	9%	8%	14%	2%	100%	

5.5.3 EU-27 total system impact

In this section, the total environmental impacts calculated for the base-cases at EU-27 level are compared with other results from similar studies. The annual primary energy consumption of the stock of all pumps covered within the ENER Lot 28 preparatory study is around 273 PJ (76.4 TWh).

From Table 5.23 above, it is evident that the energy consumption of ENER Lot 28 pumps is around 18.2% that of ENER Lot 11 pumps. ENER Lot 28 pumps contribute 18.2% to the environmental impacts on the energy consumptions, emissions of CO_2 and of SO_2 per year.

5.6 Conclusions

Task 5 report analysed the environmental impacts and economic costs of the likely eight Base-Cases most relevant for proposing Ecodesign requirements for ENER Lot 28 pumps. The selection of Base-Cases and subsequent analysis was based upon the market analysis presented in Task 2, the consumer behaviour and existing infrastructure described in Task 3 and the technical analysis of products carried out in Task 4. The Base-Cases were constructed as an "abstraction" of the average product in the EU market representing the wide range of products considered in this ENER Lot 28 preparatory study. These Base-Cases are used to estimate the environmental impacts of ENER Lot 28 pump in the EU.

The combined energy consumption of the installed stock of all Base-Cases is around 273 PJ/year (75.8 TWh/year). Based on the environmental impact assessment carried out in this chapter using the EcoReport tool, some general findings are observed for all the ENER Lot 28 pumps such as:

- The use phase is the most dominant phase of the entire life cycle in the contribution to the environmental impacts.
- The material acquisition phase is also a dominant phase especially for BC-3 and BC-4 in terms of non-hazardous/landfill waste generation, POPs, PAHs, particulate matter and Eutrophication.
- The manufacturing phase generally has minor contributions to the overall environment impacts compared to other phases.
- Distribution phase contributes noticeable impacts to the indicators such as particulate matter, volatile organic compounds and PAHs.
- The end-of-life phase has significant contribution to the indicators such as hazardous/incinerated waste generation, heavy metal in air and water, particulate matter and eutrophication.

It must however be noted that the distribution of the environmental impacts varies considerably across the analysed Base-Cases. For example, more than 90% of contribution to environmental indicators is due to the use phase for some Base-Cases (BC-1, BC-2, BC-5, BC-6, BC-7A and BC-7B), while for other Base-Cases (BC-3 and BC-4), the use phase and the material acquisition phase have similar contributions (even if distributed differently over the indicators). This is primarily due to the influence of the factors such as the weight of the appliance, its lifespan and its power output.

The environmental and economic analysis of the Base-Cases will serve as point of reference when evaluating the possible improvement potentials in Task 6 and the design options in Task 7.

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