Preparatory Studies for Eco-design Requirements of Energy-using Products

Lot 24: Professional Dishwashers, Washing Machines and Dryers

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Part: Washing Machines and Dryers

Task 5: Definition of Base Case

Öko-Institut e.V.
Institute for Applied Ecology, Germany
Kathrin Graulich
Markus Blepp
Eva Brommer
Carl-Otto Gensch
Ina Rüdenauer

BIO Intelligence Service, France
Shailendra Mudgal
Raul Cervantes
Thibault Faninger
Lorcan Lyons

Öko-Institut e.V.
Freiburg Head Office
P.O. Box 17 71
79017 Freiburg, Germany
Street Address
Merzhauser Str. 173
79100 Freiburg, Germany
Tel. +49 (0) 761 – 4 52 95-0
Fax +49 (0) 761 – 4 52 95-88

Darmstadt Office
Rheinstr. 95
64295 Darmstadt, Germany
Tel. +49 (0) 6151 – 81 91-0
Fax +49 (0) 6151 – 81 91-33

Berlin Office
Schicklerstr. 10
10179 Berlin, Germany
Tel. +49 (0) 30 – 40 50 85-0
Fax +49 (0) 30 – 40 50 85-388

For reasons of better readability, two Task 5 reports were prepared.

The report at hand covers ***professional washing machines and dryers***.

The Task 5 report on *professional dishwashers*
is published separately.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective of Task 5

In the eco-design methodology, one or two average product(s) or a representative product category are defined as the "base cases" (BCs) for the whole of the EU. Most of the environmental and Life Cycle Cost analyses will be built on these BCs throughout the rest of the study. The base case is a conscious abstraction of reality, but a necessary one for practical reasons (budget, time). Having said that, the question of whether this abstraction leads to inadmissible conclusions for certain market segments will be addressed in the impact and sensitivity analyses.

In principle, the aim of a BC assessment is to quantify the environmental impacts of a service or product throughout its life. This includes the phases from the extraction of the materials contained within its components to the disposal of these materials at the end-of-life. The method used to develop these impacts is the Life Cycle Assessment (LCA).

First, all incoming and outgoing flows of materials and energy are detailed for each phase of the life cycle (manufacturing and design, transport, use, end-of-life). Figure 1 shows an example of how materials and energy flows are summarised for a simplified LCA.

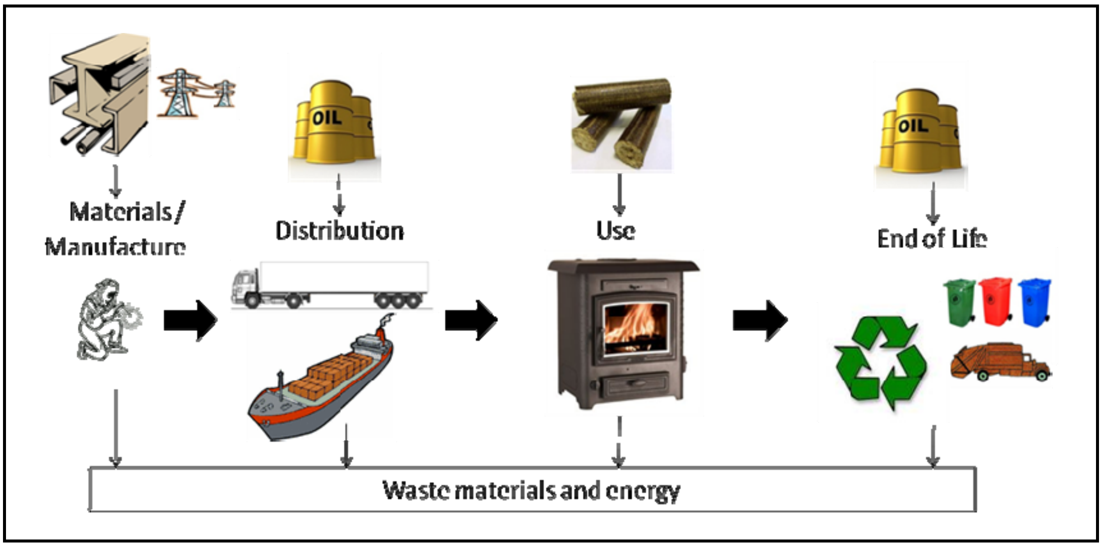

Figure 1 Simplified material flow diagram for LCA

These material and energy flows are then aggregated over the lifetime of the product to compute total environmental impacts. These environmental impacts can be expressed in many different ways, but are expressed in this study with 17 environmental indicators that were predefined for all Eco-design studies. These indicators will be described in more detail later in the report. As the results are presented through several indicators of environmental impact, LCA is a multi-criteria approach.

The benefit of the LCA approach is that one can understand all the resources consumed, as well as all the environmental side effects caused by a product. The drawback of this approach is that each product on a market has a different life cycle and it can be difficult to determine the net environmental impact of an entire market or of a range of product groups. To help overcome this problem, BCs are created to represent a theoretical approximation of the 'average' products on the EU market and use these to extrapolate the environmental impacts of the entire market of professional washing machines and dryers.

While this study has been completed as comprehensively and accurately as possible, it relies on data that have been extrapolated from the literature and stakeholder inputs. The performance of real appliances can vary substantially from the data provided in this report. This is understood and mitigated as much as possible while manipulating and calculating the data during the analysis, however rough approximations are ultimately unavoidable. When assumptions are made, it is also important to assess and check their influence on the final results. Thus, some parameters might have negligible impacts on the overall results so that assumptions can be easily accepted. If that is not the case, the sensitivity analysis in Task 8 will ensure the consistency of the results by studying the influence of the most important parameters. The results of the study are valuable as they represent the best indication to date of the environmental impacts of professional laundry appliances in the EU.

The description of the BCs is the synthesis of the results of Tasks 1 to 4. Most of the environmental and Life Cycle Cost (LCC) analyses are built on these BCs throughout the rest of the study and it serves as the point of reference for Task 6 (technical analysis of Best Available Technology), Task 7 (improvement potential), and Task 8 (policy, impact and sensitivity analysis).

2 Product-specific inputs

This section describes the technical analysis of typical professional laundry appliances which exist on the EU market. This data will cover the production phase, the distribution phase, the use phase and the end-of-life phase. Bill of materials (BOM) and resource consumption during product life are some of the important parameters to be looked at.[1] These parameters will be used as the general input for the base case environmental impact assessment, in Section 3.

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[1] Necessary input into EuP EcoReport.

2.1 Definition of base cases

The objective of this subsection is to define and describe the BCs, based on the previous tasks and the information gathered from the stakeholders and the literature review. The BCs are "a conscious abstraction of reality" and have to cover the wide variety of existing professional laundry machines in order to be representative of the EU market as much as possible. Thus, BCs are not necessarily representative of real products. When two products have a similar BOM, technology and efficiency, they may be represented by a single BC. The number of BCs is optimised to be small enough to enable a simplified analysis of the market, but large enough to deal with the technological spectrum of professional washing machines and dryers.

Although the MEEuP methodology foresees one or two BCs to cover the entire EU market for the products considered in each preparatory study, this study uses 14 BCs for the laundry appliances. Such a high number of BCs is necessary to adequately cover the broad range of technical specifications and functionalities of professional laundry machines. Table 1 and Table 2 give an overview of the 14 BCs, which are products that have already been presented in the previous tasks.

Table 1 Description of the professional washing machines BCs

Base case	Name	Typical market segment	Short description	Typical capacity per cycle (kg)	Nominal annual capacity (kg)
WM1	Semi-professional washer extractor	Coin & Card, Apartment Household Laundry	These machines have a maximum loading capacity of 7 kg per cycle. They might be used by professional and non-professional users. They can be front-, side- or top-loaded. The cleaning mechanism is determined by the drum rotation movement.	6	7 000
WM2	Professional washer extractor, <15 kg	Coin & Card, Apartment Household Laundry	This category presents a maximum capacity of 15 kg per cycle. They can be loaded from the front or side, and they present more heating options than category WM1 (e.g. gas, indirect heat system, etc.). The liquor tank is fixed to the door. The drum will be equipped with lifting vanes. They present reversing rotation mechanism.	10	14 400
WM3	Professional washer extractor, 15–40 kg	Hospitality	This category presents capacity of 15 to 40 kg per cycle. They can be loaded from the front or side, and they present more heating options than category WM1 (e.g. gas, indirect heat system, etc.). The liquor tank is fixed to the door. The drum is equipped with lifting vanes. They present reversing rotation mechanism.	24	42 200

Base case	Name	Typical market segment	Short description	Typical capacity per cycle (kg)	Nominal annual capacity (kg)
WM4	Professional washer extractor, >40 kg	Commercial Industrial Laundry	This category presents capacities beyond of 40 kg per cycle. They can be loaded from the front or side, and they present more heating options than category WM1 (e.g. gas, indirect heat system, etc.). The liquor tank is fixed to the door. The drum is equipped with lifting vanes. They present a reversing rotation mechanism.	90	194 400
WM5	Professional washer dryer	Hospitality	The washing and drying processes are made in the same machine. They are compact and can be connected to sinks. They present temperature controls, customisable cycle controls, and ventless systems.	6	7 400
WM6	Professional barrier Washer	Healthcare	Used in sanitisation, they present an input and an output door. These two ends of the machine are separated by a physical barrier, i.e. a wall. This feature avoids contact between the soiled and clean laundry.	32	56 300
WM7	Washing tunnel machine	Commercial Industrial Laundry	This machine can be represented by a tunnel with different sections for each sub-process of the laundry cleaning (pre-wash, main wash, rinse, after treatment and extraction). The process is continuous. The laundry flow within the machine can be either by oscillating drum movement or rotating drum movement.	1 500 (kg/hour)	3 825 000

Table 2 Description of the professional laundry dryers BCs

Base case	Name	Typical market segment	Short description	Typical capacity per cycle (kg)	Nominal annual capacity (kg)
D1	Semi-professional dryer, condenser	Coin & Card, Apartment Household Laundry	In these machines, heated air passes through the load. The humid air is dried by condensation afterwards. The condensation can be via water or air processes. This improves the heat use, keeping it as much as possible within the unit. These machines are equipped with rotating drums.	6	6 500
D2	Semi-professional dryer, air vented	Coin & Card, Apartment Household Laundry	Similarly to BC D1, in this type of machine a current of heated air passes through the load. However, in this case the humid air is exhausted using ventilation ducts.	6	6 500

Base case	Name	Typical market segment	Short description	Typical capacity per cycle (kg)	Nominal annual capacity (kg)
D3	Professional cabinet dryer	Coin & Card, Apartment Household Laundry	This machine uses hangers to hold the clothing during the drying process. This is useful not only for delicate clothes, but for loads that need to be dried without being previously washed.	8	6 300
D4	Professional tumble dryer, <15 kg	Coin & Card, Apartment Household Laundry	Similar to BC D1 and BC D2, in this type of machine a current of heated air passes through the load. In this case the humid air is exhausted using ventilation ducts and the electrical heating source is replaced by gas burners or heat exchangers. The capacity of this category is less than 15 kg.	10	14 400
D5	Professional tumble dryer, 15–40 kg	Hospitality	Similar to BC D1 and BC D2, in this type of machine a current of heated air passes through the load. In this case the humid air is exhausted using ventilation ducts and the electrical heating source is replaced by gas burners or heat exchangers. The capacity of this category is between 15 anD40 kg.	23	40 500
D6	Professional tumble dryer, >40 kg	Commercial Industrial Laundry	Similar to BC D1 and BC D2, in this type of machine a current of heated air passes through the load. In this case the humid air is exhausted using ventilation ducts and the electrical heating source is replaced by gas burners or heat exchangers. The capacity of this category is greater than 40 kg.	70	168 000
D7	Pass-through (transfer) tumble dryer	Commercial Industrial Laundry	These dryers have the loading and unloading on opposite ends, and capacities ranging from 40 to 240 kg. They can be electric-, steam-, gas- or heat-exchanger equipped. They have controllers for the temperature and heat recovery, among other features.	400 (kg/hour)	1 020 000

2.2 Inputs in the production phase

Production phase data related to typical EU professional washing machines and dryers consists of the OMs and the sheetmetal scrap generated during production. The BOM for each category was already presented in Task 4. In Table 3 and Table 4, the BOM is presented according to the different categories of materials (e.g. bulk plastics, ferrous materials)[2] and packaging material is included.

[2] The full composition can be found in Annex.

Table 3 Composition of the seven professional washing machine BCs, by category of materials

Base case	Unit	1 Bulk Plastics	2 Tech. Plastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7 Misc.	Total
WM1	g	12 977	544	32 362	5 398	0	165	25 143	76 589
	%	16.9%	0.7%	42.3%	7.0%	0.0%	0.2%	32.8%	100.0%
WM2	g	8 650	1 050	176 820	18 030	0	4 300	20 100	228 950
	%	3.8%	0.5%	77.2%	7.9%	0.0%	1.9%	8.8%	100.0%
WM3	g	24 400	3 600	472 400	79 900	0	18 200	56 400	654 900
	%	3.7%	0.5%	72.1%	12.2%	0.0%	2.8%	8.6%	100.0%
WM4	g	94 200	13 800	1 794 000	303 600	0	69 000	232 900	2 507 500
	%	3.8%	0.6%	71.5%	12.1%	0.0%	2.8%	9.3%	100.0%
WM5	g	9 904	0	332 340	30 560	0	10 696	23 500	407 000
	%	2.4%	0.0%	81.7%	7.5%	0.0%	2.6%	5.8%	100.0%
WM6	g	73 100	20 100	742 500	100 400	0	60 200	78 000	1 074 300
	%	6.8%	1.9%	69.1%	9.3%	0.0%	5.6%	7.3%	100.0%
WM7	g	360 000	0	11 400 000	0	0	120 000	0	11 880 000
	%	3.0%	0.0%	96.0%	0.0%	0.0%	1.0%	0.0%	100.0%

Table 4 Composition of the 7 professional dryers BCs, by category of materials

Base case	Unit	1 Bulk Plastics	2 Tech. Plastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7 Misc.	Total
D1	g	13 534	1 000	40 500	3 500	0	1 900	6 566	67 000
	%	20.2%	1.5%	60.4%	5.2%	0.0%	2.8%	9.8%	100.0%
D2	g	11 965	1 000	39 100	3 500	0	1 800	4 635	62 000
	%	19.3%	1.6%	63.1%	5.6%	0.0%	2.9%	7.5%	100.0%
D3	g	4 555	0	120 350	14 500	0	3 045	29 550	37 150
	%	12.3%	0.0%	69.9%	8.4%	0.0%	8.2%	79.5%	100.0%
D4	g	6 250	0	131 580	9 180	0	4 600	15 890	26 740
	%	23.4%	0.0%	78.6%	5.5%	0.0%	17.2%	59.4%	100.0%
D5	g	13 900	0	299 300	20 850	0	10 400	30 350	54 650
	%	25.4%	0.0%	79.9%	5.6%	0.0%	19.0%	55.5%	100.0%
D6	g	26 100	0	640 700	44 700	0	22 350	0	48 450
	%	53.9%	0.0%	86.0%	6.0%	0.0%	46.1%	0.0%	100.0%
D7	g	9 975	0	2 849 850	66 50	0	3 325	0	2 869 800
	%	0.3%	0.0%	99.3%	0.2%	0.0%	0.1%	0.0%	100.0%

All professional washing machines base cases, except WM1, have at least 70% of ferrous materials in their BOMs. For the case of professional laundry dryers, this ferrous material share is at least 60%. It is expected that the impacts of the production and manufacturing phases will be mainly due to this category of materials.

Because the EcoReport was initially designed as a simple and generic tool for eco-design preparatory studies, its database does not include some materials found in professional laundry machines. These are:

- polybutylene terephthalate (PBT);
- ethylene propylene diene monomer (EPDM) rubber;
- polyoxymethylene (POM);
- PE foil;
- glass;
- chromium;
- wood.

When possible, the materials not presented in the database have been re-allocated to the most similar materials available in the tool:

- EPDM rubber was considered as low density polyethylene (LDPE);
- PE foil as LDPE;
- other plastics as HDPE;
- glass as glass for lamps;
- POM as high density polyethylene (HDPE); and
- wood as cardboard.

These equivalent materials were determined based on the composition of the initial materials ("closest" material available in EcoReport): for instance, EPDM is usually made of around 60% of LDPE. The choices were also supported by preliminary environmental analysis (see Table 5, all results were obtained using the method CML 2 baseline 2000 V2.04). EPDM and LDPE on one hand have very close environmental impacts for most of the indicators. POM was not found in any life cycle inventory and could thus not be compared to HDPE. Cardboard has impacts around twice as more important as wood impacts but this approximation is considered acceptable as soon as packaging is not identified as a major contributor to any type of environmental impact in the base cases analysis.

Table 5 Life cycle impact assessment of missing individual components (part 1), for 1 kg[3]

Impact category	Unit	EPDM rubber	LDPE	Wood	Cardboard
Abiotic depletion	kg Sb eq	4.33E-02	4.16E-02	3.37E-03	5.71E-03
Acidification	kg SO_2 eq	2.91E-02	2.74E-02	3.43E-03	7.29E-03
Eutrophication	kg PO_4^{3-} eq	1.32E-03	1.02E-03	2.71E-04	6.77E-04
Global warming (GWP100)	kg CO_2 eq	3.24E+00	3.07E+00	-2.41E+00	-1.05E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	7.94E-06	8.32E-06	2.88E-07	6.79E-07
Photochemical oxidation	kg C_2H_4	1.07E-02	3.92E-03	2.71E-04	3.53E-04

No equivalent materials were found for chromium and PBT so only the ‘category’ cell (e.g. bulk plastics, ferrous material) and the weight were completed for these materials. Consequently, the specific impacts due to the nature of the material are not taken into account for these two categories but their weight is nonetheless included in the environmental analysis. This assumption is considered as acceptable since these materials are only found in BC WM1 and the share of these material categories in the total weight of the washing machine is very low (2% altogether).

A preliminary environmental analysis supports this assumption, by showing that these two materials have impacts in the same order of magnitude as (or smaller than) stainless steel (which represents around 25% of the mass of BC WM1), which justifies the fact that these materials are neglected based on the low mass allocated to them (see Table 6, all results were obtained using the method CML 2 baseline 2000 V2.04). Only for the ozone layer depletion indicator, the two materials have much higher impacts than stainless steel but this indicator is not taken into account in EcoReport. PBT was not found in any life cycle inventory so that it was assumed that the impacts of PBT were similar to the ones of PET, to compare with the stainless steel.

[3] All materials from ETH-ESU 96 database.

Table 6 Life cycle impact assessment of missing individual components (part 2), for 1 kg[4]

Impact category	Unit	Stainless steel	PET	Chromium
Abiotic depletion	kg Sb eq	2.35E-02	3.46E-02	1.92E-01
Acidification	kg SO_2 eq	1.68E-01	9.77E-03	1.02E-01
Eutrophication	kg PO_4 eq	1.22E-03	3.00E-03	7.83E-03
Global warming (GWP100)	kg CO_2 eq	3.68E+00	2.73E+00	2.65E+01
Ozone layer depletion (ODP)	kg CFC-11 eq	5.26E-09	1.21E-07	1.85E-06
Photochemical oxidation	kg C_2H_4	7.22E-03	6.23E-04	5.54E-03

Regarding the sheetmetal scrap percentage generated during the production phase, a rate of **5%** has been assumed, based on manufacturers' feedback and information contained in the preparatory study on washing machines and dishwashers (Lot 14).

2.3 Inputs in the distribution phase

Input data related to the distribution phase of the product to be used in the MEEuP EcoReport calculations are based on the volume of the packaged product. These volumes are exposed in Table 7 and Table 8 below.

Table 7 Volume of packaged product for washing machines base cases

Base case	Volume of packaged product (in m^3)
WM1 Semi-professional washer extractor	0.95
WM2 Professional washer extractor, <15 kg	1.04
WM3 Professional washer extractor, 15-40 kg	2.22
WM4 Professional washer extractor, >40 kg	6.15
WM5 Professional washer dryer	2.02
WM6 Professional barrier washer	5.04
WM7 Washing tunnel machine	16.58

Shown values correspond to average of values as presented in Task 4

[4] All materials from EcoInvent 2.0 database.

Table 8 Volume of packaged product for dryers base cases

Base case	Volume of packaged product (in m^3)
D1 Semi-professional dryer, condenser	0.53
D2 Semi-professional dryer, air-vented	0.53
D3 Professional cabinet dryer	1.76
D4 Professional tumble dryer, <15 kg	1.52
D5 Professional tumble dryer, 15-40 kg	2.58
D6 Professional tumble dryer, >40 kg	5.75
D7 Pass-trough (transfer) tumble dryer	13.00

Shown values correspond to average of values as presented in Task 4

Two other pieces of information are required in this section. These parameters will be common for all base cases:

- Is it an ICT or Consumer Electronics product <15 kg: **No**
- Is it an installed appliance: **Yes**

2.4 Inputs in the use phase

Task 3 has shown that products have different resource consumption and functional performance whether ideal user behaviour or real-life user behaviour is considered. No standard is commonly applied in Europe to measure the energy, water, and detergent consumption of professional laundry machines (cf. Task 1 report). The analysis of the environmental impacts of the use phase is based on the real-life consumption of energy, water and detergent in each category. In addition to the ideal use, the data includes the additional consumption through partial workload, maloperation (e.g. deviation from the use of the standard programs) and the standby consumption in low-power modes (see Task 4).

As presented in Task 3, there can be different energy sources to heat the water or the air for a same product category. Washing machines can use electricity, internal gas heating, internal steam heating or can be supplied (partly or fully) with warm water, in which case the heating happens outside the machine (different energy options also available). In the case of dryers, the possible options are electricity, internal gas heating or internal steam heating. The shares of the different heating options in machines sold today are presented per BC in Table 9 and Table 10.

Table 9 Heating options used for water heating in new professional washing machines

Washing machine category	**Internal heating, Electricity (%)**	**Internal heating, Natural gas (%)**	**Internal heating, Steam (or thermo oil) (%)**	**External heating (warm water input), any source (gas, fuel, etc.) (%)**
WM1: Semi-professional washer extractor	60	0	<5	35
WM2: Professional washer extractor, <15 kg	55	<2	8	35
WM3: Professional washer extractor, 15-40 kg	40	15	25	20
WM4: Professional washer extractor, >40 kg	15	18	60	7
WM5: Professional washer dryer	100	0	0	0
WM6: Professional barrier washer	25	10	45	20
WM7: Washing tunnel machine	0	5	95	0

Table 10 Heating options used for air heating in new professional dryers

Dryer category	**Internal heating, Electricity (%)**	**Internal heating, Natural gas (%)**	**Internal heating, Steam (or thermo oil) (%)**
D1: Semi-professional dryer, condenser	100	0	0
D2: Semi-professional dryer, air vented	65	35	0
D3: Professional Cabinet dryer	100	0	0
D4: Professional tumble dryer, <15 kg	45	50	5
D5: Professional tumble dryer, 15-40 kg	30	45	25
D6: Professional tumble dryer, >40 kg	10	50	40
D7: Pass-trough (transfer) tumble dryer	0	65	35

The EcoReport Tool enables energy consumption to be split between electricity and heat input. However, a single energy source (gas, oil, wood pellets, etc.) has to be selected for the heat input, along with single process efficiency. Consequently, for simplicity reasons, the options internal heating with gas, internal heating with steam and external heating will be modelled together in the case of washing machines, by a gas heating process (atmospheric) with an efficiency of 90% (Lower Heating Value). This was determined as an average EU situation with the support of experts of Lot 24, part: dishwasher, in the case of warm water supply (the external boiler used to heat externally the water is estimated to be an atmospheric gas boiler). As customers from professional dishwashers and laundry appliances belong to similar market segments (e.g. hotels and catering sector), the same assumption will be used for the washing machines and dryers. The internal gas heating may be a bit more efficient than the internal steam heating (which necessitates firstly the external heating of the steam) or the warm water supply options, as these options are subject to additional energy losses during the transport of the warm water or the steam through pipes. However, the efficiency difference between these three options is estimated much less important than the difference between their “average” model efficiency (90%, gas atmospheric) and the efficiency of electric heating. For dryers, the same reasoning applies and internal gas and internal steam heating will be modelled together.

Table 11 and Table 12 summarise the way the energy split (to heat the water or the air) will be modelled in the analysis and are directly obtained from Table 9 and Table 10. The heat input with a gas atmospheric process of 90% is now called “Alternative heating” while the internal electric heating remains “electricity”.

Table 11 Modelling of the water heating for washing machines BCs

Washing machine category	Electricity (in % of the final energy required)	Alternative heating, ‘heat input‘ (in % of the final energy required)
WM1: Semi-professional washer extractor	60	40
WM2: Professional washer extractor, <15 kg	55	45
WM3: Professional washer extractor, 15–40 kg	40	60
WM4: Professional washer extractor, >40 kg	15	85
WM5: Professional washer dryer	100	0
WM6: Professional barrier washer	25	75
WM7: Washing tunnel machine	0	100

Table 12 Modelling of the air heating for dryers BCs

Dryer category	Electricity (in % of the final energy required)	Alternative heating, ‘heat input’ (in % of the final energy required)
D1: Semi-professional dryer, condenser	100	0
D2: Semi-professional dryer, air vented	65	35
D3: Professional cabinet dryer	100	0
D4: Professional tumble dryer, <15 kg	45	55
D5: Professional tumble dryer, 15-40 kg	30	70
D6: Professional tumble dryer, >40 kg	10	90
D7: Pass-through (transfer) tumble dryer	0	100

In washing machines and dryers, energy is not only required to heat the water or the air but also for electronics and the mechanical parts and actions of the appliances (motors, pumps, etc.). Therefore, only the share needed for the water/air heating (i.e. not the total energy consumption) will be split according to the above tables. The remaining share of energy needed for the functioning of the mechanical parts is always brought in the form of electricity.

The distribution of the energy between the mechanical parts share and the water/air heating share is presented per BC in Table 13 and Table 14.

Table 13 Energy use split between mechanical and heating parts for washing machines[5]

Base case	Percentage of energy for motor and electronic devices etc. (always electricity)	Percentage of energy for water heating
WM1 Semi-professional washing machine and washer extractor	13.5%	86.5%
WM2 Professional washer extractor, <15 kg	13.5%	86.5%
WM3 Professional washer extractor, 15-40 kg	13.5%	86.5%
WM4 Professional washer extractor, >40 kg	12.5%	87.5%
WM5 Professional washer dryer	20.0%	80.0%
WM6 Professional barrier washer	12.5%	87.5%
WM7 Washing tunnel machines	5.0%	95.0%

Table 14 Energy use split between mechanical and heating parts for dryers[5]

Base case	Percentage of energy for motor and electronic devices etc. (always electricity)	Percentage of energy for air heating
D1 Semi-professional dryer, condenser	5.0%	95.0%
D2 Semi-professional dryer, air-vented	5.0%	95.0%
D3 Professional cabinet dryer	5.0%	95.0%
D4 Professional tumble dryer, <15 kg	8.0%	92.0%
D5 Professional tumble dryer, 15-40 kg	8.0%	92.0%
D6 Professional tumble dryer, >40 kg	15.0%	85.0%
D7 Pass-trough (transfer) tumble dryer	11.0%	89.0%

All improvement options considered later (see Task 6) will be applicable for implementation on the BCs, whatever the heating option considered (electric or alternative) that is why it is

5 Source: From manufacturers' responses to questionnaire.

acceptable to perform the environmental and economic analysis based on these weighted BCs.

Table 15 presents the methodology used to establish the energy consumption split per machine. The example corresponds to the category WM1. According to stakeholders, 60% of the market runs exclusively on electricity, while 40% of the market uses “alternative heating” for water heating. Thus, 871 kWh of final energy are consumed under the form electricity (with associated environmental impacts and costs), while 461 kWh of final energy are brought under the form of ‘heat’, which is modelled to be produced by a gas boiler (atmospheric, efficiency 90% LHV): (gas) costs and environmental impacts associated with this process are different than for electricity but are accounted for in the analysis.

Table 15 Example of energy split calculation considering base case WM1

Total energy consumption (kWh)	Market distribution water heating	Energy use split	% of energy use	Electrical energy consumption	Alternative energy consumption
1 332	60% Electric heating	Mechanic	13.5%	108	-
		Water heating	86.5%	691	-
	40% Alternative heating	Mechanic	13.5%	72	-
		Water heating	86.5%	-	461
Total (kWh)				**871**	**461**

2.4.1 Energy consumption

The energy consumption during the use phase is expected to be one of the major contributors to the environmental impacts of a professional washing machine or dryer. The annual energy (under electricity or heat input) consumption is required as an input in EcoReport, as well as the product lifetime which was evaluated in the market analysis (see Task 2). These inputs will also be used to calculate the LCC of the BCs.

Based on the energy consumption per kg of laundry processed as presented in Task 4, the total annual energy required per BC is shown in Table 16 and Table 17. Furthermore, the tables illustrate the proportion of electricity and alternative energy consumption for each of the BCs, according to the modelling approach previously presented.

Table 16 Total annual energy consumption and proportion of electricity and alternative energy consumption for all professional washing machine base cases

Base case	Total annual energy consumption (kWh per year)	Proportion of electricity consumption (kWh per year)	Proportion of alternative energy consumption (kWh per year)
WM1 Semi-professional washing machine and washer extractor	**1 332**	*871*	*461*
WM2 Professional washer extractor, <15 kg	**3 026**	*1 979*	*1 047*
WM3 Professional washer extractor, 15-40 kg	**10 973**	*5 278*	*5 695*
WM4 Professional washer extractor, >40 kg	**81 648**	*29 597*	*52 051*
WM5 Professional washer dryer	**7 400**	*7 400*	-
WM6 Professional barrier washer	**26 461**	*9 096*	*17 365*
WM7 Washing tunnel machines	**1 606 500**	*80 325*	*1 526 175*

Table 17 Total annual energy consumption and proportion of electricity and alternative energy consumption for all professional dryer base cases

Base case	Total annual energy consumption (kWh per year)	Proportion of electricity consumption (kWh per year)	Proportion of alternative energy consumption (kWh per year)
D1 Semi-professional dryer, condenser	**4 877**	*4 877*	-
D2 Semi-professional dryer, air-vented	**4 552**	*3 038*	*1 514*
D3 Professional cabinet dryer	**5 924**	*5 924*	-
D4 Professional tumble dryer, <15 kg	**9 936**	*4 908*	*5 028*
D5 Professional tumble dryer, 15-40 kg	**32 805**	*11 679*	*21 126*
D6 Professional tumble dryer, >40 kg	**171 360**	*40 270*	*131 090*
D7 Pass-trough (transfer) tumble dryer	**979 200**	*107 712*	*871 488*

2.4.2 Water consumption

Table 18 presents the annual water consumption of the 7 washing machine base cases.

Table 18 Water consumption per year for all professional washing machine base cases

Base case	Water consumption (in m^3 per year)
WM1 Semi-professional washer extractor	85
WM2 Professional washer extractor, <15 kg	233
WM3 Professional washer extractor, 15-40 kg	741
WM4 Professional washer extractor, >40 kg	3 266
WM5 Professional washer dryer	100
WM6 Professional barrier washer	1 081
WM7 Washing tunnel machines	27 540

2.4.3 Detergent and laundry aid consumption

Table 19 presents the annual detergent consumption including laundry aid of the 7 professional washing machine base cases.

Table 19 Detergent consumption per year for all professional washing machine base cases

Base case	Detergent consumption (in kg per year)
WM1 Semi-professional washer extractor	161
WM2 Professional washer extractor, <15 kg	330
WM3 Professional washer extractor, 15-40 kg	798
WM4 Professional washer extractor, >40 kg	4 199
WM5 Professional washer dryer	140
WM6 Professional barrier washer	1 216
WM7 Washing tunnel machines	41 310

2.4.4 Travelling distance for maintenance and repair over the product life

For all base cases, the number of kilometres travelled for maintenance and repair for one machine was estimated to be **100 km** for category WM2 and D4 over the product lifetime. This value was then extrapolated in proportion to the price for the other categories. The values are presented in Table 20 and Table 21. The transportation of the garments by the user (for instance, a customer driving to a launderette) is not taken into account in the analysis.

Table 20 Travelled distance for maintenance and repair during the lifetime for all professional washing machine base cases

Category	Price (€)	Distance (km)
WM1 Semi-professional washer extractor	2 670	53
WM2 Professional washer extractor, <15 kg	5 000	100
WM3 Professional washer extractor, 15-40 kg	15 250	305
WM4 Professional washer extractor, >40 kg	58 750	1 175
WM5 Professional washer dryer	8 000	160
WM6 Professional barrier washer	38 250	765
WM7 Washing tunnel machines	390 000	7 800

Table 21 Travelled distance for maintenance and repair during the lifetime for all professional dryer base cases

Category	Price (€)	Distance (km)
D1 Semi-professional dryer, condenser	1 970	49
D2 Semi-professional dryer, air-vented	1 680	42
D3 Professional cabinet dryer	3 500	88
D4 Professional tumble dryer, <15 kg	4 000	100
D5 Professional tumble dryer, 15-40 kg	7 125	178
D6 Professional tumble dryer, >40 kg	21 500	538
D7 Pass-through (transfer) tumble dryer	62 500	1 563

2.5 Inputs in the end-of-life phase

There is no evidence of hazardous materials that could be released into the environment during the end-of-life phase, e.g. refrigerant or mercury, in these machines. According to stakeholder feedback, the use of silver ions due to their antimicrobial properties is not applied anymore. Due to warnings from the German Bundesinstitut für Risikobewertung BfR (Federal Institute for Risk Assessment)[6], especially for nano silver, the market seems to be giving up this option. Possible harmful aspects, bacterial resistance and the lack of comprehensive data to allow conclusive risk assessments are the main reasons for the warnings expressed regarding the use of silver ions (for further details see Task 4).

Heat pumps for heat recovery are considered as improvement options. The refrigerants contained in these equipments will be taken into account in Tasks 6 and 7 only.

It is assumed that an important share of the professional laundry machines' materials are recycled and reused. We assumed that during the end-of-life phase:

6 www.bfr.bund.de

- 5% by weight of the products are not recovered (i.e. go to landfill)
- 95% by weight recovery rate; the materials follow one of the following options:
  – Metals are recycled;
  – Paper, cardboard, and plastics are incinerated (thermal recycling with possible benefits of energy recovery) or mechanically recycled. Plastics may also be directly reused;
  – Other types of waste (concrete, bitumen) go to landfill. Hazardous waste consists only of electronic components, which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

Regarding the plastic fraction, the following end-of-life management options were estimated for all base cases, based on stakeholders' feedback:

- Re-use, closed loop recycling: 1%
- Material (or mechanical) recycling: 29%
- Thermal recycling: 70%.

2.6 Economic inputs

Economic data used for the calculation of the LCCs were elaborated in Task 2 (product lifetime and product prices, electricity rates, water and consumables rates) and completed thanks to a complementary questionnaire. The product prices were estimated with the data aggregation used for the definition of the base cases and based on stakeholders' comments.

In Table 22, the inputs of lifetime from Task 2 and Task 3 are presented for all base cases.

Table 22 Professional washing machines and dryers lifetimes (years)

Category	Cycles per lifetime	Cycles per year	Lifetime (in years)
WM1 Semi-professional washing machine and washer extractor	15 000	1 800	8
WM2 Professional washer extractor, <15 kg	30 000	2 400	12
WM3 Professional washer extractor, 15-40 kg	30 000	2 200	14
WM4 Professional washer extractor, >40 kg	40 000	2 700	15
WM5 Professional washer dryer	20 000	1 760	11
WM6 Professional barrier washer	30 000	2 200	14
WM7 Washing tunnel machines	40 000*	3 000	13
D1 Semi-professional dryer, condenser	15 000	1 800	8
D2 Semi-professional dryer, air-vented	15 000	1 800	8
D3 Professional cabinet dryer	20 000	1 760	15
D4 Professional tumble dryer, <15 kg	30 000	2 400	13

Category	Cycles per lifetime	Cycles per year	Lifetime (in years)
D5 Professional tumble dryer, 15-40 kg	30 000	2 200	14
D6 Professional tumble dryer, >40 kg	40 000	3 000	13
D7 Pass-through (transfer) tumble dryer	40 000*	3 000	13

** hours*

Table 23 and Table 24 present the sales and stock figures and product prices for the 14 base cases. The installation cost of the laundry appliance is taken into account as a percentage of the product price: 9% for categories WM7 and D7, and 4% for all the other categories. The maintenance costs, as expressed in Task 2, are:

- 3% of the purchase price of the product over the whole lifetime for categories WM1-2-3-5 and D1-2-3-4-5;
- 25% of the purchase price over the whole lifetime for categories WM4-6-7;
- 18% of the purchase price over the whole lifetime for categories D6-7.

The disposal costs were considered to be zero, as the machines are never landfilled but processed by recyclers.

Table 23 EcoReport economic inputs of the professional washing machine base cases

Base case	Sales (mln units)	Stock (mln units)	Product price (€)	Installation (€)	Maintenance costs (€)
WM1 Semi-professional washer extractor	0.02500	0.193138	2 670	107	80
WM2 Professional washer extractor, <15 kg	0.04550	0.557279	5 000	200	150
WM3 Professional washer extractor, 15-40 kg	0.00620	0.081378	15 250	610	458
WM4 Professional washer extractor, >40 kg	0.00020	0.002799	58 750	2 350	14 688
WM5 Professional washer dryer	0.00020	0.002093	8 000	320	240
WM6 Professional barrier washer	0.00085	0.010470	38 250	1 530	9 563
WM7 Washing tunnel machines	0.00025	0.003062	390 000	35 100	97 500

Table 24 EcoReport economic inputs of the professional dryer base cases

Base case	Sales (mln units)	Stock (mln units)	Product price (€)	Installation (€)	Maintenance costs (€)
D1 Semi-professional dryer, condenser	0.0032	0.024722	1 970	79	59
D2 Semi-professional dryer, air-vented	0.0043	0.033220	1 680	67	50
D3 Professional cabinet dryer	0.0107	0.149738	3 500	140	105
D4 Professional tumble dryer, <15 kg	0.0160	0.195966	4 000	160	120
D5 Professional tumble dryer, 15-40 kg	0.0035	0.045939	7 125	285	214
D6 Professional tumble dryer, >40 kg	0.0003	0.003674	21 500	860	3 870
D7 Pass-through (transfer) tumble dryer	0.0012	0.014697	62 500	5 625	11 250

The running costs will be calculated based on the user behaviour and the consumables rates presented in Table 25 and

Table 26. Gas costs of the "alternative heating" are included in the analysis.

Table 25 Energy, water and consumables rates, by professional washing machine base case

Base case	Electricity rate (€/kWh)	Gas rate (€/GJ)	Water rate (€/m^3)	Detergent/ Rinse aid rate (€/kg)
WM1 Semi-professional washing machine and washer extractor	0.138	11.2115	2.64	2.00
WM2 Professional washer extractor, <15 kg				
WM3 Professional washer extractor, 15-40 kg	0.105	10.0097		
WM4 Professional washer extractor, >40 kg	0.090	8.7921		
WM5 Professional washer dryer	0.105	10.0097		
WM6 Professional barrier washer				
WM7 Washing tunnel machines	0.090	8.7921		

Table 26 Energy rates, by professional dryer base case

Base case	Electricity rate (€/kWh)	Gas rate (€/GJ)
D1 Semi-professional dryer, condenser	0.138	11.2115
D2 Semi-professional dryer, air-vented		
D3 Professional cabinet dryer		
D4 Professional tumble dryer, <15 kg		
D5 Professional tumble dryer, 15-40 kg	0.105	10.0097
D6 Professional tumble dryer, >40 kg	0.090	8.7921
D7 Pass-through (transfer) tumble dryer		

The discount rate was provided by the European Commission: **4%** will be used for all base cases.

There is a significant efficiency difference between the appliances being sold today and the appliances being used in the stock. This is a direct result from the steady progress that the industry has been making towards the reduction of the products' environmental impacts, combined with the quite long lifetimes of products in this study. This could lead to an underestimation of the environmental impacts of the products in this study as all the base cases represent products currently sold on the market, are thus expected to be more efficient than the average product in stock.

According to the industry, the energy and water consumption has decreased around 65% when comparing the top class current model with the average ten-year old model. The water consumption over the past 25 years has decreased around 75%. However, comparing top of the range machines, the improvement has been 15%. This overall improvement ratio is considered for all base cases.

Table 27 Overall improvement ratios for all professional laundry appliance base cases

Improvement ratios: ten year old product consumption divided by new product consumption		**Overall improvement ratio**
Energy consumption	**Water consumption**	
1.60	1.15	1.30

3 Base case environmental impact assessment

The aim of this subtask is to assess the environmental impact of each base case following the MEEuP (EcoReport Unit Indicators) for each life cycle stage:

- Raw Materials Use and Manufacturing (Production phase);
- Distribution;
- Use;
- End-of-Life.

The BC environmental impact assessment will lead to the identification of basic technological design parameters of outstanding environmental relevancy.[7] These parameters will be listed as they will serve as an important input to the identification of Eco-design options. The assessment results are tracked back to the main contributing components (e.g. motor, drum), materials and features of professional laundry machines and dryers.

Seventeen environmental indicators are considered in the EcoReport tool. Of these, 13 are relevant to professional laundry appliances, while others have no to very little impact:

- Total Gross Energy Requirement, in MJ primary;
- Electricity, in kWh;
- Process Water, in litre;
- Hazardous Solid Waste, in g;
- Non-hazardous waste, in g;
- Global Warming Potential (GWP), in CO_2 equivalent;
- Acidification potential, in SO_2 equivalent;

[7] As far as the MEEuP EcoReport allows the identification of such indicators.

- Volatile Organic Compounds (VOC), in mg;
- Persistent Organic Pollutants (POP), in I-Teq;
- Heavy Metals (HM), in Nickel equivalent;
- Polycyclic Aromatic Hydrocarbons (PAH), in Nickel equivalent;
- Particulate Matter;
- Eutrophication Potential, in PO_4 equivalent.

3.1 Base case WM1: Semi-professional washer extractor

Table 28 shows the environmental impacts of a semi-professional washer extractor over its whole life cycle. The total energy consumption for the whole life cycle of base case WM1 is 135 897 MJ, of which 74 187 MJ (i.e. 7 065 kWh) electricity[8].

Figure 2 exposes the contribution of each life cycle phase to each impact. The total impact of a category is shown as 100%. However, this does not mean that each of the impacts in each category is equally important. The categories are not directly comparable. Several observations can be made from this analysis:

- The materials involved in the production of these machines have high relative impact with regard to heavy metals and PAHs. They have medium impact in the production of non-hazardous waste and POP. The main contributor to the impact is the stainless steel, followed by the propylene, aluminium and copper.
- The manufacturing phase has little impact over the lifetime of these machines. For all categories its impact is between 0 and 1% of the total impact.
- The distribution phase has the biggest impact regarding the particulate matter impact, since these are installed machines that require preliminary transportation.
- The use phase represents more than the 75% of the impact for most of the categories. Its influence is less important for hazardous waste, VOCs, heavy metals to air, PAHs and particulate matter. In particular, it accounts for about 95% of the total energy consumption (98% of the total electricity consumption) and 99% of lifetime water consumption.
- The end-of-life phase has significant impact only for the hazardous waste indicator (more than 75%). The amount of plastics in this machine is the main reason for this high value. Also, it is the second most important phase regarding the particulate matter indicator, closely followed by the use phase.

[8] In MEEuP, a conversion factor of 10.5 MJ/kWh_e for the public grid is specified.

Table 28 Life Cycle Impact (per unit) of base case 1 – WM1 Semi-professional washer extractor

Life Cycle phases / Resource Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Dis-posal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	3 376	945	4 321	1 101	130 349	925	800	125	135 897
of which, electricity (in primary MJ)	MJ	448	566	1 014	3	73 185	0	15	-15	74 187
Water (process)	ltr	1 786	8	1 795	-	686 278	-	10	-10	688 062
Water (cooling)	ltr	1 133	264	1 398	-	195 147	-	82	-82	196 462
Waste, non-haz./ landfill	g	61 491	3 129	64 620	480	133 282	4 708	58	4 650	203 032
Waste, hazardous/ incinerated	g	180	0	180	10	2 638	9 465	9	9 456	12 283
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO_2 eq	221	53	273	66	5 877	69	49	20	6 237
Ozone Depletion, emissions	mg R-11 eq	Negligible								
Acidification, emissions	g SO_2 eq	1 954	227	2 181	201	29 813	141	67	74	32 269
Volatile Organic Compounds (VOC)	G	7	0	7	20	57	3	1	2	86
Persistent Organic Pollutants (POP)	ng i-Teq	262	13	275	3	753	33	-	33	1 063
Heavy Metals	mg Ni eq	3 185	30	3 215	24	2 023	253	-	253	5 515
PAHs	mg Ni eq	322	0	322	44	257	-	1	-1	622
Particulate Matter (PM, dust)	G	397	35	432	3 230	1 109	1 266	2	1 263	6 034
Emissions (Water)										
Heavy Metals	mg Hg/20	2 057	0	2 057	1	492	75	-	75	2 625
Eutrophication	g PO_4	55	0	55	0	69 041	4	0	4	69 100
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

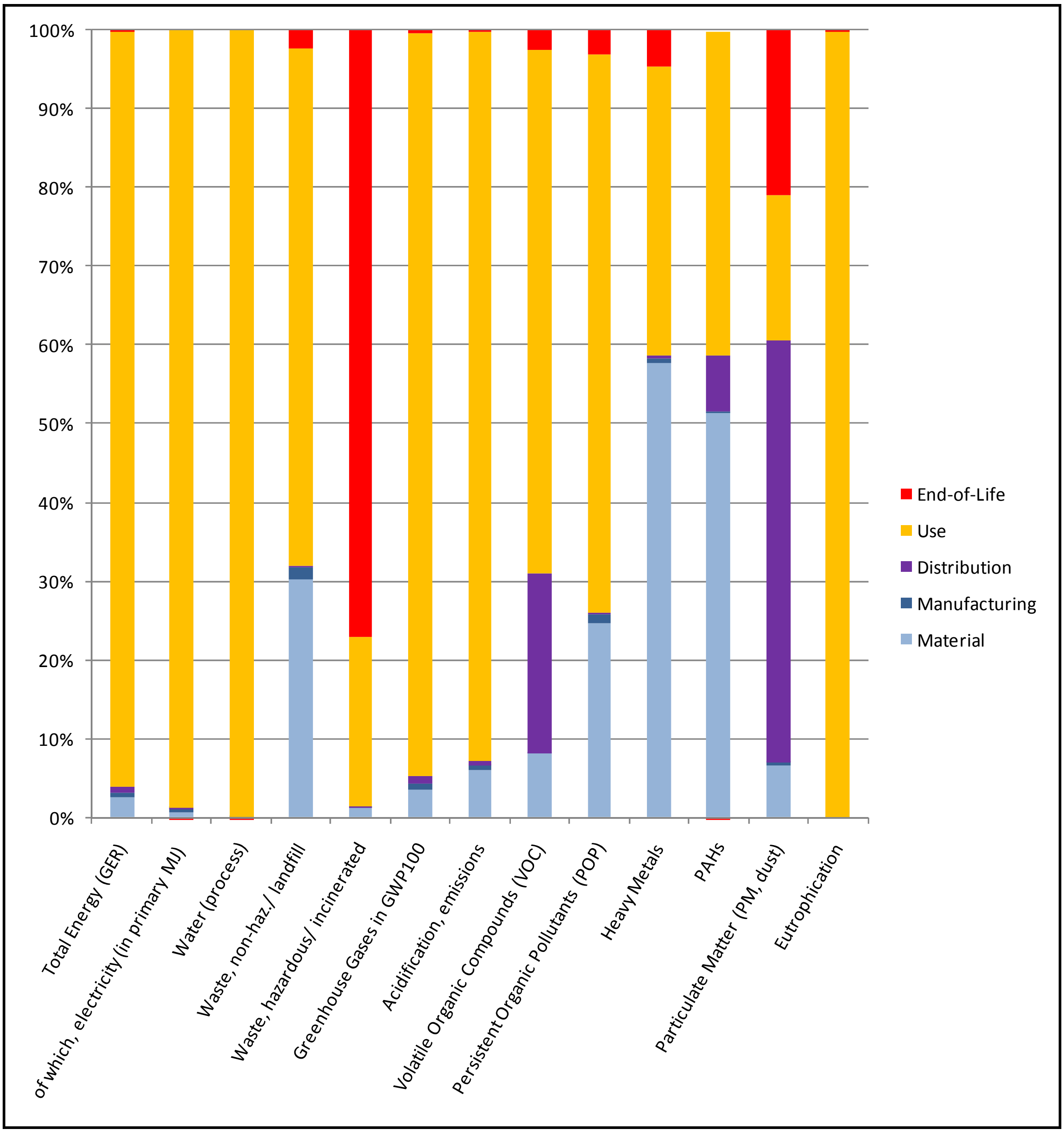

Figure 2 Distribution of environmental impacts of BC WM1 per life cycle phase

3.2 Base case WM2: Professional washer extractor <15 kg

Table 29 shows the environmental impacts of a professional washer extractor <15 kg over its whole life cycle. The total energy consumption for the whole life cycle of base case WM2 is 449 673 MJ, of which 254 710 MJ (i.e. 24 258 kWh) electricity.

Figure 3 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase is responsible for almost 100% of the total energy consumption (including electricity), water (process) and eutrophication. The latter is related to the amount of detergent discarded from the process. The influence of this phase is also very important during the production of greenhouse-gas emissions, acidification and VOCs. For other indicators such as non-hazardous wastes, hazardous wastes, POPs and heavy metals, its impact is around 50% of the total.
- The materials involved in production have a significant influence in PAHs, heavy metals emissions, POP and non-hazardous waste. The reason for this is the amount of metal and plastics required for the production of the machines, i.e. stainless steel, galvanised steel, plastics, aluminium and electronics.
- The impact of manufacturing is minor for all categories.
- The impact of the distribution phase is only important regarding particulate matter. This is related to the transportation for the installation.
- Finally, the end-of-life phase is responsible for around 35% of the production of hazardous waste along the life cycle, and almost 20% of the particulate matter.

Table 29 Life Cycle Impact (per unit) of base case 2 – WM2 Professional washer extractor <15 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	14 572	3 196	17 768	1 207	430 291	1 258	851	407	449 673
of which, electricity (in primary MJ)	MJ	3 406	1 904	5 310	3	249 408	0	11	-11	254 710
Water (process)	ltr	6 461	28	6 489	-	2 819 066	-	7	-7	2 825 547
Water (cooling)	ltr	1 564	878	2 442	-	664 970	-	59	-59	667 353
Waste, non-haz./ landfill	G	331 973	11 265	343 238	523	439 496	14 043	42	14 002	797 259
Waste, hazardous/ incinerated	G	2 866	1	2 866	10	8 695	6 790	7	6 784	18 355
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	1 060	179	1 239	72	19 417	94	56	38	20 766
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	6 957	771	7 728	220	98 022	188	74	114	106 084
Volatile Organic Compounds (VOC)	g	54	1	55	22	185	5	1	4	266
Persistent Organic Pollutants (POP)	ng i-Teq	3 426	94	3 521	3	2 500	97	-	97	6 121
Heavy Metals	mg Ni eq.	8 700	221	8 921	27	6 594	355	-	355	15 896
PAHs	mg Ni eq.	1 633	0	1 633	48	811	-	1	-1	2 491
Particulate Matter (PM, dust)	g	1 317	119	1 436	3 555	2 980	1 682	2	1 680	9 651
Emissions (Water)										
Heavy Metals	mg Hg/20	7 040	0	7 041	1	1 678	104	-	104	8 823
Eutrophication	g PO4	155	1	156	0	212 269	6	0	6	212 431
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

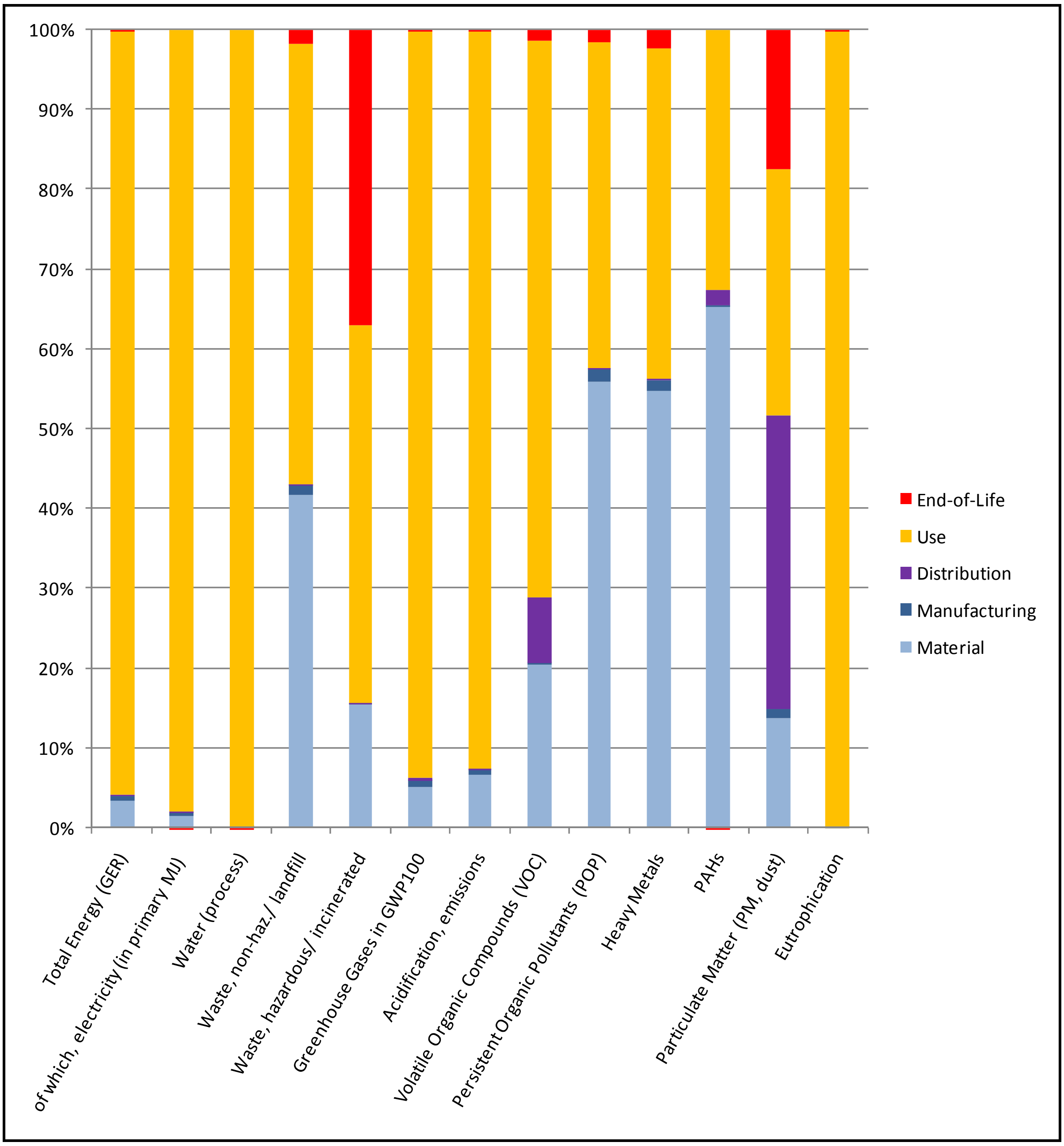

Figure 3 Distribution of environmental impacts of BC WM2 per life cycle phase

3.3 Base case WM3: Professional washer extractor, 15-40 kg

Table 30 shows the environmental impacts of a professional washer extractor, 15-40 kg over its whole life cycle. The total energy consumption for the whole life cycle of base case WM3 is 1 514 124 MJ, of which 783 294 MJ (i.e. 74 599 kWh) electricity.

Figure 4 exposes the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- In this case, the use phase is as expected the biggest contributor for almost all the impacts. For the total energy, water (process), hazardous waste, green house gases, and acidification, this phase accounts for more than 90% of the impacts. For non-hazardous waste, VOCs, persistent organic pollutants (POP), particulate matter and heavy metals, its contribution is between 50 and 90%.
- The materials involved in the production phase are the 2nd biggest contributor to the impacts, having relevance in the heavy metals, POP, particulate matter, non-hazardous waste and PAHs indicators. The main materials identified are stainless steel, steel, plastics (polyster, Acrylonitrile Butadiene Styrene, etc) and aluminum.
- End-of-life and distribution phases have significant contributions only for hazardous waste and particulate matter respectively. The end-of-life also contributes to particulate matter production with almost 20% of the total. The transportation (often by truck) required for the installation of these rather heavy machines generates particulate matter.

Table 30 Life Cycle Impact (per unit) of base case 3 – WM 3 Professional washer extractor, 15-40 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	36 493	4 743	41 236	2 517	1 475 857	3 611	9 097	-5 486	1 514 124
of which, electricity (in primary MJ)	MJ	4 546	2 832	7 377	6	775 942	0	31	-31	783 294
Water (process)	ltr	12 948	42	12 990	0	10 428 906	0	20	-20	10 441 876
Water (cooling)	ltr	35 475	1 312	36 787	0	2 069 349	0	171	-171	2 105 965
Waste, non-haz./ landfill	g	345 533	16 331	361 864	1 059	1 317 798	40 171	120	40 050	1 720 770
Waste, hazardous/ incinerated	g	2 119	1	2 120	21	26 139	19 601	19	19 582	47 862
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	2 157	265	2 421	149	68 411	269	656	-387	70 595
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	13 569	1 142	14 711	456	298 171	540	835	-295	313 043
Volatile Organic Compounds (VOC)	g	54	1	55	46	688	13	11	2	791
Persistent Organic Pollutants (POP)	ng i-Teq	3 900	111	4 011	6	7 469	277	0	277	11 763
Heavy Metals	mg Ni eq.	20 338	260	20 598	54	19 810	1 020	0	1 020	41 482
PAHs	mg Ni eq.	325	0	325	100	2 404	0	2	-2	2 828
Particulate Matter (PM, dust)	g	4 720	176	4 896	7 588	9 069	4 828	17	4 811	26 364
Emissions (Water)										
Heavy Metals	mg Hg/20	12 658	0	12 658	2	5 130	297	0	297	18 087
Eutrophication	g PO4	947	2	949	0	598 864	17	1	16	599 829
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

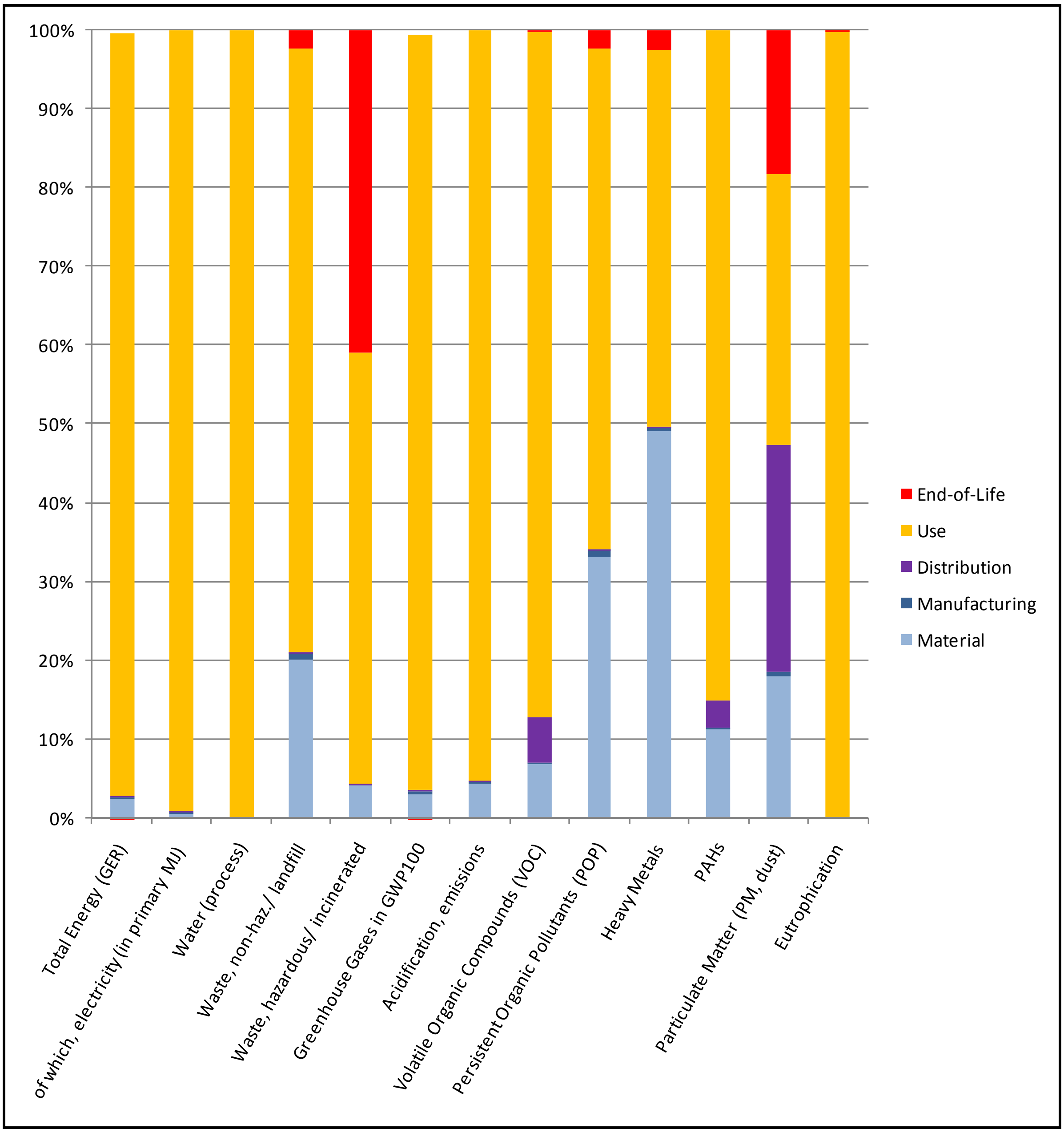

Figure 4 Distribution of environmental impacts of BC WM3 per life cycle phase

3.4 Base case WM4: Professional washer extractor, >40 kg

Table 31 shows the environmental impacts of a professional washer extractor, >40 kg over its whole life cycle. The total energy consumption for the whole life cycle of base case WM4 is 10 193 432 MJ, of which 4 687 820 MJ (i.e. 446 459 kWh) electricity.

Figure 5 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- As for the other models, the use phase is the one with the greater impact. Its impact is almost 100% regarding total energy (GER), water (process), GHG and acidification emissions and eutrophication. This is a consequence of the high energy consumption per cycle, and the use of detergent in the laundry process. The impact of the use phase is over 90% for VOCs and around 60% for non-hazardous wastes, POPs and heavy metals. This phase has less relevant impact for PAHs and particulate matter generation (around 40%).
- The extraction of raw materials involved in the machine production can be considered as the second most impacting phase. This phase contributes almost 60% of the PAHs and around 40% for POP, heavy metals and non-hazardous waste. The materials having the largest contributions are steel, copper and polyamide used for the construction of the machines.
- The distribution phase contributes 20% of the particulate matter, since these are installed units.
- The end-of-life phase contributes with more than 35% of the hazardous waste and over 15% of the particulate matter.

Table 31 Life Cycle Impact (per unit) of base case WM4 – Professional washer extractor, >40 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Dis-posal	Re-cycling	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	133 054	26 272	159 327	6 882	10 023 676	13 864	10 317	3 547	10 193 432
of which, electricity (in primary MJ)	MJ	10 407	15 663	26 070	17	4 661 851	0	120	-119	4 687 820
Water (process)	ltr	42 134	231	42 365	0	49 347 985	0	79	-79	49 390 271
Water (cooling)	ltr	15 217	7 234	22 450	0	12 431 133	0	659	-659	12 452 924
Waste, non-haz./ landfill	g	4 518 972	91 836	4 610 808	2 842	7 788 304	153 807	463	153 344	12 555 297
Waste, hazardous / incinerated	g	843	4	847	56	153 878	75 602	73	75 529	230 311
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	9 276	1 467	10 743	406	476 486	1 033	682	352	487 987
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	79 527	6 333	85 861	1 242	1 777 768	2 075	905	1 169	1 866 039
Volatile Organic Compounds (VOC)	g	250	8	258	127	4 996	50	12	39	5 420
Persistent Organic Pollutants (POP)	ng i-Teq	27 618	718	28 336	16	44 052	1 060	0	1 060	73 464
Heavy Metals	mg Ni eq.	84 330	1 682	86 012	144	116 032	3 915	0	3 915	206 104
PAHs	mg Ni eq.	20 560	2	20 562	273	14 065	0	7	-7	34 894
Particulate Matter (PM, dust)	g	15 789	974	16 763	21 021	48 193	18 540	26	18 514	104 491
Emissions (Water)										
Heavy Metals	mg Hg/20	63 161	1	63 162	5	30 691	1 141	0	1 141	94 998
Eutrophication	g PO4	1 461	11	1 472	0	3 376 216	65	3	63	3 377 751
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

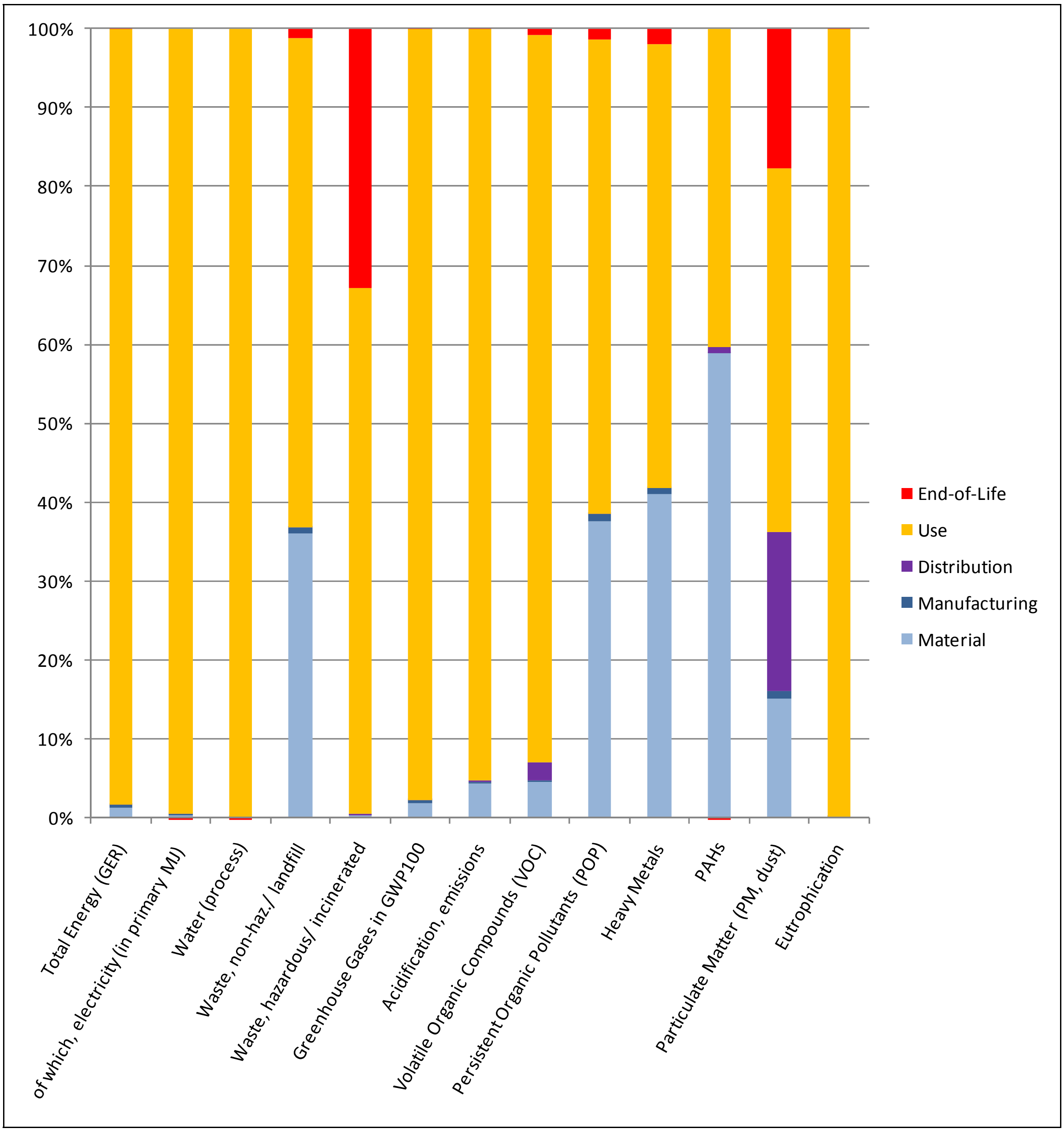

Figure 5 Distribution of environmental impacts of BC WM4 per life cycle phase

3.5 Base case WM5: Professional washer dryer

Table 32 shows the environmental impacts of a professional washer dryer over its whole life cycle. The total energy consumption for the whole life cycle of base case WM5 is 937 133 MJ, of which 865 385 MJ (i.e. 7 864 kWh) electricity.

Figure 6 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- For this category, the impact of the use phase is less dominating than for the previous ones. However, it is still almost 100% regarding energy consumption (including electricity), water (process), GHGs, acidification and eutrophication. It also has an important impact on non-hazardous waste production, hazardous waste production, VOCs and heavy metals. Its contribution to these indicators varies from 60 to 80%.
- The materials used in the production phase have a high contribution for POP, PAHs, non-hazardous waste and heavy metals production. This is a result of the amount of metals used for these machines. The components having the greatest impact are galvanised steel and electronics components (printed wiring boards).
- The distribution phase only has an influence on the particulate matter generation along the lifetime. This is related to the long distance travelled during the distribution of the equipment for installation. It represents almost 40% of the total impact.
- Finally, the end-of-life phase has non negligible impacts on the hazardous waste and particulate matter, between 10 and 20%. This is related to the plastics and electronics found in these machines.

Table 32 Life Cycle Impact (per unit) of base case WM5 – Professional washer extractor, >40 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	23 676	5 502	29 178	2 289	904 666	1 876	876	1 000	937 133
of which, electricity (in primary MJ)	MJ	7 309	3 275	10 584	6	854 806	0	11	-11	865 385
Water (process)	ltr	8 167	48	8 215	0	1 157 135	0	7	-7	1 165 344
Water (cooling)	ltr	2 062	1 508	3 570	0	2 279 236	0	60	-60	2 282 745
Waste, non-haz./ landfill	g	694 615	19 528	714 143	966	1 055 265	24 958	42	24 915	1 795 289
Waste, hazardous/ incinerated	g	7 022	1	7 023	19	20 901	6 933	7	6 926	34 870
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	1 706	307	2 013	136	39 499	140	57	83	41 731
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	10 127	1 328	11 455	415	233 005	279	77	202	245 078
Volatile Organic Compounds (VOC)	g	114	2	116	42	348	7	1	6	512
Persistent Organic Pollutants (POP)	ng i-Teq	8 231	173	8 403	5	6 009	172	0	172	14 590
Heavy Metals	mg Ni eq.	6 897	405	7 301	49	15 665	536	0	536	23 552
PAHs	mg Ni eq.	1 676	0	1 677	91	1 881	0	1	-1	3 648
Particulate Matter (PM, dust)	g	1 610	204	1 814	6 888	6 401	2 488	2	2 485	17 588
Emissions (Water)										
Heavy Metals	mg Hg/20	8 046	0	8 046	2	5 591	155	0	155	13 794
Eutrophication	g PO4	145	2	147	0	82 573	9	0	9	82 729
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

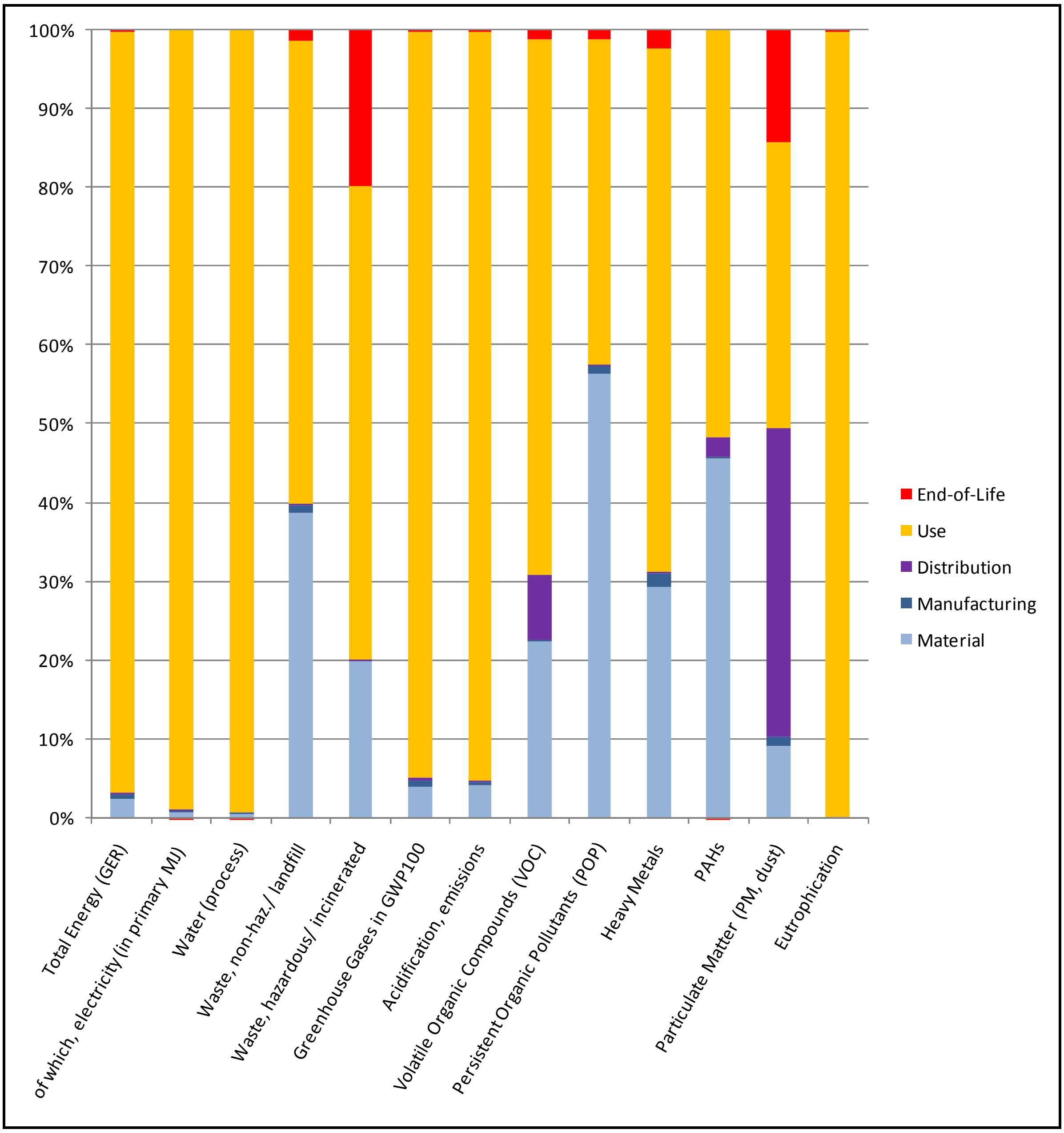

Figure 6 Distribution of environmental impacts of BC WM5 per life cycle phase

3.6 Base case WM6: Professional barrier washer

Table 33 shows the environmental impacts of a professional barrier washer over its whole life cycle. The total energy consumption for the whole life cycle of the base case WM6 is 2 998 936 MJ, of which 1 351 850 MJ (i.e. 128 747 kWh) electricity.

Figure 7 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- For these machines, the impact of the use phase is similar to the category WM5. It is still almost 100% regarding the energy consumption (including electricity), the water (process), GHG, acidification and eutrophication. It also has an important impact on the non-hazardous waste production and VOC. Its contribution to these impacts varies from 65 to 90%. However, regarding the hazardous waste production it is around 40%, while for heavy metals production it is around than 30%.
- The materials used in the production phase have a high contribution to heavy metals, POP, PAHs and non-hazardous waste. This is a result of the amount of metals used in these machines. The main contributing components and materials are stainless steel, polyamide and electronics components.
- The distribution phase has great impact on the particulate matter generation along the lifetime since these machines require of transportation for their installation. It has a minor impact in VOC production. This is related to the long distance travelled during the distribution of the equipment and the maintenance.
- Finally, the end-of-life phase has an impact on hazardous waste, accounting for around 60%. For particulate matter it represents around 20%. This is related to the plastics and electronics found in these machines.

Table 33 Life Cycle Impact (per unit) of base case WM6 – Professional barrier washer

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	54 769	12 751	67 520	5 649	2 925 058	8 242	7 533	709	2 998 936
of which, electricity (in primary MJ)	MJ	7 072	7 613	14 684	14	1 337 254	0	103	-103	1 351 850
Water (process)	ltr	35 462	112	35 575	0	15 235 907	0	68	-68	15 271 413
Water (cooling)	ltr	15 604	3 527	19 131	0	3 565 811	0	569	-569	3 584 374
Waste, non-haz./ landfill	g	1 154 573	43 889	1 198 462	2 338	2 194 056	65 942	400	65 542	3 460 398
Waste, hazardous/ incinerated	g	1 023	2	1 025	46	43 377	65 242	63	65 179	109 627
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	4 157	711	4 868	333	139 850	614	486	128	145 179
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	33 006	3 070	36 076	1 020	502 798	1 245	653	592	540 486
Volatile Organic Compounds (VOC)	g	110	3	113	104	1 497	28	8	20	1 734
Persistent Organic Pollutants (POP)	ng i-Teq	9 411	297	9 708	13	12 433	456	0	456	22 610
Heavy Metals	mg Ni eq.	68 556	696	69 252	119	33 378	2 289	0	2 289	105 038
PAHs	mg Ni eq.	3 546	1	3 548	224	4 170	0	6	-6	7 937
Particulate Matter (PM, dust)	g	5 877	472	6 349	17 227	17 453	11 153	20	11 133	52 162
Emissions (Water)										
Heavy Metals	mg Hg/20	42 184	0	42 184	4	9 044	676	0	676	51 908
Eutrophication	g PO4	1 114	6	1 119	0	912 555	39	2	36	913 711
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

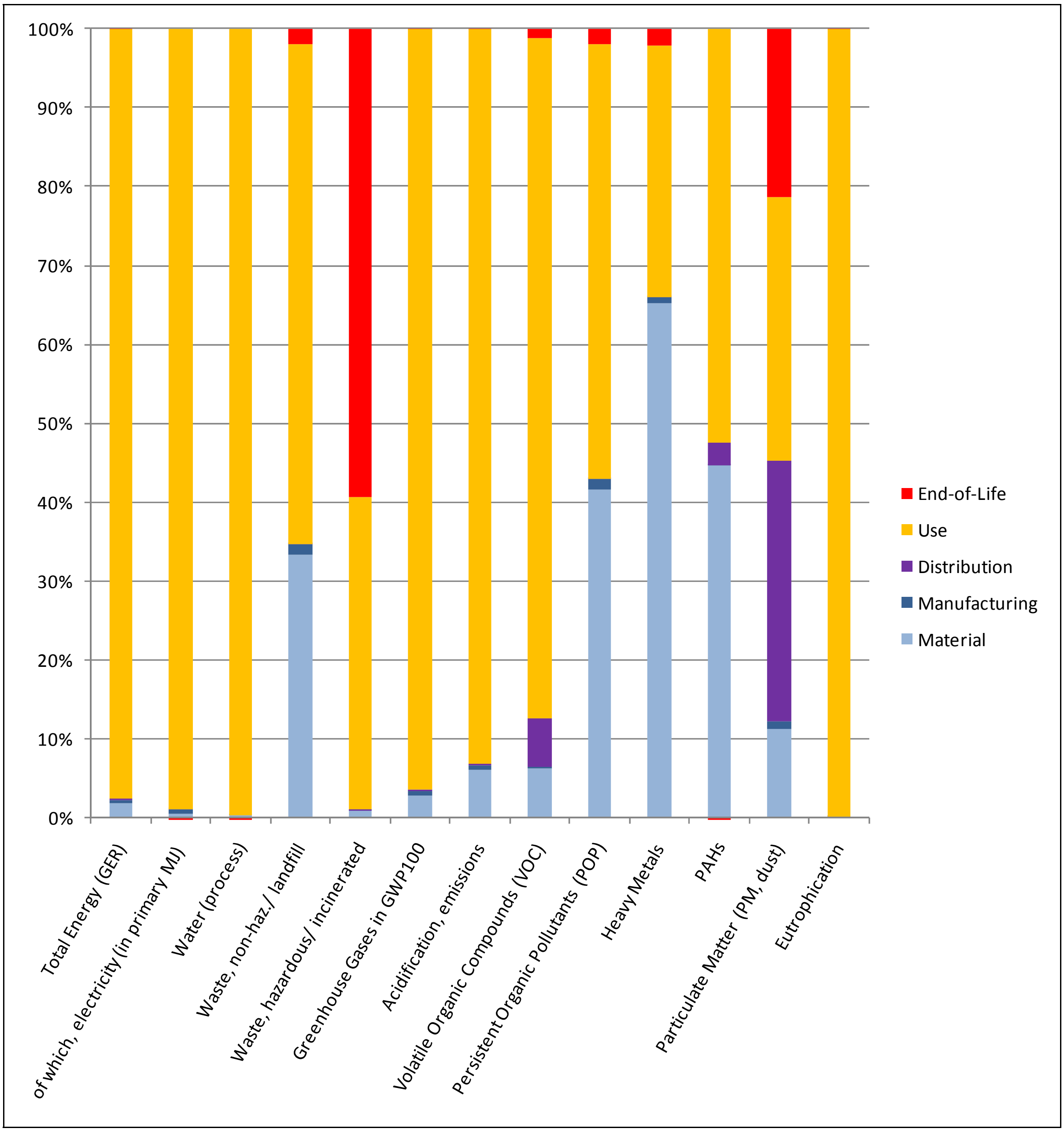

Figure 7 Distribution of environmental impacts of BC WM6 per life cycle phase

3.7 Base case WM7: Washing tunnel machine

Table 34 shows the environmental impacts of a washing tunnel machine over its whole life cycle. The total energy consumption for the whole life cycle of WM7 is 114 095 012 MJ, of which 11 242 144 MJ (i.e. 1 070 680 kWh) electricity.

Figure 7 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase is extremely influential in this equipment. It accounts for almost 100% of GER, process water, GHG, acidification and VOCs.
- The materials used in production have a large impact on heavy metals production, around 75%, while its impact in non-hazardous wastes and POP is around 35%. The main contributor is the stainless steel involved in production, though polypropylene, Acrylonitrile Butadiene Styrene (ABS) and copper have an influence as well.
- The distribution phase counts for 10% of the total impact in particulate matter.
- Finally, the end-of-life impacts the hazardous waste production, around 20% of total, and the particulate matter, around 15%.

Table 34 Life Cycle Impact (per unit) of base case WM7 – Washing tunnel machines

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	781 423	180 891	962 314	18 466	113 099 409	52 642	37 819	14 824	114 095 012
of which, electricity (in primary MJ)	MJ	167 587	107 657	275 244	47	10 967 115	1	263	-262	11 242 144
Water (process)	ltr	792 199	1 580	793 779	0	359 168 061	0	174	-174	359 961 666
Water (cooling)	ltr	118 262	49 530	167 792	0	29 239 978	0	1 449	-1 449	29 406 321
Waste, non-haz./ landfill	g	16 871 287	643 831	17 515 118	7 574	32 816 094	735 648	1 020	734 628	51 073 414
Waste, hazardous/ incinerated	g	79 172	33	79 204	151	649 503	166 325	160	166 164	895 022
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	71 805	10 110	81 915	1 087	5 925 781	3 926	2 628	1 298	6 010 081
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	674 500	43 664	718 163	3 328	8 654 339	7 805	3 405	4 399	9 380 230
Volatile Organic Compounds (VOC)	g	2 356	59	2 415	342	72 760	203	45	158	75 675
Persistent Organic Pollutants (POP)	ng i-Teq	110 382	5 814	116 196	43	185 689	5 066	0	5 066	306 993
Heavy Metals	mg Ni eq.	1 451 204	13 620	1 464 824	384	501 692	15 095	0	15 095	1 981 995
PAHs	mg Ni eq.	13 730	7	13 737	732	62 031	0	15	-15	76 485
Particulate Matter (PM, dust)	g	91 438	6 713	98 151	56 672	248 384	69 614	81	69 533	472 740
Emissions (Water)										
Heavy Metals	mg Hg/20	896 737	7	896 744	12	79 683	4 350	0	4 350	980 789
Eutrophication	g PO4	23 080	71	23 151	0	28 785 905	249	6	243	28 809 299
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

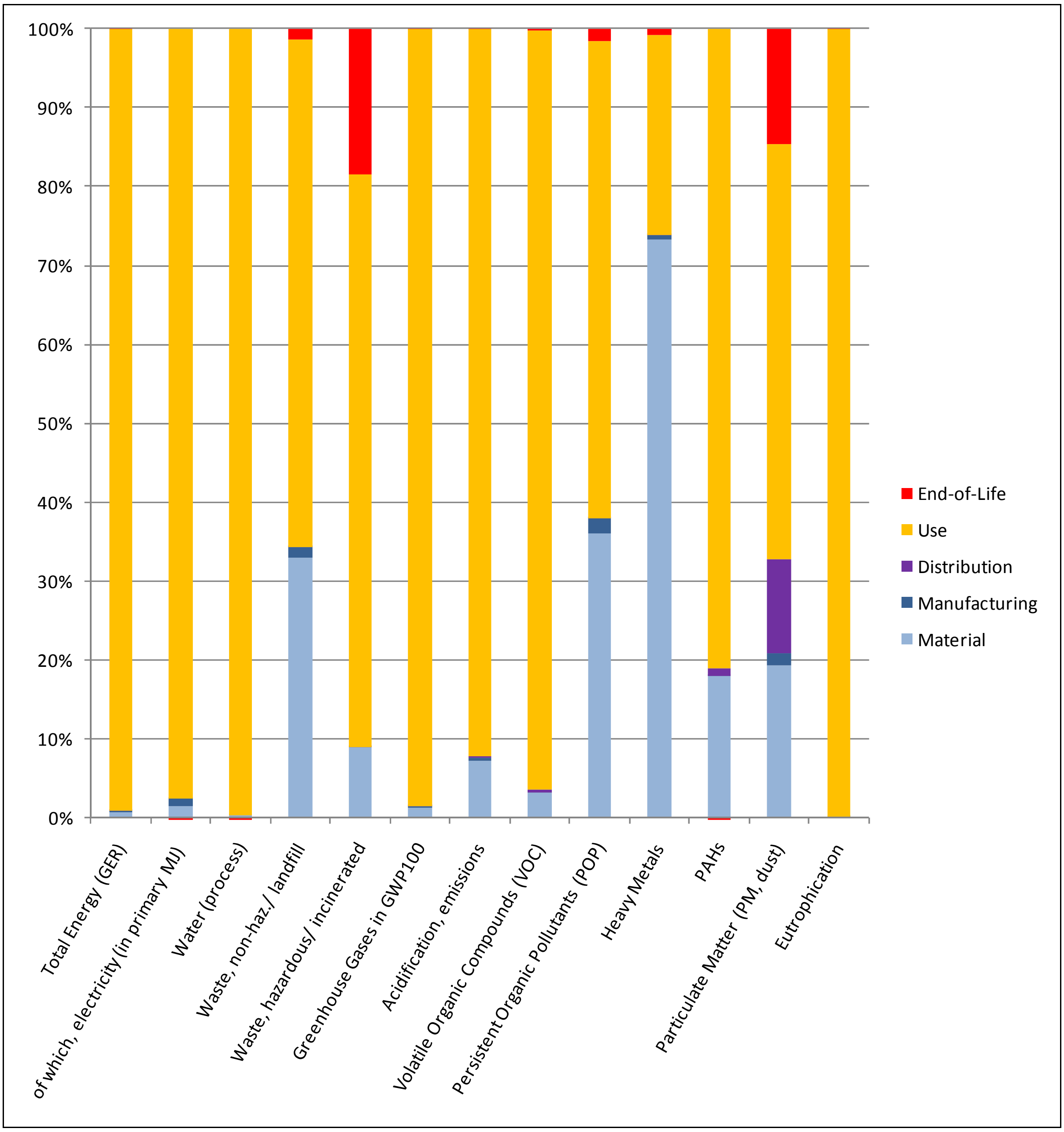

Figure 8 Distribution of environmental impacts of BC WM7 per life cycle phase

3.8 Base case D1: Semi-professional dryer, condenser

Table 35 shows the environmental impacts of a semi-professional dryer (condenser) over its whole life cycle. The total energy consumption for the whole life cycle of base case D1 is 417 234 MJ, of which 411 934 MJ (i.e. 39 231 kWh) electricity.

Figure 4 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has a great influence on the lifetime impacts of this equipment. It is not surprising that it accounts for almost 100% of energy consumption, GHGs and acidification. In contrast with professional washing machines, the impact on eutrophication is not high, representing almost 10% and related to the electricity generation. This phase only contributes to 45% of the production of hazardous wastes and particulate matter; and around 60% of the emissions of heavy metals. For other impacts, the use phase contributes between 85 and 95%.
- The second most contributing element is the materials involved in production. The greatest contribution concerns eutrophication (over 80%) due to the plastics in the machines. It also contributes 40% of the generation of heavy metals, and about 30% of the PAHs. It has a less important contribution to water use (process), non-hazardous waste generation, GHG production, acid emissions, VOC and particulate matter. The material with the most contribution is stainless steel, but plastics such as Acrylonitrile Butadiene Styrene (ABS) and Polypropylene (PP) also have significant impacts.
- The end-of-life has an important influence on the production of hazardous waste. This impact is more than 40%. This phase also contributes less than 20% of the particulate matter produced over the lifetime.
- Finally, distribution only has a relevant influence in particulate matter generation, since these machines are installed on the premises of the customer, hence they require transportation. This phase represents about 25% of the total impact over the lifetime.

Table 35 Life Cycle Impact (per unit) of base case D1 – Semi-professional dryer, condenser

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	5 321	1 178	6 499	640	410 015	878	798	80	417 234
of which, electricity (in primary MJ)	MJ	1 552	705	2 257	2	409 691	0	15	-15	411 934
Water (process)	ltr	3 694	10	3 705	0	27 348	0	10	-10	31 043
Water (cooling)	ltr	1 499	328	1 827	0	1 092 466	0	84	-84	1 094 210
Waste, non-haz./ landfill	g	100 660	3 970	104 630	292	476 033	3 703	59	3 645	584 600
Waste, hazardous/ incinerated	g	1 303	0	1 303	6	9 453	9 590	9	9 581	20 343
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	383	66	448	39	17 904	65	48	17	18 408
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	3 754	283	4 038	118	105 539	134	67	67	109 762
Volatile Organic Compounds (VOC)	g	18	0	19	11	156	3	1	2	188
Persistent Organic Pollutants (POP)	ng i-Teq	398	21	419	2	2 689	26	0	26	3 136
Heavy Metals	mg Ni eq.	5 435	49	5 484	15	7 109	239	0	239	12 846
PAHs	mg Ni eq.	404	0	404	26	837	0	1	-1	1 266
Particulate Matter (PM, dust)	g	398	44	442	1 812	2 692	1 205	3	1 202	6 148
Emissions (Water)										
Heavy Metals	mg Hg/20	3 933	0	3 933	0	2 681	72	0	72	6 686
Eutrophication	g PO4	93	1	93	0	14	4	0	4	111
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

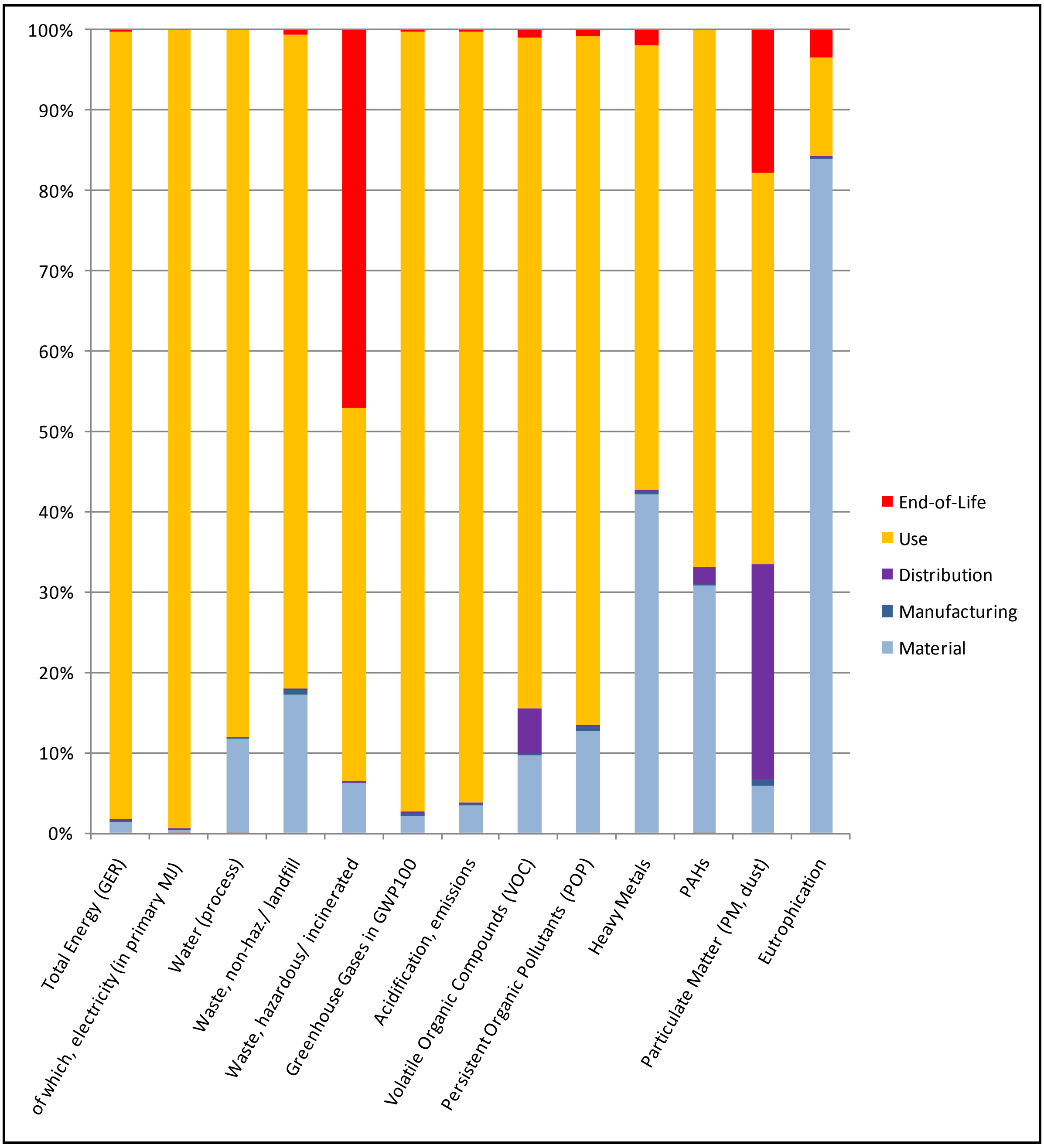

Figure 9 Distribution of environmental impacts of BC D1 per life cycle phase

3.9 Base case D2: Semi-professional dryer, air-vented

Table 51 shows the environmental impacts of a semi-professional dryer (air-vented) over its whole life cycle. The total energy consumption for the whole life cycle of base case D2 is 314 189 MJ, of which 257 355 MJ (i.e. 24 510 kWh) electricity.

Figure 10 exposes the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has a great influence on the lifetime impacts of this machine. It is not surprising that it accounts for almost 100% of the energy consumption, GHG and acidification. In contrast with professional washing machines, the impact on the eutrophication is not high, representing 10% and related to the electricity generation. This phase only contributes with 40% for the production of hazardous wastes and particulate matter; and less than 50% for the production of heavy metals. For the other impacts, the use phase contributes between 80 and 95%.
- The second most contributing phase is the production phase - materials. The greatest contribution concerns the eutrophication (almost 90%) due to the plastics in the machines. It also contributes to about 50% of the generation of heavy metals, and more than 40% of the PAHs. It has less important contribution in terms of the water use (process), non-hazardous waste generation, GHG production, acid emissions, VOC and particulate matter. The material with the most contribution is stainless steel, but plastics such as Acrylonitrile Butadiene Styrene (ABS) and Polypropylene (PP) also have significant impact.
- The end-of-life has an important influence on the production of hazardous waste. This phase also contributes to around 55% of the hazardous waste and 20% of the particulate matter produced over the lifetime.
- Finally, distribution only has a big influence on particulate matter generation, since these machines are installed and require of transportation to the customer premises. This phase represents about 30% of the total impact over the lifetime.

Table 36 Life Cycle Impact (per unit) of base case D2 – Semi-professional dryer, air-vented

Resources Use and Emissions / Life Cycle phases		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	5 022	1 090	6 112	640	307 358	794	714	80	314 189
of which, electricity (in primary MJ)	MJ	1 463	652	2 115	2	255 252	0	14	-13	257 355
Water (process)	ltr	3 501	10	3 510	0	17 050	0	9	-9	20 552
Water (cooling)	ltr	1 424	303	1 727	0	680 632	0	74	-74	682 285
Waste, non-haz./ landfill	g	98 766	3 680	102 445	292	296 950	3 518	52	3 466	403 153
Waste, hazardous/ incinerated	g	1 230	0	1 230	6	5 894	8 540	8	8 532	15 661
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	364	61	425	39	14 026	59	43	16	14 506
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	3 602	262	3 864	118	66 614	121	60	61	70 657
Volatile Organic Compounds (VOC)	g	17	0	18	11	138	2	1	2	168
Persistent Organic Pollutants (POP)	ng i-Teq	386	20	406	2	1 677	24	0	24	2 109
Heavy Metals	mg Ni eq.	5 161	47	5 208	15	4 483	216	0	216	9 922
PAHs	mg Ni eq.	397	0	397	26	560	0	1	-1	983
Particulate Matter (PM, dust)	g	386	40	426	1 812	2 305	1 089	2	1 087	5 630
Emissions (Water)										
Heavy Metals	mg Hg/20	3 745	0	3 745	0	1 683	65	0	65	5 493
Eutrophication	g PO4	88	1	89	0	9	4	0	3	101
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

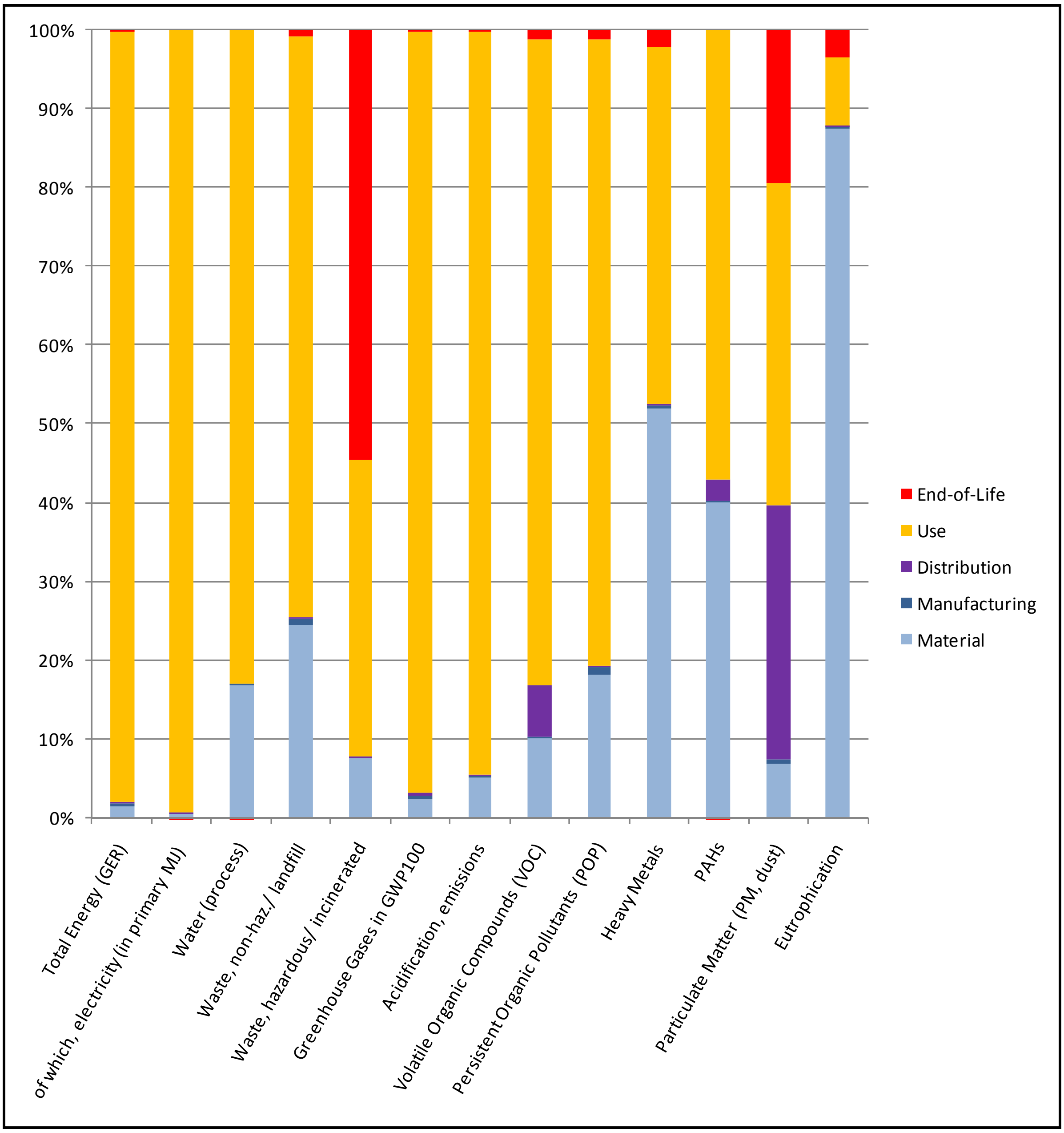

Figure 10 Distribution of environmental impacts of BC D2 per life cycle phase

3.10 Base case D3: Professional cabinet dryer

Table 37 shows the environmental impacts of a professional cabinet dryer over its whole life cycle. The total energy consumption for the whole life cycle of base case D3 is 949 425 MJ, of which 936 636 MJ (i.e. 89 203 kWh) electricity.

Figure 11 exposes the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has a great influence on the lifetime impacts of this equipment. It is not surprising that it accounts for almost 100% of the energy consumption, GHG and acidification. In contrast with professional washing machines, the impact on eutrophication is not high, representing around 45% (related to the electricity generation) and 50% of the PAH production. This phase also contributes almost 70% to the production of POP and particulate matter; and around 90% to the production of heavy metals and hazardous waste. For the other impacts, the use phase contributes between 90 and 95%.
- The second most contributing phase is the extraction of the materials involved in the production. The greatest contribution concerns the eutrophication and PAHs emissions (almost 50%) due to the plastics found in the machines. It also contributes about 30% of the POP and 20% of the generation of non-hazardous wastes. It has a less important contribution in terms of heavy metals, water use (process), hazardous waste generation, GHG production, acid emissions, VOC and particulate matter. The galvanised steel, aluminium and materials contained in the electronics components involved in the production have the greatest impact.
- The end-of-life has an influence on the production of hazardous waste. This impact is more than 10%. This phase also contributes 7% of the particulate matter and eutrophication produced over the lifetime.
- Finally, distribution has a big influence on particulate matter generation since these machines are transported to be installed in the customer premises. This phase represents about 35% of the total impact over the lifetime while it represents 10% for the VOCs.

Table 37 Life Cycle Impact (per unit) of base case D3 – Professional cabinet dryer

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	10 989	2 349	13 338	2 006	933 665	798	381	417	949 425
of which, electricity (in primary MJ)	MJ	2 173	1 398	3 571	5	933 066	0	6	-6	936 636
Water (process)	ltr	2 020	21	2 041	0	62 222	0	4	-4	64 259
Water (cooling)	ltr	601	644	1 245	0	2 488 092	0	34	-34	2 489 303
Waste, non-haz./ landfill	g	288 479	8 321	296 799	850	1 084 763	9 412	24	9 388	1 391 801
Waste, hazardous/ incinerated	g	2 013	0	2 013	17	21 520	3 899	4	3 895	27 445
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	724	131	855	119	40 764	59	24	36	41 774
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	3 900	567	4 467	364	240 339	119	33	87	245 256
Volatile Organic Compounds (VOC)	g	38	1	39	36	360	3	0	3	438
Persistent Organic Pollutants (POP)	ng i-Teq	2 997	73	3 070	5	6 146	65	0	65	9 286
Heavy Metals	mg Ni eq.	1 377	170	1 547	43	16 131	226	0	226	17 947
PAHs	mg Ni eq.	2 160	0	2 160	80	1 968	0	0	0	4 208
Particulate Matter (PM, dust)	g	748	87	835	6 016	6 978	1 064	1	1 062	14 891
Emissions (Water)										
Heavy Metals	mg Hg/20	2 543	0	2 543	1	6 041	66	0	66	8 651
Eutrophication	g PO4	33	1	34	0	29	4	0	4	66
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

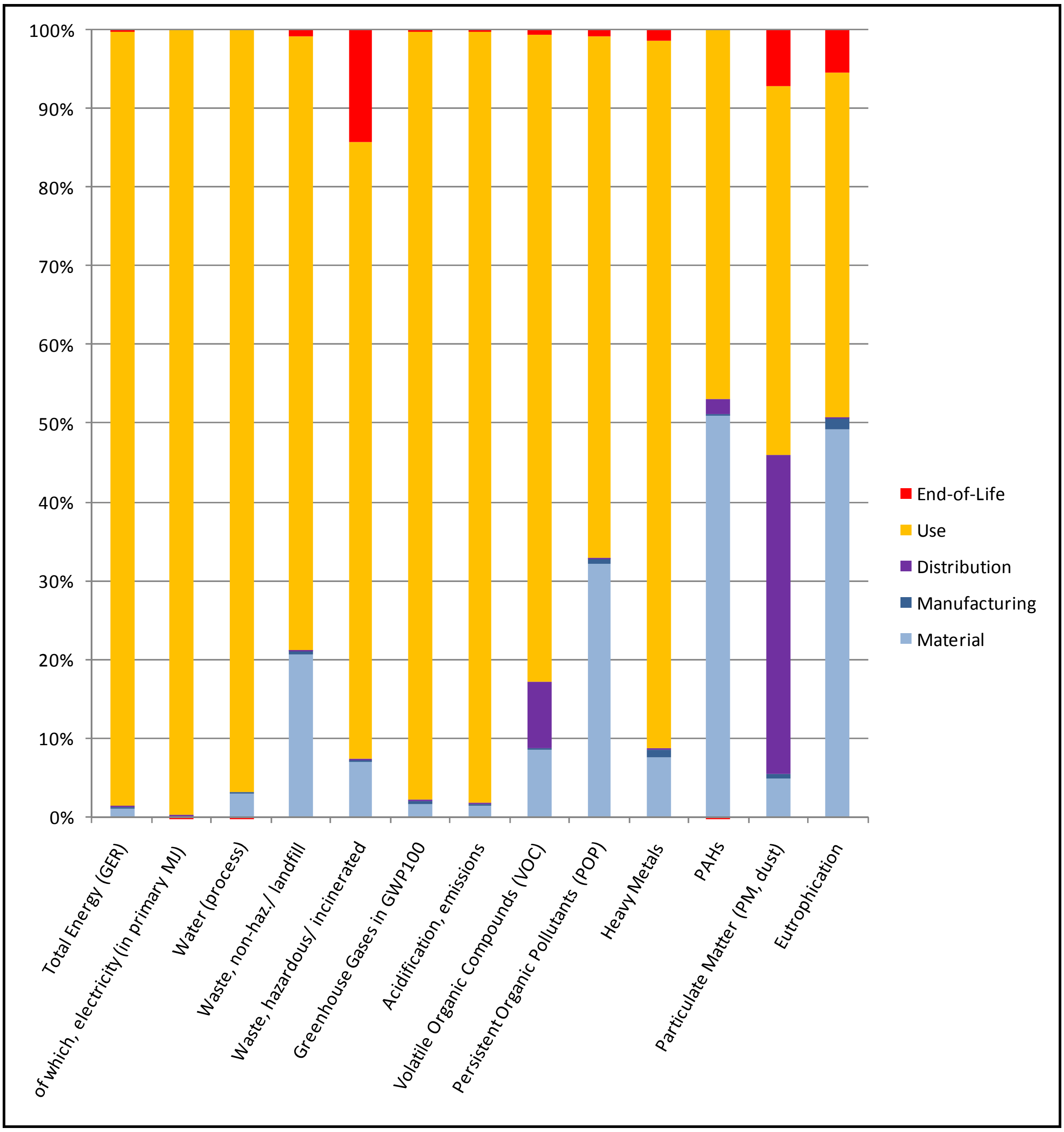

Figure 11 Distribution of environmental impacts of BC D3 per life cycle phase

3.11 Base case D4: Professional tumble dryer, <15 kg

Table 38 shows the environmental impacts of a professional tumble dryer (<15 kg) over its whole life cycle. The total energy consumption for the whole life cycle of base case D4 is 960 721 MJ, of which 671 839 MJ (i.e. 63 984 kWh) electricity.

Figure 12 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has a great influence on the lifetime impacts of this equipment. It is not surprising that it accounts for almost 100% of the energy consumption, water use (process), GHG and acidification. In contrast with washing machines, the impact on the eutrophication is moderate, representing around 45% and related to the electricity generation. This phase only contributes with 60% for the production of POP and particulate matter; and around 90% for the production of heavy metals, PAHs, hazardous and non-hazardous waste.
- The second most contributing element is the materials involved in the production. The greatest contribution is to eutrophication, contributing 50% of the total. It also contributes more than 20% of POP. The influence on non-hazardous generation, heavy metals and PAHs is between 5 and 10%. It has a less important contribution in terms of the water use (process), GHG, VOC and particulate matter. The main material contributors are the galvanised steel and copper.
- Distribution has an influence on particulate matter generation, since these machines are transported to be installed in the customer’s premises. This phase represents less than 30% of the total impact over the lifetime while it represents less than 5% for the VOCs.
- Finally, the end-of-life has an influence on the production of hazardous wastes. This impact is almost 10%. This phase also contributes with around 5% for the particulate matter and eutrophication produced over the lifetime.

Table 38 Life Cycle Impact (per unit) of base case D4 – Professional tumble dryer, <15 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	6 582	2 083	8 665	1 740	950 399	804	886	-82	960 721
of which, electricity (in primary MJ)	MJ	587	1 240	1 827	4	670 013	0	5	-5	671 839
Water (process)	ltr	1 186	18	1 204	0	44 678	0	3	-3	45 879
Water (cooling)	ltr	2 254	571	2 825	0	1 786 680	0	29	-29	1 789 476
Waste, non-haz./ landfill	g	206 601	7 379	213 980	741	778 960	10 272	20	10 252	1 003 933
Waste, hazardous/ incinerated	g	118	0	119	15	15 440	3 304	3	3 301	18 874
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	457	116	574	104	44 755	60	62	-2	45 430
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	1 823	503	2 326	316	177 095	120	80	39	179 777
Volatile Organic Compounds (VOC)	g	19	1	19	31	465	3	1	2	518
Persistent Organic Pollutants (POP)	ng i-Teq	3 008	64	3 072	4	4 422	71	0	71	7 569
Heavy Metals	mg Ni eq.	2 227	151	2 378	38	11 642	229	0	229	14 287
PAHs	mg Ni eq.	244	0	244	69	1 454	0	0	0	1 767
Particulate Matter (PM, dust)	g	523	77	600	5 196	5 869	1 068	2	1 066	12 731
Emissions (Water)										
Heavy Metals	mg Hg/20	1 480	0	1 480	1	4 335	66	0	66	5 882
Eutrophication	g PO4	44	1	44	0	21	4	0	4	69
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

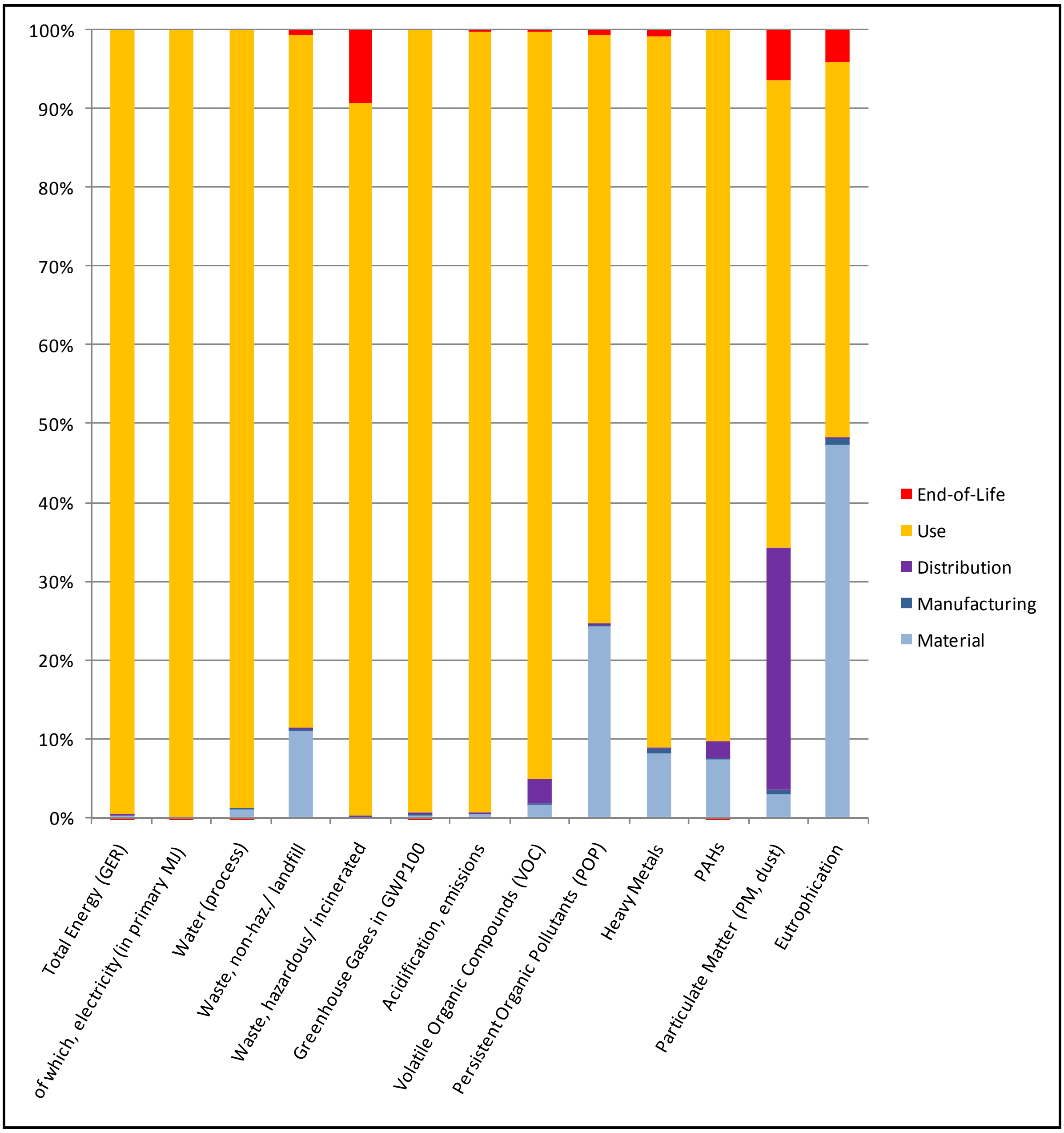

Figure 12 Distribution of environmental impacts of BC D4 per life cycle phase

3.12 Base case D5: Professional tumble dryer, 15-40 kg

Table 39 shows the environmental impacts of a professional tumble dryer (15-40 kg) over its whole life cycle. The total energy consumption for the whole life cycle of base case D5 is 3 015 100 MJ, of which 1 727 027 MJ (i.e. 164 478 kWh) electricity.

Figure 13 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has much influence in the lifetime impacts of this equipment. It accounts for almost 100% of the energy consumption, water use (process), GHG and acidification emissions. In contrast to washing machines, the impact on the eutrophication is medium, representing around 25% which is related to the electricity generation. This phase contributes with more than 50% for the production of particulate matter; and around 80% for the production of heavy metals, PAHs and non-hazardous waste.
- The second most contributing element is the materials involved in the production. The greatest contribution concerns the eutrophication, contributing with more than 40% of the total. It also contributes with almost 40% of the POP. The influence on non-hazardous generation, heavy metals and PAHs is between 10 and 20%. It has a less important contribution in terms of the water use (process), GHG, VOC and particulate matter. The galvanised steel and materials contained in the electronics components present the biggest influence during the phase.
- Distribution influences particulate matter generation since these machines are transported to their final installation place. This phase represents about 30% of the total impact along the lifetime.
- Finally, the end-of-life phase has an influence on the production of hazardous waste. This impact is less than 20%. This phase also contributes around 10% of the particulate matter and eutrophication generated over the lifetime.

Table 39 Life Cycle Impact (per unit) of base case D5 – Professional tumble dryer, 15-40 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	22 205	5 142	27 347	2 911	2 983 976	1 962	1 096	866	3 015 100
of which, electricity (in primary MJ)	MJ	7 119	3 062	10 182	7	1 716 853	0	15	-15	1 727 027
Water (process)	ltr	7 599	45	7 644	0	114 527	0	10	-10	122 160
Water (cooling)	ltr	1 932	1 411	3 343	0	4 578 037	0	85	-85	4 581 295
Waste, non-haz./ landfill	g	620 030	18 171	638 201	1 220	1 996 858	22 988	60	22 928	2 659 206
Waste, hazardous/ incinerated	g	6 850	1	6 851	24	39 627	9 730	9	9 721	56 223
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	1 574	287	1 861	173	145 006	146	70	76	147 116
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	9 306	1 240	10 547	527	462 631	293	95	198	473 903
Volatile Organic Compounds (VOC)	g	109	2	110	53	1 586	7	1	6	1 755
Persistent Organic Pollutants (POP)	ng i-Teq	7 058	156	7 214	7	11 325	158	0	158	18 704
Heavy Metals	mg Ni eq.	5 806	364	6 170	62	29 735	556	0	556	36 523
PAHs	mg Ni eq.	1 396	0	1 397	116	3 652	0	1	-1	5 164
Particulate Matter (PM, dust)	g	1 448	191	1 639	8 802	13 553	2 618	3	2 615	26 609
Emissions (Water)										
Heavy Metals	mg Hg/20	7 248	0	7 248	2	11 142	162	0	162	18 553
Eutrophication	g PO4	128	2	130	0	54	9	0	9	193
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

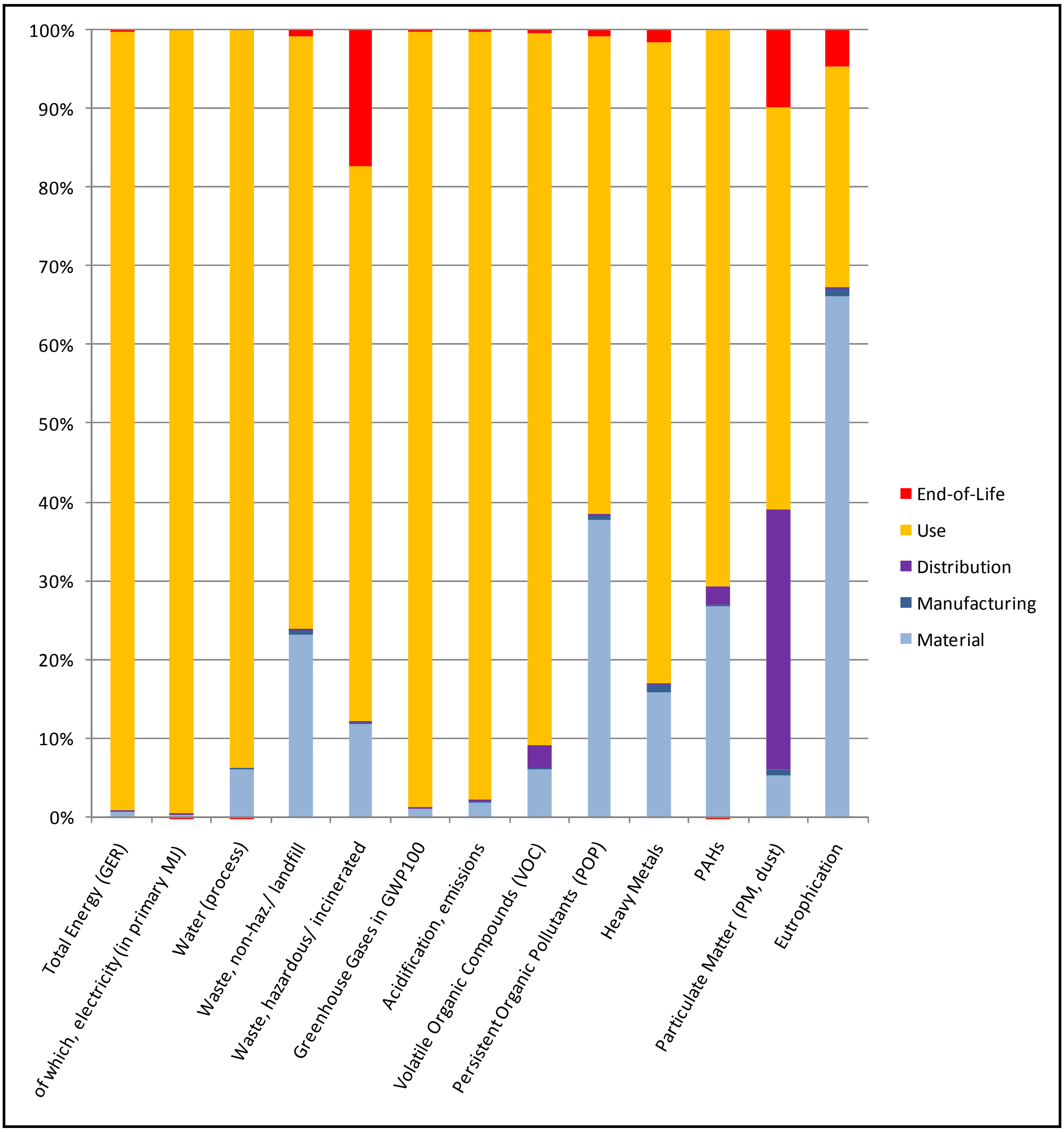

Figure 13 Distribution of environmental impacts of BC D5 per life cycle phase

3.13 Base case D6: Professional tumble dryer, >40 kg

Table 40 shows the environmental impacts of a professional tumble dryer (>40 kg) over its whole life cycle. The total energy consumption for the whole life cycle of base case D6 is 12 859 778 MJ, of which 5 518 537 MJ (i.e. 525 574 kWh) electricity.

Figure 14 exposes the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has a great influence on the lifetime impacts of this equipment. It is not surprising that it accounts for almost 100% of energy consumption, water use (process), GHG and acidification, and more than 80% of non-hazardous and hazardous waste, VOC, POP, heavy metals generation and particulate matter. The contribution in eutrophication is moderate, representing around 35% and being related to the electricity generation.
- The second most contributing element is the materials involved in the production. The greatest contribution concerns eutrophication, with 60% of the total. Materials also contribute between 20 to 30% to the POP and PAHs. The influence for non-hazardous and hazardous generation, VOC, heavy metals and particulate matter is more than 10%. The main contributors are galvanised steel and materials contained in the electronics components used for the production.
- Distribution has an important influence on particulate matter generation. This phase represents about 25% of the total impact along the lifetime.
- Finally, the end-of-life influences the production of hazardous waste and particulate matter. Its impact is around 10% for each.

Table 40 Life Cycle Impact (per unit) of base case D6 – Professional tumble dryer, >40 kg

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste										
Total Energy (GER)	MJ	45 629	11 000	56 630	6 349	12 794 521	3 899	1 621	2 278	12 859 778
of which, electricity (in primary MJ)	MJ	14 985	6 551	21 536	16	5 497 016	0	31	-30	5 518 537
Water (process)	ltr	15 958	96	16 054	0	366 614	0	20	-20	382 648
Water (cooling)	ltr	4 183	3 019	7 202	0	14 658 206	0	168	-168	14 665 240
Waste, non-haz./ landfill	g	1 306 798	38 879	1 345 677	2 624	6 386 685	45 693	118	45 575	7 780 561
Waste, hazardous/ incinerated	g	14 708	2	14 709	52	126 810	19 321	19	19 302	160 873
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	3 319	615	3 934	375	643 427	291	98	192	647 928
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	19 872	2 654	22 526	1 146	1 533 333	582	136	446	1 557 451
Volatile Organic Compounds (VOC)	g	232	3	235	117	7 433	14	2	13	7 798
Persistent Organic Pollutants (POP)	ng i-Teq	14 887	333	15 220	15	36 181	315	0	315	51 731
Heavy Metals	mg Ni eq.	12 400	780	13 180	133	95 102	1 105	0	1 105	109 519
PAHs	mg Ni eq.	2 996	1	2 996	252	11 728	0	2	-2	14 975
Particulate Matter (PM, dust)	g	3 584	408	3 992	19 381	43 601	5 201	5	5 196	72 171
Emissions (Water)										
Heavy Metals	mg Hg/20	15 515	0	15 515	4	35 597	321	0	321	51 437
Eutrophication	g PO4	269	4	273	0	172	18	1	18	463
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

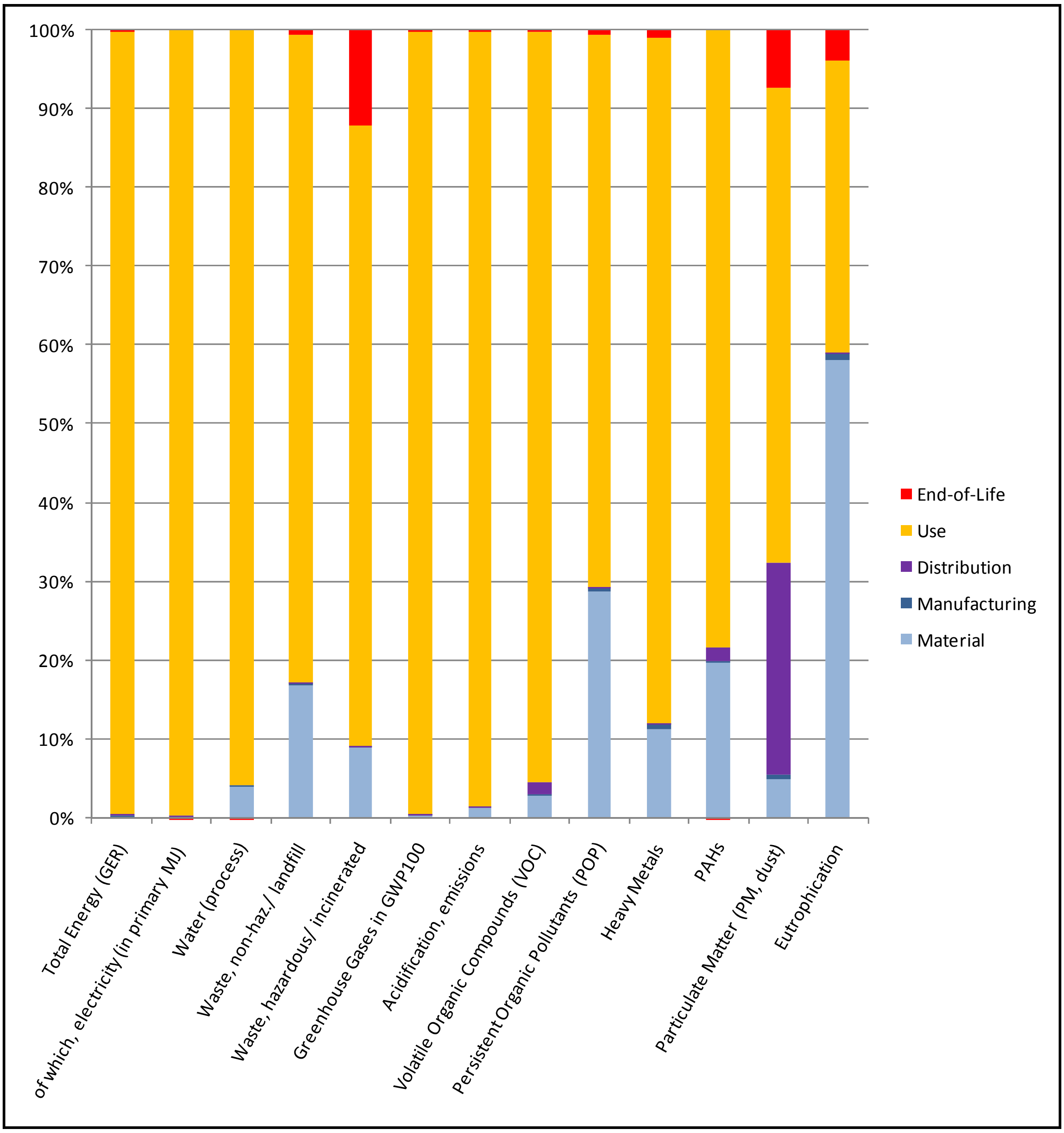

Figure 14 Distribution of environmental impacts of BC D6 per life cycle phase

3.14 Base case D7: Pass-through (transfer) tumble dryer

Table 41 shows the environmental impacts of a pass-through (transfer) tumble dryer over its whole life cycle. The total energy consumption for the whole life cycle of the base case D7 is 63 374 310 MJ, of which 14 738 602 MJ (i.e. 1 403 676 kWh) electricity.

Figure 15 shows the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- The use phase has a great influence in the lifetime impacts of this equipment. It accounts for almost 100% for most indicators. This is not surprising due to high energy consumption per cycle and the relative medium size of the equipment.
- In contrast to other dryers, the materials involved in the production phase do not have a high impact. They represent more than 40% of the POP impact, 30% of the eutrophication (related to the electricity generation) and 20% of the non-hazardous wastes production. The biggest contributions are from steel, polyethylene and materials contained in the electronics components.
- The distribution phase represents around 20% of the particulate matter. This is a consequence of the transportation required for the installation of the machines at the customer's premises.
- The end-of-life contributes to less than 10% of the eutrophication potential and particulate matter generation.

Table 41 Life Cycle Impact (per unit) of base case D7 – Pass-through (transfer) tumble dryer

Life Cycle phases / **Resources Use and Emissions**		**PRODUCTION**			**DISTRI-BUTION**	**USE**	**END-OF-LIFE***			**TOTAL**
		Material	**Manuf.**	**Total**			**Disposal**	**Recycl.**	**Total**	
Other Resources & Waste										
Total Energy (GER)	MJ	100 863	45 246	146 109	14 490	63 204 054	10 293	635	9 658	63 374 310
of which, electricity (in primary MJ)	MJ	8 621	26 911	35 532	37	14 703 043	0	11	-11	14 738 602
Water (process)	ltr	3 072	394	3 466	0	980 214	0	7	-7	983 672
Water (cooling)	ltr	1 457	12 364	13 820	0	39 207 306	0	61	-61	39 221 066
Waste, non-haz./ landfill	g	4 944 119	162 099	5 106 218	5 950	17 097 995	175 920	43	175 877	22 386 040
Waste, hazardous/ incinerated	g	2 204	9	2 212	118	338 815	6 983	7	6 976	348 122
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	8 314	2 530	10 843	853	3 323 370	768	39	729	3 335 796
Ozone Depletion, emissions	mg R-11 eq.	Negligible								
Acidification, emissions	g SO2 eq.	24 058	10 927	34 985	2 612	4 567 750	1 511	54	1 457	4 606 803
Volatile Organic Compounds (VOC)	g	412	16	427	268	40 993	42	1	41	41 729
Persistent Organic Pollutants (POP)	ng i-Teq	73 749	1 534	75 283	34	97 123	1 210	0	1 210	173 650
Heavy Metals	mg Ni eq.	12 959	3 594	16 553	302	254 343	3 000	0	3 000	274 197
PAHs	mg Ni eq.	635	1	637	575	32 263	0	1	-1	33 473
Particulate Matter (PM, dust)	g	7 980	1 680	9 660	44 435	127 346	13 446	2	13 444	194 886
Emissions (Water)										
Heavy Metals	mg Hg/20	12 843	2	12 845	9	94 927	854	0	854	108 635
Eutrophication	g PO4	241	17	258	0	455	49	0	49	761
Persistent Organic Pollutants (POP)	ng i-Teq	Negligible								

Negative values indicate environmental credits (impacts avoided) due to recycling

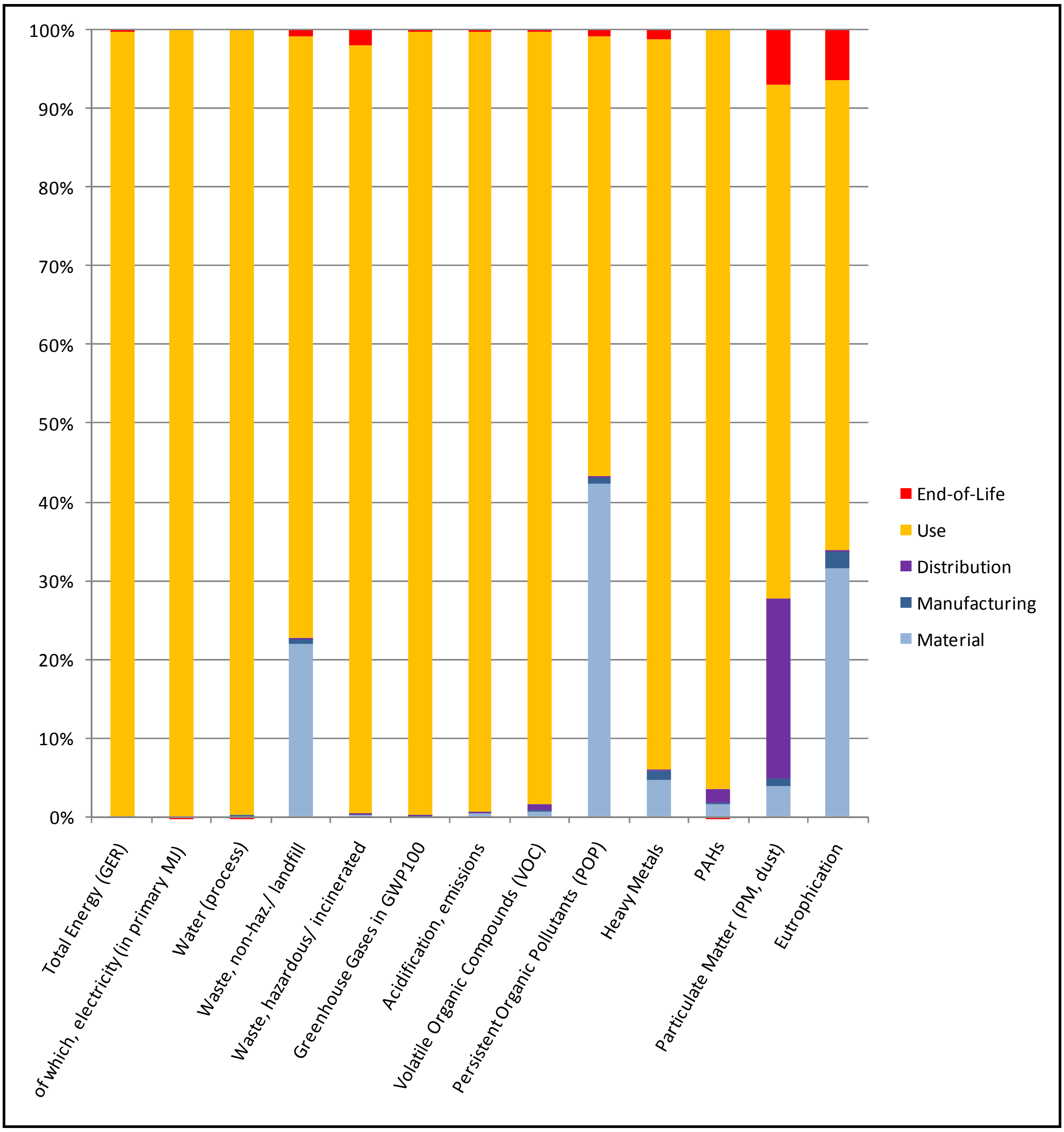

Figure 15 Distribution of environmental impacts of BC D7 per life cycle phase

3.15 Influence of energy sources for water / air heating: Comparison of electricity and alternative energy

Taking the base cases WM1 and D4 as examples, it is possible to make a comparison between the impacts of a machine with only electricity as energy source (to heat the water) and the ones of a machine with only 'alternative' energy source, i.e. other than electricity (to heat the water[9]).

Comparing the results per indicator (Figure 16 to Figure 19), it is noticeable that the use phase has a lower (relative) contribution in the case of equipment using alternative energy sources for water heating. Indeed, in absolute value, the electricity used during the manufacturing phase, the distribution and the end-of-life remains the same for the two options (Table 42 to Table 45). However, since the primary energy and the electricity consumption during the use phase decrease in case of alternative heating, the shares of the other phases increase.

Table 46 and Table 47 compare the total environmental impacts of these two products. The product using an 'alternative' heating source to heat water scores better for all environmental impacts. For the case of professional washing machines, the most relevant reductions are for the electricity consumption and water cooling (-86%), primary energy consumption (-36%), acidification emissions (-58%), and GHG emissions (-19%). For professional dryers, the primary energy reduction would be 54%, the electricity and cooling water would be reduced by 92%, and for other indicators the reduction would be also very high.

This underlines the fact that energy sources do not have the same efficiency and can influence greatly the environmental impacts of a product. In particular, this is the reason why "weighted base cases" were "averaged" between the energy sources, to try to be as representative as possible of the EU-27 situation in the overall results. On the other hand, it points out the improvement potential at infrastructural level given the possibility to change the existing (electricity heating) energy source into a more efficient (alternative heating) one.

The economic impacts of having machines running exclusively on electricity and machines using alternative energy sources for water heating is presented in

Table 48 and Table 49. Since the purchase prices that have been gathered in Task 2 are average prices for the whole market sector, the price of both kinds of machines is assumed to be the same. Therefore, installation (of the machine) and maintenance cost are assumed to be the same as well. The LCC is reduced by 9% for WM1 washing machines and by 47% for D4 laundry dryers when using alternative energy sources. **Thus the better environmental performance of the alternative heated products goes along with important monetary savings for the customer, and no additional costs for the manufacturer.**

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[9] Electricity is still required for electronics and mechanical action (motors, pumps).

Table 42 Life Cycle Impact (per unit) of base case WM1 – Semi-professional washer extractor using only electricity as heating source

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							**debit**	**credit**		
Total Energy (GER)	MJ	3 376	945	4 321	1 101	153 281	925	800	125	158 829
of which, electricity (in primary MJ)	MJ	448	566	1 014	3	111 898	0	15	- 15	112 900
Water (process)	ltr	1 786	8	1 795	-	688 858	-	10	- 10	690 643
Water (cooling)	ltr	1 133	264	1 398	-	298 382	-	82	- 82	299 697
Waste, non-haz./ landfill	g	61 491	3 129	64 620	480	178 168	4 708	58	4 650	247 918
Waste, hazardous/ incinerated	g	180	0	180	10	3 530	9 465	9	9 456	13 175
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	221	53	273	66	6 694	69	49	20	7 054
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO2 eq.	1 954	227	2 181	201	39 527	141	67	74	41 983
Volatile Organic Compounds (VOC)	g	7	0	7	20	60	3	1	2	89
Persistent Organic Pollutants (POP)	ng i-Teq	262	13	275	3	1 006	33	-	33	1 317
Heavy Metals	mg Ni eq.	3 185	30	3 215	24	2 687	253	-	253	6 179
PAHs	mg Ni eq.	322	0	322	44	333	-	1	- 1	698
Particulate Matter (PM, dust)	g	397	35	432	3 230	1 317	1 266	2	1 263	6 242
Emissions (Water)										
Heavy Metals	mg Hg/20	2 057	0	2 057	1	742	75	-	75	2 875
Eutrophication	g PO4	55	0	55	0	69 042	4	0	4	69 101
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Table 43 Life Cycle Impact (per unit) of base case WM1 – Semi-professional washer extractor using only alternative energy source for water heating (and electricity for mechanic parts)

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							**debit**	**credit**		
Total Energy (GER)	MJ	3 376	945	4 321	1 101	95 950	925	800	125	101 498
of which, electricity (in primary MJ)	MJ	448	566	1 014	3	15 115	0	15	- 15	16 117
Water (process)	ltr	1 786	8	1 795	-	682 406	-	10	- 10	684 191
Water (cooling)	ltr	1 133	264	1 398	-	40 294	-	82	- 82	41 609
Waste, non-haz./ landfill	g	61 491	3 129	64 620	480	65 954	4 708	58	4 650	135 703
Waste, hazardous/ incinerated	g	180	0	180	10	1 300	9 465	9	9 456	10 945
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	221	53	273	66	4 652	69	49	20	5 012
Ozone Depletion, emissions	mg R-11 eq.					negligible				
Acidification, emissions	g SO2 eq.	1 954	227	2 181	201	15 241	141	67	74	17 697
Volatile Organic Compounds (VOC)	g	7	0	7	20	52	3	1	2	81
Persistent Organic Pollutants (POP)	ng i-Teq	262	13	275	3	372	33	-	33	682
Heavy Metals	mg Ni eq.	3 185	30	3 215	24	1 026	253	-	253	4 518
PAHs	mg Ni eq.	322	0	322	44	143	-	1	- 1	508
Particulate Matter (PM, dust)	g	397	35	432	3 230	796	1 266	2	1 263	5 721
Emissions (Water)										
Heavy Metals	mg Hg/20	2 057	0	2 057	1	118	75	-	75	2 251
Eutrophication	g PO4	55	0	55	0	69 039	4	0	4	69 098
Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Table 44 Life Cycle Impact (per unit) of base case D4 – Professional air tumble dryer, <15 kg using only electricity as energy source

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							**debit**	**credit**		
Total Energy (GER)	MJ	3 376	945	4 321	1 101	153 281	925	800	125	158 829
of which, electricity (in primary MJ)	MJ	448	566	1 014	3	111 898	0	15	- 15	112 900
Water (process)	ltr	1 786	8	1 795	-	688 858	-	10	- 10	690 643
Water (cooling)	ltr	1 133	264	1 398	-	298 382	-	82	- 82	299 697
Waste, non-haz./ landfill	g	61 491	3 129	64 620	480	178 168	4 708	58	4 650	247 918
Waste, hazardous/ incinerated	g	180	0	180	10	3 530	9 465	9	9 456	13 175
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	221	53	273	66	6 694	69	49	20	7 054
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO2 eq.	1 954	227	2 181	201	39 527	141	67	74	41 983
Volatile Organic Compounds (VOC)	g	7	0	7	20	60	3	1	2	89
Persistent Organic Pollutants (POP)	ng i-Teq	262	13	275	3	1 006	33	-	33	1 317
Heavy Metals	mg Ni eq.	3 185	30	3 215	24	2 687	253	-	253	6 179
PAHs	mg Ni eq.	322	0	322	44	333	-	1	- 1	698
Particulate Matter (PM, dust)	g	397	35	432	3 230	1 317	1 266	2	1 263	6 242
Emissions (Water)										
Heavy Metals	mg Hg/20	2 057	0	2 057	1	742	75	-	75	2 875
Eutrophication	g PO4	55	0	55	0	69 042	4	0	4	69 101
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Table 45 Life Cycle Impact (per unit) of base case D4 – Professional air tumble dryer, <15 kg using only alternative energy source for water heating (and electricity for mechanic parts)

Life Cycle phases / Resources Use and Emissions		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	Total	
Other Resources & Waste							debit	credit		
Total Energy (GER)	MJ	3 376	945	4 321	1 101	95 950	925	800	125	101 498
of which, electricity (in primary MJ)	MJ	448	566	1 014	3	15 115	0	15	- 15	16 117
Water (process)	ltr	1 786	8	1 795	-	682 406	-	10	- 10	684 191
Water (cooling)	ltr	1 133	264	1 398	-	40 294	-	82	- 82	41 609
Waste, non-haz./ landfill	g	61 491	3 129	64 620	480	65 954	4 708	58	4 650	135 703
Waste, hazardous/ incinerated	g	180	0	180	10	1 300	9 465	9	9 456	10 945
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	221	53	273	66	4 652	69	49	20	5 012
Ozone Depletion, emissions	mg R-11 eq.	negligible								
Acidification, emissions	g SO2 eq.	1 954	227	2 181	201	15 241	141	67	74	17 697
Volatile Organic Compounds (VOC)	g	7	0	7	20	52	3	1	2	81
Persistent Organic Pollutants (POP)	ng i-Teq	262	13	275	3	372	33	-	33	682
Heavy Metals	mg Ni eq.	3 185	30	3 215	24	1 026	253	-	253	4 518
PAHs	mg Ni eq.	322	0	322	44	143	-	1	- 1	508
Particulate Matter (PM, dust)	g	397	35	432	3 230	796	1 266	2	1 263	5 721
Emissions (Water)										
Heavy Metals	mg Hg/20	2 057	0	2 057	1	118	75	-	75	2 251
Eutrophication	g PO4	55	0	55	0	69 039	4	0	4	69 098
Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

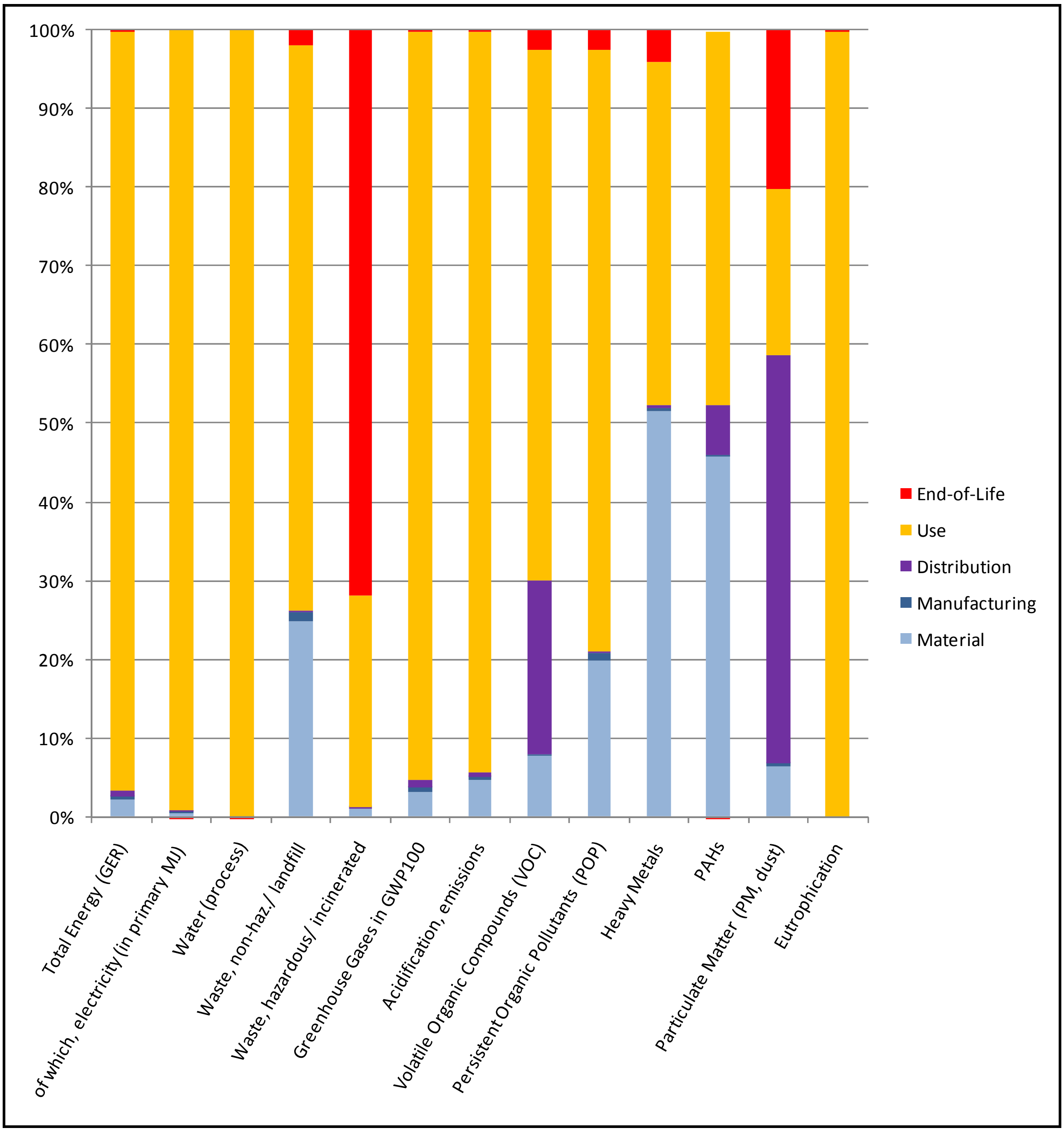

Figure 16 Distribution of environmental impacts of WM1 using only electricity for water heating, per life cycle phase

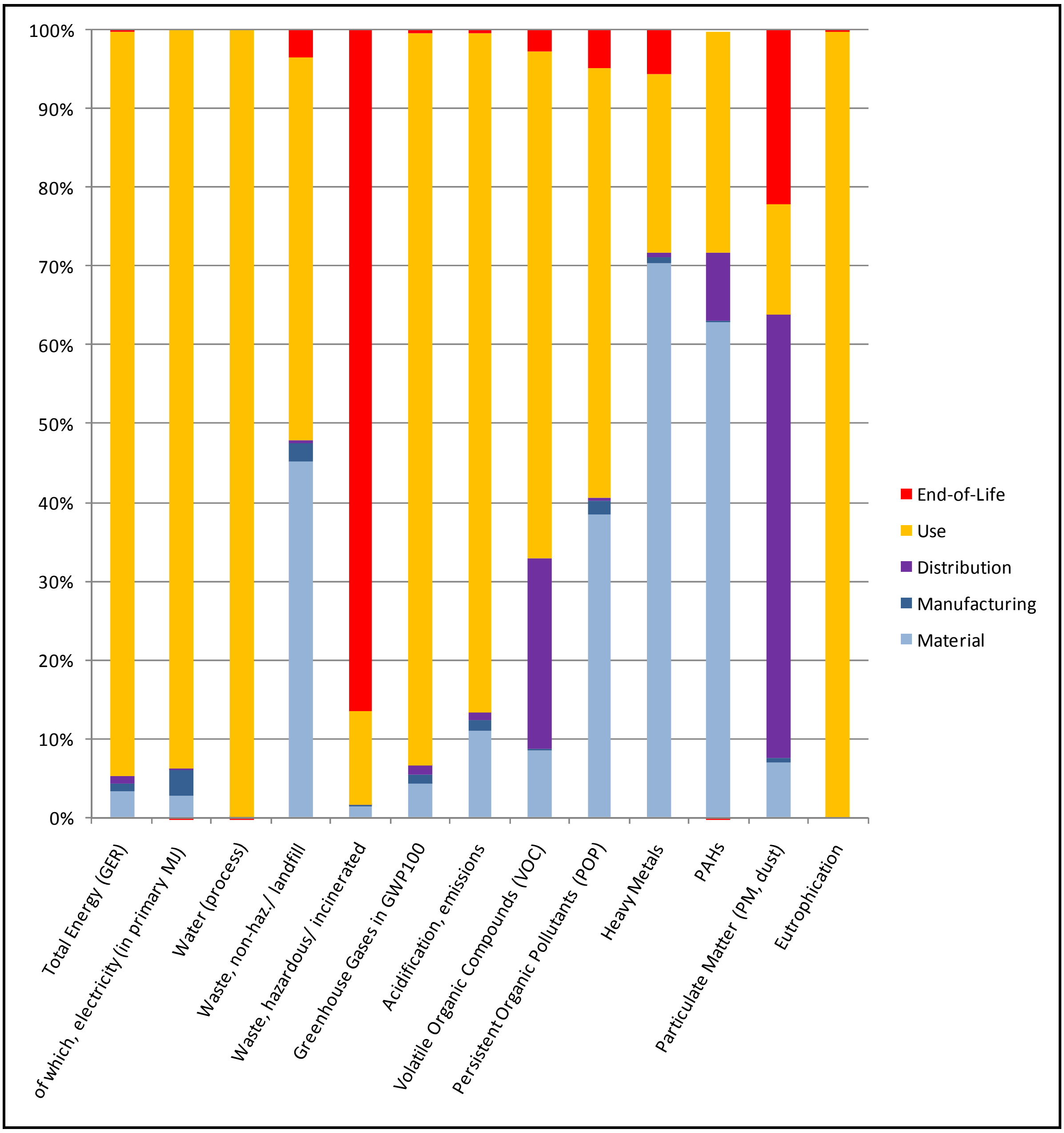

Figure 17 Distribution of environmental impacts of WM1 using only alternative energy source for water heating, per life cycle phase

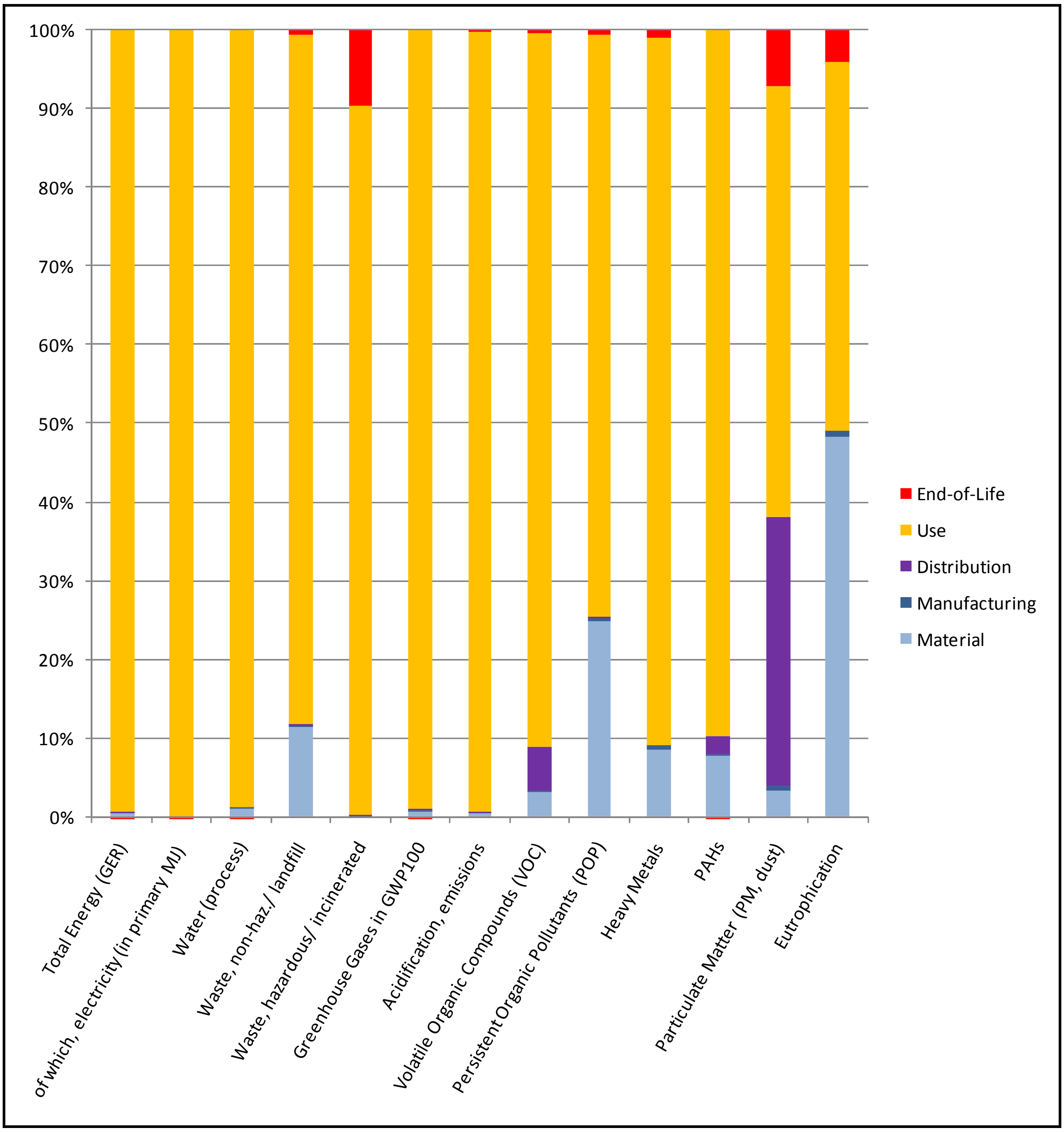

Figure 18 Distribution of environmental impacts of D4 using only electricity for water heating, per life cycle phase

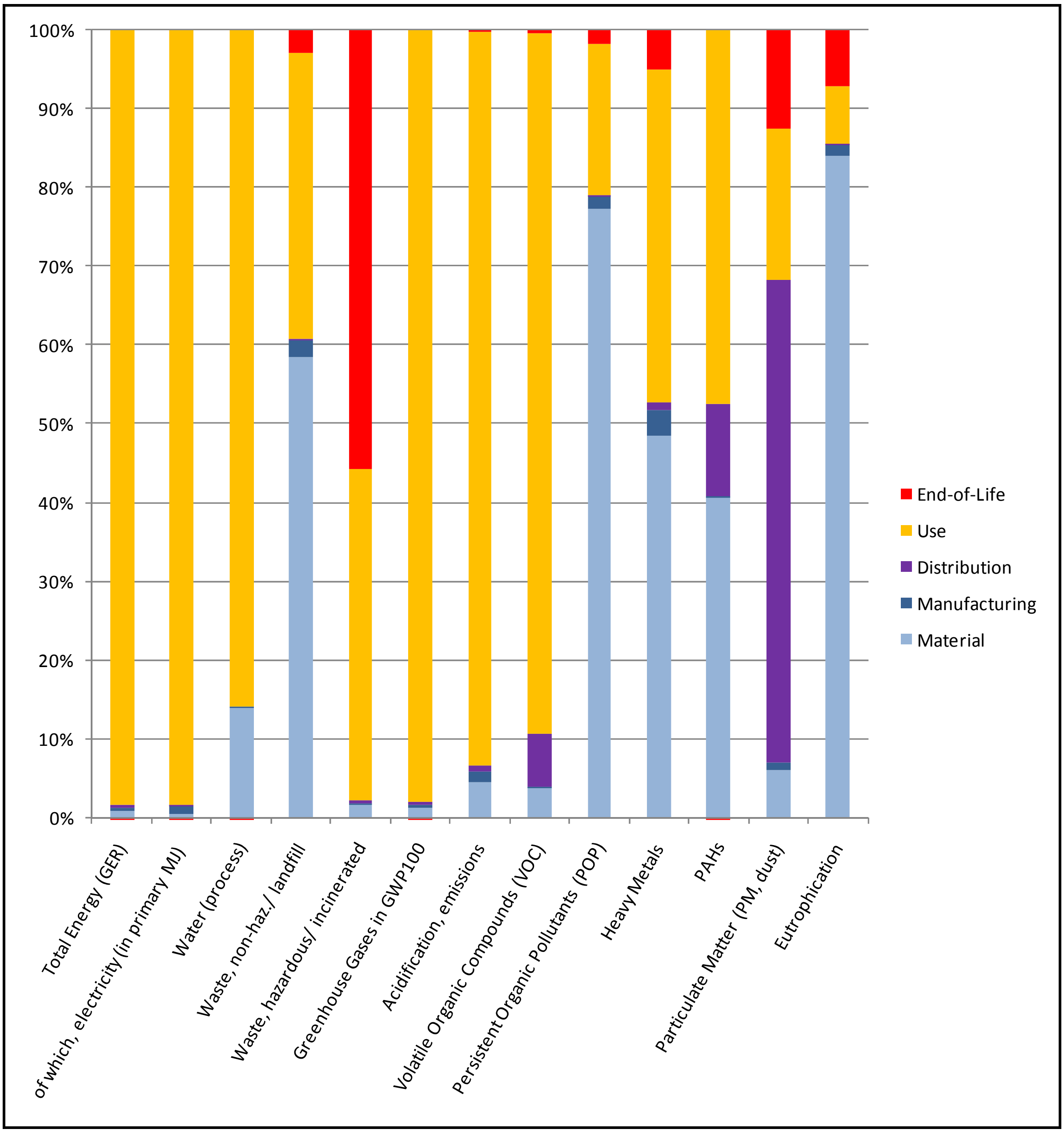

Figure 19 Distribution of environmental impacts of D4 using only alternative energy source for water heating, per life cycle phase

Table 46 Comparison of environmental indicators between WM1 units using only electricity and units using only alternative energy source for water heating[9]

Indicator	Unit	Electricity	Alternative energy source[9]	Variation
Total Energy (GER)	MJ	158 829	101 498	-36%
of which, electricity (in primary MJ)	MJ	112 900	16 117	-86%
Water (process)	ltr	690 643	684 191	-1%
Water (cooling)	ltr	299 697	41 609	-86%
Waste, non-haz./ landfill	g	247 918	135 703	-45%
Waste, hazardous/ incinerated	g	13 175	10 945	-17%
Emissions (Air)				
Greenhouse Gases in GWP100	kg CO2 eq.	7 054	5 012	-29%
Ozone Depletion, emissions	mg R-11 eq.	negligible		
Acidification, emissions	g SO2 eq.	41 983	17 697	-58%
Volatile Organic Compounds (VOC)	g	89	81	-9%
Persistent Organic Pollutants (POP)	ng i-Teq	1 317	682	-48%
Heavy Metals	mg Ni eq.	6 179	4 518	-27%
PAHs	mg Ni eq.	698	508	-27%
Particulate Matter (PM, dust)	g	6 242	5 721	-8%
Emissions (Water)				
Heavy Metals	mg Hg/20	2 875	2 251	-22%
Eutrophication	g PO4	69 101	69 098	0%
Persistent Organic Pollutants (POP)	ng i-Teq	negligible		

Table 47 Comparison of environmental indicators between D4 units using only electricity and units using only alternative energy source for water heating[9]

Indicator	Unit	Electricity	Alternative energy source[9]	Variation
Total Energy (GER)	MJ	1 366 914	627 777	-54%
of which, electricity (in primary MJ)	MJ	1 358 108	110 346	-92%
Water (process)	ltr	91 631	8 446	-91%
Water (cooling)	ltr	3 619 529	292 161	-92%
Waste, non-haz./ landfill	g	1 799 624	352 913	-80%
Waste, hazardous/ incinerated	g	34 688	5 936	-83%
Emissions (Air)				
Greenhouse Gases in GWP100	kg CO2 eq.	59 886	33 555	-44%
Ozone Depletion, emissions	mg R-11 eq.	negligible		
Acidification, emissions	g SO2 eq.	351 961	38 852	-89%
Volatile Organic Compounds (VOC)	g	568	468	-18%
Persistent Organic Pollutants (POP)	ng i-Teq	12 067	3 889	-68%
Heavy Metals	mg Ni eq.	25 989	4 582	-82%
PAHs	mg Ni eq.	3 040	596	-80%
Particulate Matter (PM, dust)	g	15 209	8 489	-44%
Emissions (Water)				
Heavy Metals	mg Hg/20	10 307	2 262	-78%
Eutrophication	g PO4	90	52	-43%
Persistent Organic Pollutants (POP)	ng i-Teq	negligible		

Table 48 Comparison of economic indicators between WM1 units using only electricity for water heating and units using only alternative energy source for water heating[9]

Item	Electricity (€)	Alternative energy source[9] (€)	Variation
Product price	2 670	2 670	0%
Installation/ acquisition costs (if any)	107	107	0%
Fuel (gas, oil, wood)	0	348	-
Electricity	1 238	167	-87%
Water	1 512	1 512	0%
Detergent dishw.	2 168	2 168	0%
Repair & maintenance costs	67	67	0%
Total	**7 761**	**7 039**	**-9%**

Table 49 Comparison of economic indicators between D4 units using only electricity and units using only alternative energy source for water heating[9]

Item	Electricity (€)	Alternative energy source[9] (€)	Variation
Product price	4 000	4 000	0%
Installation/ acquisition costs (if any)	160	160	0%
Fuel (gas, oil, wood)	0	4 094	-
Electricity	13 692	1 095	-92%
Repair & maintenance costs	92	92	0%
Total	**17 944**	**9 441**	**-47%**

3.16 Summary by kg of laundry processed

The environmental impacts per kg of laundry processed for professional washing machines are shown in Table 50. This table takes into account the lifetime of the product and the capacity of laundry processing per annum, and divides the total environmental impacts by the total number of kg of laundry washed over the lifetime. If energy and electricity consumption over the lifetimes are compared this way, the machine that consumes most is the category WM5, with almost 11.513 MJ/kg of primary energy and 1.013 kWh/kg of electricity required, taking into account all life cycle phases of the machine, while the least energy and electricity consuming equipment is the category WM7 with 2.295 MJ/kg and 0.022 kWh_e/kg.

The overall environmental impacts per kg of laundry processed for professional laundry dryers are shown in Table 51. The machine that consumes most is category D3 with 0.944 kWh/kg electricity and 10.05 MJ/kg primary energy required. The least electricity consuming equipment is category D7 with 0.106 kWh/kg and 4.78 MJ/kg of primary energy.

Table 50 Impact of professional washing machines per kilogram of laundry

Impact per kg of processed laundry, over the lifetime	WM1	WM2	WM3	WM4	WM5	WM6	WM7
Annual capacity (kg of laundry)	7 000	14 400	42 200	194 400	7 400	56 300	3 825 000
Lifetime (years)	8	12	14	15	11	14	13
Total Energy (GER) (in MJ)	2.427	2.602	2.563	3.496	11.513	3.805	2.295
of which electricity (in kWh)	0.126	0.140	0.126	0.153	1.013	0.163	0.022
Water process (in million m^3)	12.287	16.352	17.674	16.938	14.316	19.375	7.239
Waste, non-hazardous/landfill (in kt)	3.626	4.614	2.913	4.306	22.055	4.390	1.027
Waste, hazardous/ incinerated (in kt)	0.219	0.106	0.081	0.079	0.428	0.139	0.018
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	0.111	0.120	0.119	0.167	0.513	0.184	0.121
Acidification, emissions (in kt SO_2 eq.)	0.576	0.614	0.530	0.640	3.011	0.686	0.189
Volatile Organic Compounds (VOC) (in kt)	0.002	0.002	0.001	0.002	0.006	0.002	0.002
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.019	0.035	0.020	0.025	0.179	0.029	0.006
Heavy Metals (in ton Ni eq.)	0.098	0.092	0.070	0.071	0.289	0.133	0.040
PAHs (in ton Ni eq.)	0.011	0.014	0.005	0.012	0.045	0.010	0.002
Particulate Matter (PM, dust) (in kt)	0.108	0.056	0.045	0.036	0.216	0.066	0.010
Heavy Metals (ton Hg/20)	0.047	0.051	0.031	0.033	0.169	0.066	0.020
Eutrophication (in t PO4)	1.234	1.229	1.015	1.158	1.016	1.159	0.579

Table 51 Impact of professional dryers per kilogram of laundry

Impact per kg of processed laundry, over the lifetime	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
Annual capacity (kg of laundry)	6 500	6 500	6 300	14 400	40 500	168 000	1 020 000
Lifetime (years)	8	8	15	13	14	13	13
Total Energy (GER) (in MJ)	8.024	6.042	10.047	5.132	5.318	5.888	4.779
of which electricity (in kWh)	0.754	0.471	0.944	0.342	0.290	0.241	0.106
Water process (in million m^3)	0.597	0.395	0.680	0.245	0.215	0.175	0.074
Waste, non-hazardous/landfill (in kt)	11.242	7.753	14.728	5.363	4.690	3.563	1.688
Waste, hazardous/ incinerated (in kt)	0.391	0.301	0.290	0.101	0.099	0.074	0.026
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	0.354	0.279	0.442	0.243	0.259	0.297	0.252
Acidification, emissions (in kt SO_2 eq.)	2.111	1.359	2.595	0.960	0.836	0.713	0.347
Volatile Organic Compounds (VOC) (in kt)	0.004	0.003	0.005	0.003	0.003	0.004	0.003
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.060	0.041	0.098	0.040	0.033	0.024	0.013
Heavy Metals (in ton Ni eq.)	0.248	0.191	0.190	0.076	0.064	0.050	0.021
PAHs (in ton Ni eq.)	0.025	0.019	0.045	0.009	0.009	0.007	0.003
Particulate Matter (PM, dust) (in kt)	0.130	0.108	0.158	0.068	0.047	0.033	0.015
Heavy Metals (ton Hg/20)	0.129	0.106	0.092	0.031	0.033	0.024	0.008
Eutrophication (in t PO4)	0.002	0.002	0.001	0.000	0.000	0.000	0.000

3.17 Conclusions

The results of the impact assessments are very similar for the fourteen base cases, not in absolute values but in the predominance of certain elements on the environmental impacts:

- For all base cases, the use phase is by far the most important phase contributing to the environmental impacts, especially energy and electricity consumption. Logically, this influence increases with the number of cycles per year of the product and the energy consumption per cycle, i.e. for larger machines. This is applicable for both professional washing machines and professional dryers.
- Professional washing machines also contribute to eutrophication potential and water use, due to the detergent use and the energy and water consumption inherent to the process. The performance of these machines could be improved to reduce the amount of water and detergent used during the use phase.
- The extraction of the materials needed for the production phase has the second highest influence in general. This is a consequence of the large amount of metals used. Being a structural part of the machines, no significant improvement potential is expected. The manufacturing phase impact is negligible for all base cases and all environmental indicators.
- Distribution is always negligible except for the emissions of particulate matter, which are due to the transportation of the appliances, which is inevitable to a certain degree. Manufacturing lighter machines would reduce this impact but is not considered as a priority option (and manufacturers probably already optimise this aspect).
- The end-of-life phase mainly contributes to the quantity of hazardous waste generated. However, this indicator is only an intermediate indicator as the consequences of the management of the hazardous waste (often through incineration) are also accounted for in the emissions environmental impacts, where no major contribution of this phase appears. As no harmful compound has been identified in the bill of materials, it is unlikely that any improvement option will reduce the impacts of this phase.

Looking at the results of the previous eco-design preparatory studies on domestic laundry machines (Lot 14 and Lot 16 for former DG TREN), the environmental analysis of the base cases shows many similarities. The use phase is the most impacting one in terms of energy and eutrophication (professional washing machines). Concerning emissions, the use phase is also the main contributor to greenhouse gases, acidification and VOCs. Similarly, the production phase contributes to PAHs and heavy metals emissions and the distribution phase contributes to particulate matter emissions (although the use phase remains the main contributor). The material that has the most influence during the production phase is steel. Energy consumption and water use are also identified as the most relevant elements in the use phase. The differences in the results of these studies concern the total of energy and emissions generated. Professional machines consume more overall due to the intensity of use and therefore produce more emissions.

4 Base case life cycle costs

The capital cost does not necessarily indicate the cheapest Life Cycle Cost (LCC). The lowest LCC should take into consideration the consumables expenditure and the specific use rate of the machines. Table 52 and Table 53 present the details of the LCC breakdowns for each base case.

Table 52 EcoReport outcomes of the LCC calculations of the professional washing machine base cases

Item	WM1	WM2	WM3	WM4	WM5	WM6	WM7
Product price (€)	2 670	5 000	15 250	58 750	8 000	38 250	390 000
Installation (€)	107	200	610	2 350	320	1 530	35 100
Repair and maintenance costs (€)	67	117	345	10 887	191	7 215	74 892
Electricity cost (€)	809	2 563	5 854	29 617	6 807	10 089	72 189
Gas (€)	139	441	2 409	20 353	0	7 344	535 976
Water cost (€)	1 512	5 780	20 653	95 863	2 310	30 144	726 013
Detergent/Rinse aid cost (€)	2 168	6 194	16 859	93 372	2 453	25 690	825 014
Life Cycle Cost (€)	**7 472**	**20 295**	**61 980**	**311 192**	**20 081**	**120 262**	**2 659 184**

Table 53 EcoReport outcomes of the LCC calculations of the professional laundry dryer base cases

Item	D1	D2	D3	D4	D5	D6	D7
Product price (€)	1 970	1 680	3 500	4 000	7 125	21 500	62 500
Installation (€)	79	67	140	160	285	860	5 625
Repair and maintenance costs (€)	50	42	78	92	161	2 973	8 641
Electricity cost (€)	4 531	2 823	9 089	6 764	12 953	36 191	96 802
Gas (€)	0	457	0	2 252	8 935	46 038	306 057
Life Cycle Cost (€)	**6 630**	**5 070**	**12 807**	**13 268**	**29 460**	**107 561**	**479 625**

Figure 20 and Figure 21 show the contributions of the product price and the resources and consumables costs for each base case LCC. This data is also presented in percentage terms in Table 54 and Table 55.

For professional washing machines, the aggregated costs of detergent, water and purchase price represent from 75% to 85% of the total LCC for all categories but WM5. In the case of

WM5 this aggregate value is less, about 65%. The consumable cost (aggregate value of electricity, water, detergent and gas consumption) represent between 60 to 80% for all base cases. The maintenance and installation costs are the categories with the lower value for all the base cases. Base case WM5 is the only one where the electricity costs are substantial (more than 30% of the LCC). This is consequence of the additional drying function of the machine.

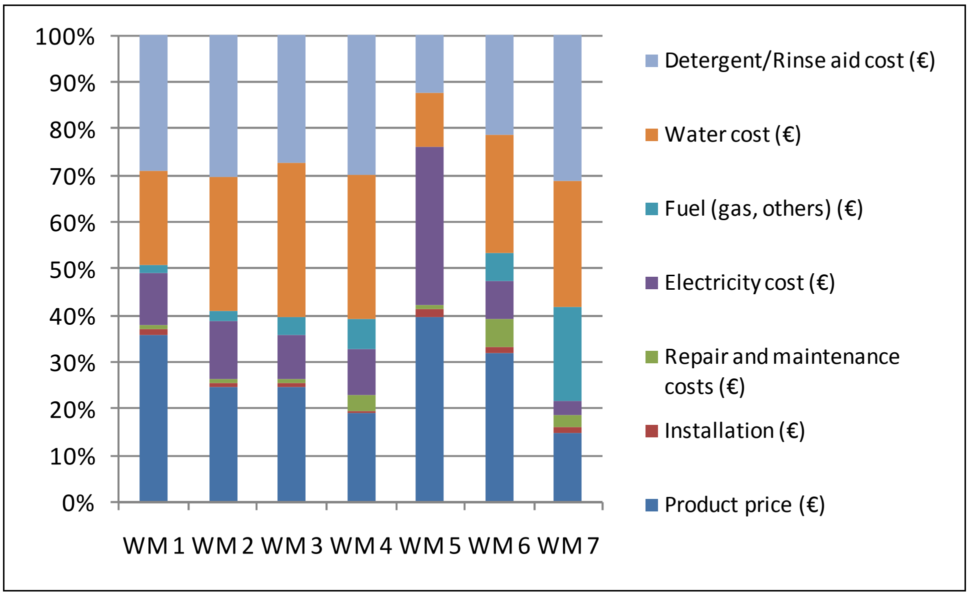

Figure 20 Breakdown of professional washing machines base cases' LCC

Regarding professional dryers, the energy costs always represent between 65% (D2) and 85% (D7) of the total LCC, which underlines the important monetary savings potential in case of a better energy efficiency of the dryer.

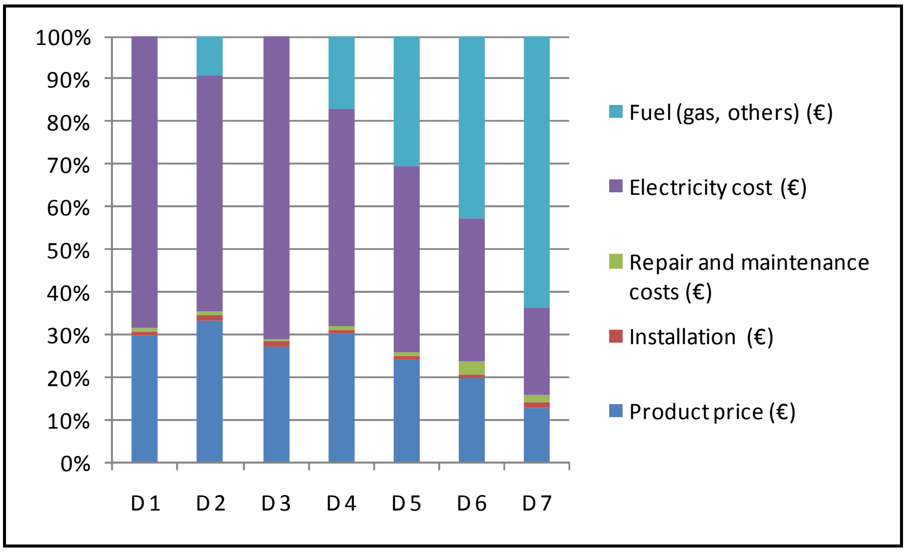

Figure 21 Breakdown of professional laundry dryer base cases' LCC

Table 54 Expenditure cost proportion for professional washing machines

Item	WM1	WM2	WM3	WM4	WM5	WM6	WM7
Product price (%)	36%	25%	25%	19%	40%	32%	15%
Installation (%)	1%	1%	1%	1%	2%	1%	1%
Repair and maintenance costs (%)	1%	1%	1%	3%	1%	6%	3%
Electricity cost (%)	11%	13%	9%	10%	34%	8%	3%
Gas (%)	2%	2%	4%	7%	0%	6%	20%
Water cost (%)	20%	28%	33%	31%	12%	25%	27%
Detergent/Rinse aid cost (%)	29%	31%	27%	30%	12%	21%	31%
Life Cycle Cost (%)	100%	100%	100%	100%	100%	100%	100%

Table 55 Expenditure cost proportion for professional dryers

Item	D1	D2	D3	D4	D5	D6	D7
Product price (%)	30%	33%	27%	30%	24%	20%	13%
Installation (%)	1%	1%	1%	1%	1%	1%	1%
Repair and maintenance costs (%)	1%	1%	1%	1%	1%	3%	2%
Electricity cost (%)	68%	56%	71%	51%	44%	34%	20%
Gas (%)	0%	9%	0%	17%	30%	43%	64%
Life Cycle Cost (%)	100%	100%	100%	100%	100%	100%	100%

5 EU totals

This section provides the environmental assessment of the base cases at the EU-27 level using stock and market data from task 2. The total impacts cover:

- The life cycle environmental impact of the new products in 2009 (i.e. impacts of the sales);
- The annual (2009) impact of production, use and disposal of the product group and the total LCC (i.e. impact and LCC of the stock – see Section 2.6).

5.1 Market data

Table 56 and Table 57 illustrate the market data of the base cases in EU-27 in 2009.

Table 56 Market and technical data for professional washing machines base cases in 2009

Base case	Lifetime (years)	Annual sales (units/year)	% of the total washing machines sales	EU stock (units)	% of the total washing machines stock
WM1	8	25 000	32%	193 138	24%
WM2	12	45 500	58%	557 279	65%
WM3	14	6 200	8%	81 378	9%
WM4	15	200	0%	2 799	0%
WM5	11	200	0%	2 093	0%
WM6	14	850	1%	10 470	1%
WM7	13	250	0%	3 062	0%

Table 57 Market and technical data for professional dryers base cases in 2009

Base case	Lifetime (years)	Annual sales (units/year)	% of the total dryers sales	EU stock (units)	% of the total dryers stock
D1	8	3 200	8%	24 722	6%
D2	8	4 300	11%	33 220	8%
D3	15	10 700	27%	149 738	29%
D4	13	16 000	41%	195 966	43%
D5	14	3 500	9%	45 939	10%
D6	13	300	1%	3 674	1%
D7	13	1 200	3%	14 697	4%

5.2 Life cycle environmental impacts

Table 58 shows the total environmental impacts of all products in operation in EU-27 in 2009, based on the extrapolation of the base cases impacts (all have the same impacts as the base case of their category).

Table 58 Environmental impacts of the EU-27 stock in 2009 for professional washing machines BC

Environmental Impact	WM1	WM2	WM3	WM4	WM5	WM6	WM7
Total Energy (GER) (in PJ)	4.2	26.9	11.4	2.5	0.2	2.9	34.9
of which electricity (in primary PJ)	2.3	15.3	5.9	1.1	0.2	1.3	3.4
Water process (in million m^3)	21.6	170.5	78.9	12.0	0.3	14.8	110.2
Waste, non-hazardous/landfill (in kt)	5.9	42.8	12.5	2.8	0.4	3.2	14.6
Waste, hazardous/ incinerated (in kt)	0.3	1.0	0.3	0.1	0.0	0.1	0.3
Emissions to air							
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	0.2	1.2	0.5	0.1	0.0	0.1	1.8
Acidification, emissions (in kt SO_2 eq.)	1.0	6.3	2.3	0.4	0.1	0.5	2.8
Volatile Organic Compounds (VOC) (in kt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.0	0.3	0.1	0.0	0.0	0.0	0.1
Heavy Metals (in ton Ni eq.)	0.2	0.8	0.3	0.0	0.0	0.1	0.5
PAHs (in ton Ni eq.)	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Particulate Matter (PM, dust) (in kt)	0.2	0.5	0.2	0.0	0.0	0.0	0.1
Emissions to water							
Heavy Metals (ton Hg/20)	0.1	0.4	0.1	0.0	0.0	0.0	0.2
Eutrophication (in mt PO4)	2.2	12.8	4.5	0.8	0.0	0.9	8.8

Table 59 Environmental impacts of the EU-27 stock in 2009 for professional dryers BC

Environmental Impact	D1	D2	D3	D4	D5	D6	D7
Total Energy (GER) (in PJ)	1.7	1.7	12.3	18.8	12.8	4.7	93.1
of which electricity (in primary PJ)	1.7	1.4	12.1	13.2	7.4	2.0	21.7
Water process (in million m^3)	0.1	0.1	0.8	0.9	0.5	0.1	1.4
Waste, non-hazardous/landfill (in kt)	2.3	2.1	17.4	18.9	10.8	2.8	31.5
Waste, hazardous/ incinerated (in kt)	0.1	0.1	0.3	0.4	0.2	0.1	0.5

Environmental Impact	D1	D2	D3	D4	D5	D6	D7
Emissions to air							
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	0.1	0.1	0.5	0.9	0.6	0.2	4.9
Acidification, emissions (in kt SO_2 eq.)	0.4	0.4	3.2	3.5	2.0	0.6	6.8
Volatile Organic Compounds (VOC) (in kt)	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.0	0.0	0.1	0.1	0.1	0.0	0.2
Heavy Metals (in ton Ni eq.)	0.0	0.0	0.2	0.3	0.2	0.0	0.4
PAHs (in ton Ni eq.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Particulate Matter (PM, dust) (in kt)	0.0	0.0	0.2	0.2	0.1	0.0	0.2
Emissions to water							
Heavy Metals (ton Hg/20)	0.0	0.0	0.1	0.1	0.1	0.0	0.2
Eutrophication (in mt PO4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0

A summary of the contribution of the base cases stock to the environmental impacts as a percentage of the total impacts is presented in Figure 22 and Figure 23.

As the figure shows for professional washing machines, the base case WM2 has the greatest impact in almost all indicators. The main reason behind is the high market share represented by this category (around 60%). The base case WM7 has the second greatest impact in almost all categories, despite its low sales, which highlights the high consumption and use rate of the high capacity machines. Then the base cases WM1 and WM3 come. The aggregated value of WM4, WM5 and WM6 contributions in all impact indicators is only around 10%.

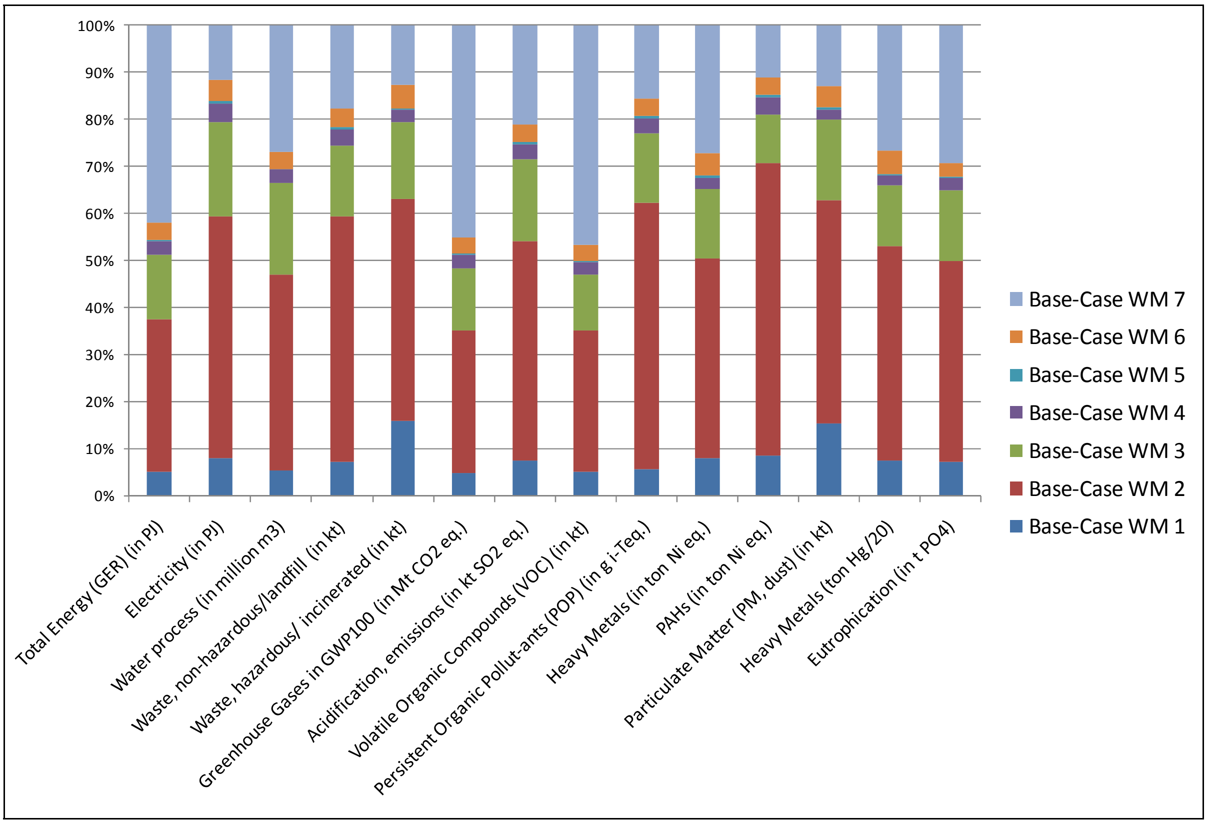

Figure 22 Professional washing machine base cases' share of the environmental impacts of the 2009 stock

For the case of professional dryers, the category D7 has the greatest impact for all indicators but eutrophication. The contributions of categories D3-4-5 are considered to be important as well. Eutrophication is the indicator with the most homogenous shares.

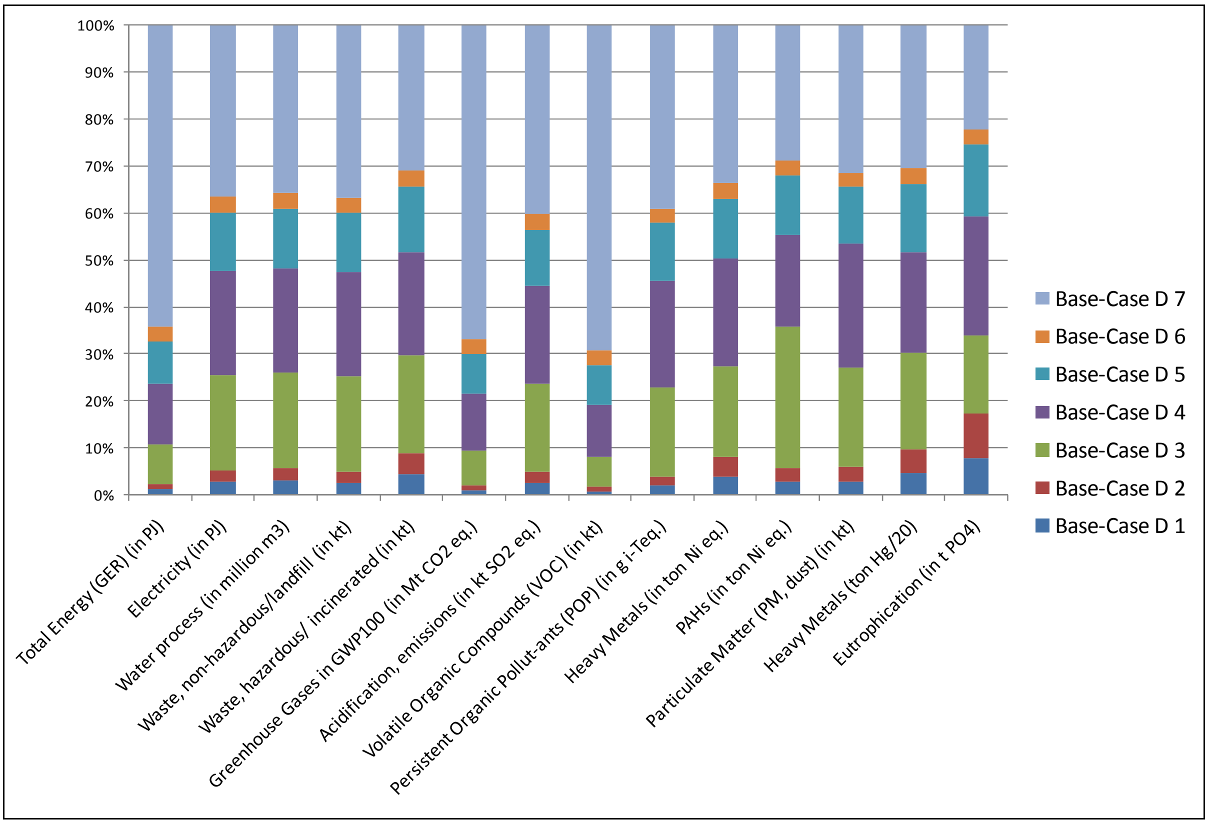

Figure 23 Professional dryer base cases' share of the environmental impacts of the 2009 stock

The total energy and electricity consumption per category is shown in Figure 24 for professional washing machines and in Figure 25 for professional laundry dryers.

The primary energy consumption for base case WM7 is by far the highest of all base cases (42% of the overall consumption). However, the electricity consumption of WM2 stock is about four times higher (52% of overall consumption) than the electricity consumption of the stock of base case WM7.

Although the market share of WM7 is almost 0%, these machines use as much as 43% of the total primary energy. The total amount of primary energy used by all professional washing machines over their lifecycles is 83.0 PJ per year (2009).

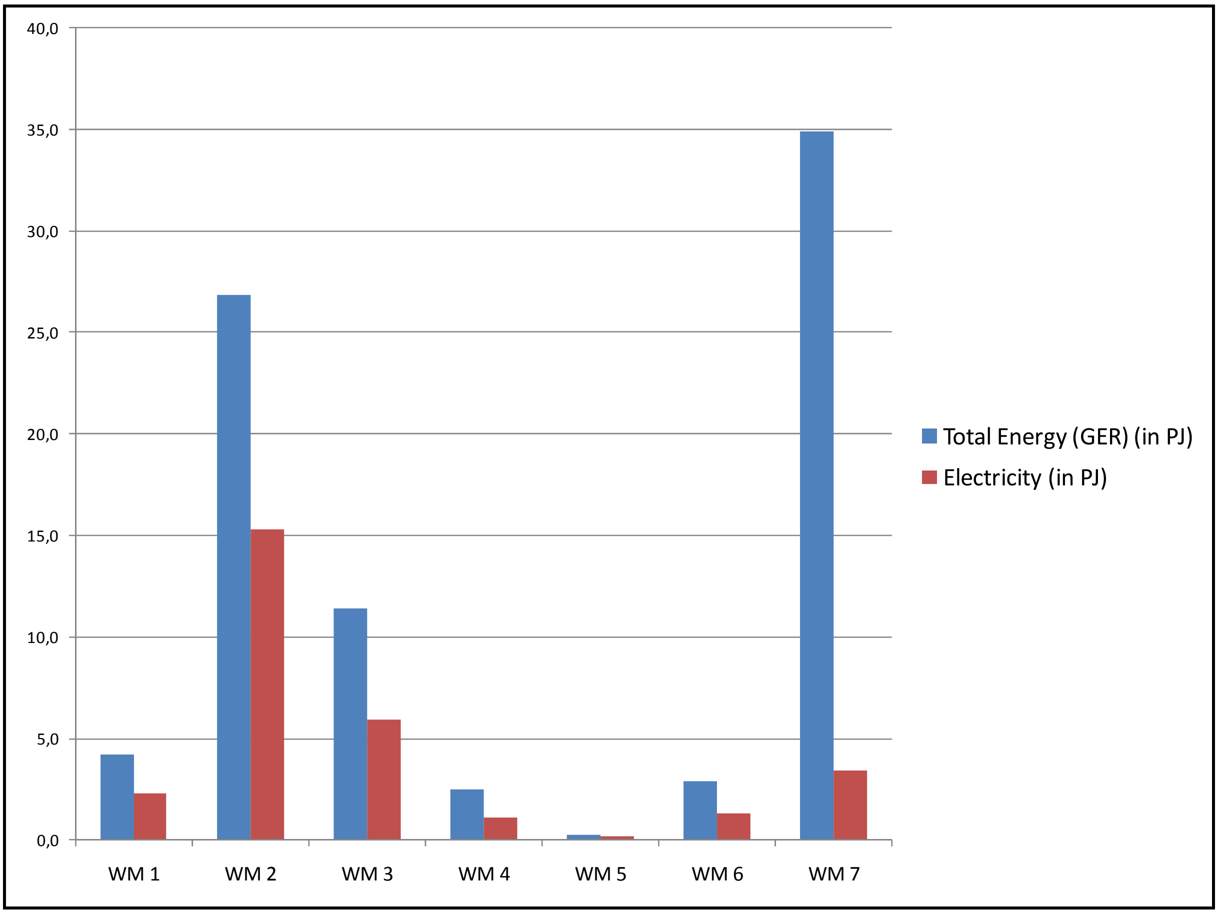

Figure 24 Energy/electricity consumption of the 2009 stock, per washing machine base case

Similarly to washing machines, larger dryers have the highest consumption by their stock. Category D7 represents 64% of the total consumption of all professional laundry dryers. The aggregate of categories D3, D4 and D5 represents 30% of the total energy consumption. In terms of electricity, the consumption for these 4 categories is more similar. The electricity consumption for D7 counts for 36% of the total, while for D3, D4 and D5 the consumption represents 20%, 22% and 12% respectively. These categories therefore represent the major part of the energy saving potential. The total primary energy consumption for all dryers together is 145.1 PJ. The total electricity consumption is 59.4 PJ (primary energy).

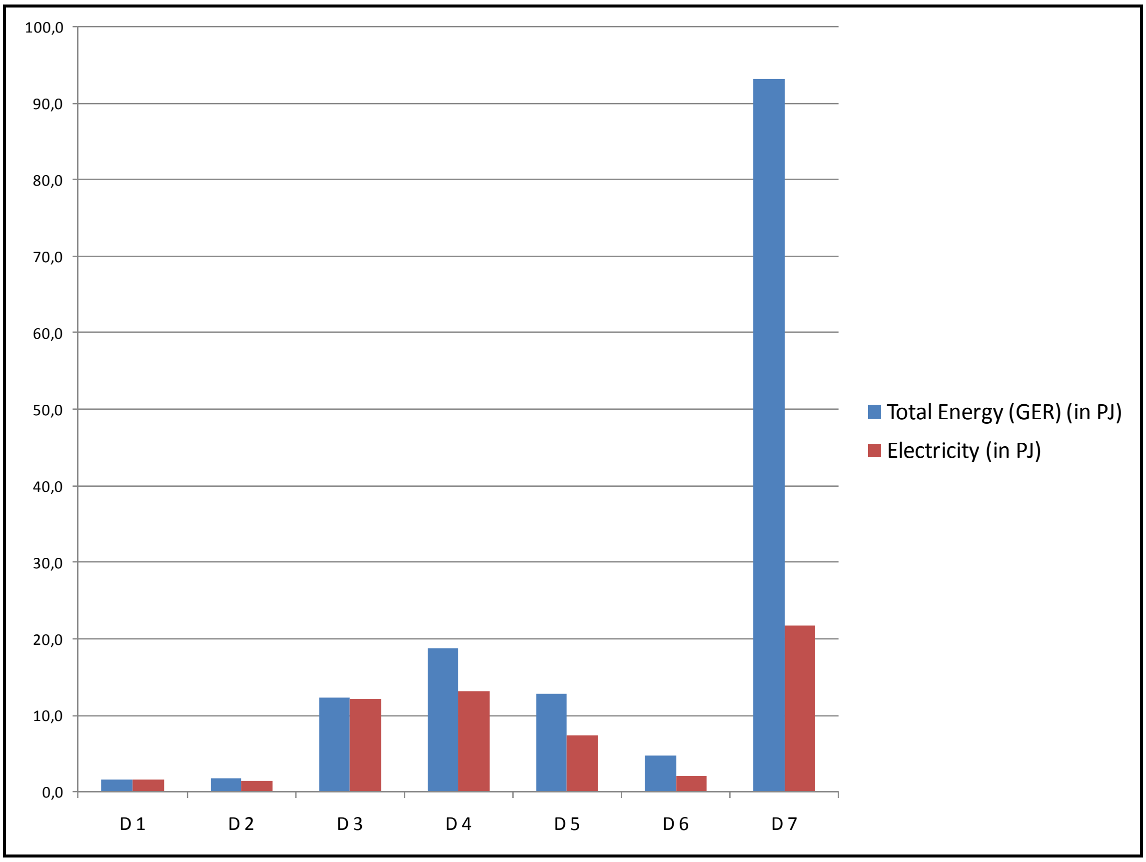

Figure 25 Energy/electricity consumption of the 2009 stock, by dryer base case

5.3 Life cycle costs

Regarding the total consumer expenditure in 2009 related to professional washing machines, between 3 to 13% of the total cost is due to electricity consumption, except for category WM5 whose electricity costs are up to 41% of total expenditure. The water costs vary from 25 to 40% for all categories, except for WM5 where they represent only around 14% of the total expenditure. The costs of detergent represent between 20 to 29% for all categories but for WM5 (11%). The costs of gas only has a substantial contribution for category WM7, accounting for 23% of the total expenditure. The cost breakdown per category is presented in Table 60 for professional washing machines.

In the case of professional dryers (Table 61), the electricity costs represent more than 75% of the annual expenditure for D1 and D3, and more than 55% for D2 and D4. Gas costs have their most important contributions for D7 and D6 (68 and 48% respectively). For almost all categories the purchase price represents between 14 to 25% of the total annual expenditure, but for D7 (9%).

Table 60 Total Annual Consumer expenditure for professional washing machines in EU-27 in 2009

Item	WM1	WM2	WM3	WM4	WM5	WM6	WM7	Total
EU-27 sales (in units)	0.02500	0.04550	0.00620	0.00020	0.00020	0.00085	0.00025	0.07820
Share of the EU-27 sales	32%	58%	8%	0%	0%	1%	0%	100%
Product Price(in million €)	67	228	95	12	2	33	98	532
Installation (in million €)	3	9	4	0	0	1	9	26
Electricity (in million €)	30	198	59	10	2	13	29	340
Fuel (gas, others) (in million €)	5	34	24	7	0	9	214	293
Water (in million €)	56	446	207	31	1	39	289	1 070
Detergent (in million €)	62	368	130	24	1	25	253	862
Repair and maintenance costs (in million €)	2	7	3	3	0	7	23	44
Total (in million €)	225	1 289	520	86	5	128	914	3 168

Table 61 Total Annual Consumer expenditure for professional dryers in EU-27 in 2009

Item	D1	D2	D3	D4	D5	D6	D7	Total
EU-27 sales (in units)	0.00320	0.00430	0.01070	0.01600	0.00350	0.00030	0.00120	0.03920
Share of the EU-27 sales	8%	11%	27%	41%	9%	1%	3%	100%
Product Price(in million €)	6	7	37	64	25	6	75	221
Installation (in million €)	0	0	1	3	1	0	7	13
Electricity (in million €)	22	18	159	173	73	17	185	647
Fuel (gas, others) (in million €)	0	3	0	57	51	22	586	719
Repair and maintenance costs (in million €)	0	0	1	2	1	1	13	18
Total (in million €)	28	29	199	298	150	47	865	1 617

From an overall perspective, the most important contribution to the annual expenditure is given by the category WM2 (41%) closely followed by category WM7 (29%) for the professional washing machines and by the category D7 (54%) for the professional laundry dryers. This is the consequence of a balance between the market shares, the operating costs per cycle and the lifetimes.

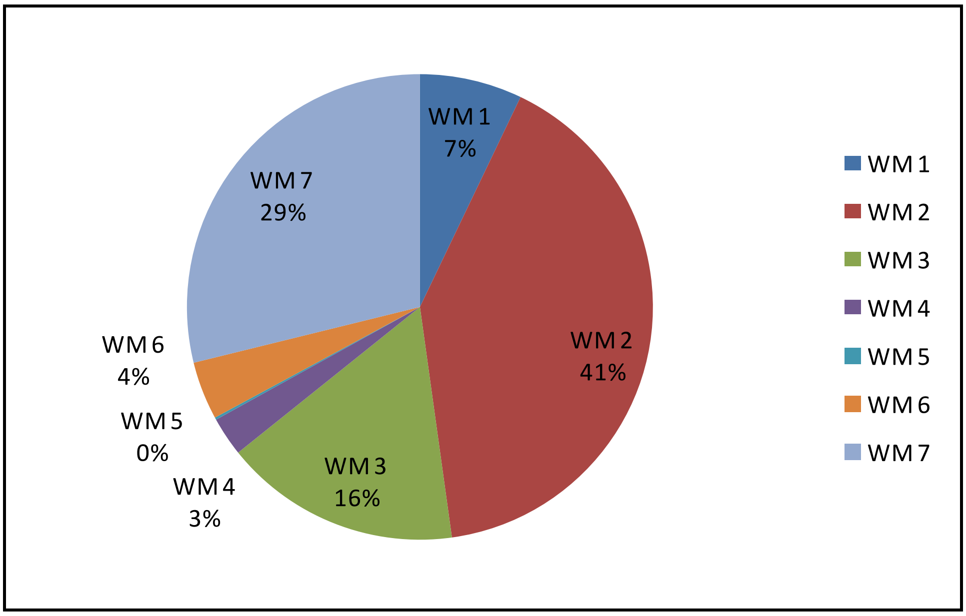

Figure 26 Base cases' share of the total consumer expenditure for professional washing machines in 2009

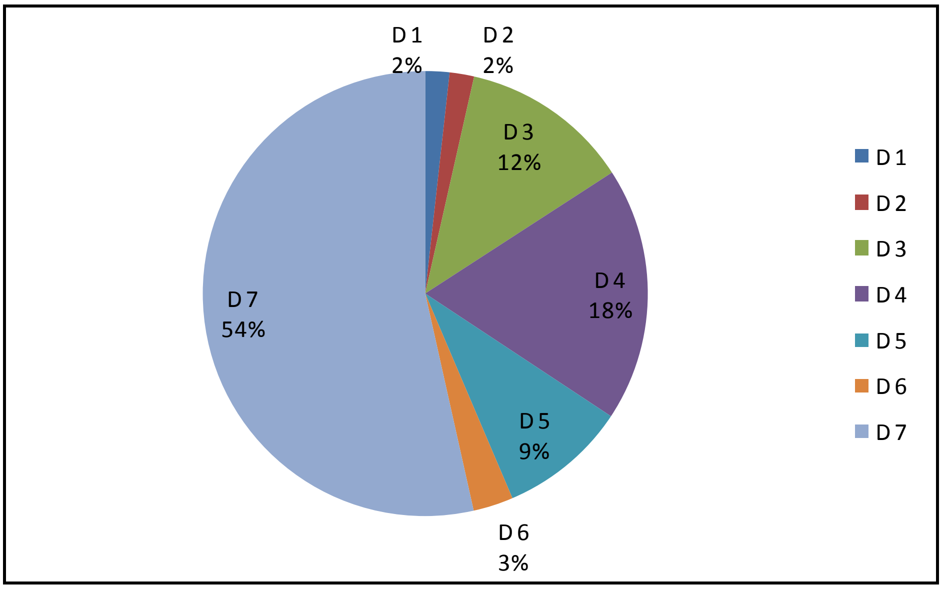

Figure 27 Base cases' share of the total consumer expenditure for professional dryers in 2009

6 EU-27 total system impact

Washing machines transfer heat to the water, or the air in the case of dryers, and to the laundry during their operation. The residual heat is normally transferred to the room if no specific heat recovery options are implemented. The environmental impacts of this heat transfer can be positive or negative:

- The climate: If the room needs to be heated, the hot laundry will complement the heating system. On the contrary, if the room needs to be cooled (not a common situation for professional premises), operating the laundry machines will require additional energy consumption from the ventilation/air conditioning system. A heat recovery system or a heat pump will reduce the energy consumption of the equipment itself, and also saves the extra work needed from the ventilation system in comparison with a basic machine, for which the extra heat is not re-used and has to be evacuated by the ventilation system, thus consuming energy.
- The energy source of the machines and of the heating system: electricity needs to be produced from primary energy, generally with low efficiency. If the appliance only uses electricity as an energy source, central heating systems will be much more efficient and indirect room heating due to the laundry equipment will reduce the global efficiency of the heating process.

Due to huge differences between Member States and appliances, no global heat transfer can be estimated at EU level with reliability.

The infrastructure of the building where the laundry equipment is installed also has an influence on the possible options to reduce the energy consumption of the system. Some of the base cases are considered as a mixture of different energy supplies (electricity and alternative). As seen in Section 3.15, the use of alternative heating can decrease the total energy and electricity consumption. Even if this alternative energy does not reduce the final energy needed at the level of the machine, the energy generation is more efficient.

7 Conclusions

The environmental impact assessments carried out with the EcoReport tool for each base case show that the use phase is by far the most impacting stage of the life cycle in terms of energy consumption, water consumption, greenhouse-gas emissions and, in the case of all professional washing machines, eutrophication. Therefore, the analysis of the improvement potential in Tasks 6 and 7 will mainly focus on technologies that reduce the energy, water and detergent consumption during the use phase of the machines.

Due to the market share, the categories WM2 for professional washing machines and D4 for professional laundry dryers have the most important impacts, both in environmental and economic terms. Although the market shares for categories WM7 and D7 are much lower, their influence on the energy consumption and on the annual expenditure are very important as well.

Task 6 will examine the relevant improvement options of professional laundry machines considered as best available technologies, in an attempt to improve upon the base cases.

8 Annex

8.1 Detailed bills of materials of the base cases

Bill of material of Base case WM1

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless Steel	20606.0	3-Ferro	25-Stainless 18/8 coil
2	Steel Sheet galvanized	564.0	3-Ferro	21-St sheet galv.
3	Cast Iron	11192.0	3-Ferro	23-Cast iron
4	Polypropylen (PP)	8021.0	1-BlkPlastics	4-PP
5	Polyamid (PA)	94.0	2-TecPlastics	11-PA 6
6	Polycarbonate	190.0	2-TecPlastics	12-PC
7	Epoxy	260.0	2-TecPlastics	14-Epoxy
8	Acrylonitrile Butadiene Styrene (ABS)	1145.0	1-BlkPlastics	10-ABS
9	Plystyrene (PS)	678.0	1-BlkPlastics	5-PS
10	Polybutylene Terephthalate (PBT)	8.0	1-BlkPlastics	
11	Polyvinylchlorid (PVC)	221.0	1-BlkPlastics	8-PVC
12	EPDM-rubber	1752.0	1-BlkPlastics	1-LDPE
13	Plastics others	1101.0	1-BlkPlastics	2-HDPE
14	Aluminium	2233.0	4-Non-ferro	26-Al sheet/extrusion
15	Cu wire	1305.0	4-Non-ferro	29-Cu wire
16	CuZn38 cast	99.0	4-Non-ferro	31-CuZn38 cast
17	Chrom	1761.0	4-Non-ferro	
18	Bitumen	38.0	7-Misc.	55-Bitumen
19	Concrete	18205.0	7-Misc.	58-Concrete
20	Glass	1773.0	7-Misc.	54-Glass for lamps
21	Wood	2452.0	7-Misc.	56-Cardboard
22	Electronics (control)	165.0	6-Electronics	98-controller board

Bill of material of Base case WM2

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	52625.0	3-Ferro	25-Stainless 18/8 coil
2	Galvanized steel	105250.0	3-Ferro	21-St sheet galv.
3	Cast Iron	18945.0	3-Ferro	23-Cast iron
4	Plastics (PP. Polyester. ABS etc.)	5200.0	1-BlkPlastics	4-PP
5	Zinc	630.0	4-Non-ferro	32-ZnAl4 cast
6	Aluminium	13900.0	4-Non-ferro	26-Al sheet/extrusion
7	Copper	3500.0	4-Non-ferro	30-Cu tube/sheet
8	PVC (cables)	210.0	1-BlkPlastics	8-PVC
9	Electronics	4300.0	6-Electronics	98-controller board
10	EDPM rubber	2740.0	1-BlkPlastics	1-LDPE
11	Glass	2100.0	7-Misc.	54-Glass for lamps
12	Polyamid (PA)	1050.0	2-TecPlastics	11-PA 6

Bill of material of Base case WM3

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	133200.0	3-Ferrous	25-Stainless 18/8 coil
2	Steel tube	72800.0	3-Ferrous	21-St sheet galv.
3	Galvanized steel	163500.0	3-Ferrous	23-Cast iron
4	Cast Iron	102900.0	3-Ferrous	4-PP
5	Plastics (PP. Polyester. ABS etc.)	12700.0	1-BlkPlastics	11-PA 6
6	Zinc	2400.0	4-Non-ferrous	12-PC
7	Aluminium	54500.0	4-Non-ferrous	14-Epoxy
8	Copper	23000.0	4-Non-ferrous	10-ABS
9	PVC (cables)	1800.0	1-BlkPlastics	5-PS
10	Electronics	18200.0	6-Electronics	13-PMMA
11	EDPM rubber	9100.0	1-BlkPlastics	8-PVC
12	Glass	7900.0	7-Misc.	1-LDPE
13	Polyamid (PA)	3600.0	2-TecPlastics	2-HDPE

Bill of material of Base case WM4

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	506000.0	3-Ferrous	25-Stainless 18/8 coil
2	Steel tube	276000.0	3-Ferrous	22-St tube/profile
3	Galvanised steel	621000.0	3-Ferrous	21-St sheet galv.
4	Cast Iron	391000.0	3-Ferrous	23-Cast iron
5	Plastics (PP. Polyester. ABS etc.)	48300.0	1-BlkPlastics	4-PP
6	Zinc	9200.0	4-Non-ferrous	32-ZnAl4 cast
7	Aluminium	207000.0	4-Non-ferrous	26-Al sheet/extrusion
8	Copper	87400.0	4-Non-ferrous	29-Cu wire
9	PVC (cables)	6900.0	1-BlkPlastics	8-PVC
10	Electronics	69000.0	6-Electronics	13-PMMA
11	EDPM rubber	34500.0	1-BlkPlastics	8-PVC
12	Glass	29900.0	7-Misc.	54-Glass for lamps
13	Polyamid (PA)	13800.0	2-TecPlastics	11-PA 6

Bill of material of Base case WM5

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	30560.0	3-Ferrous	25-Stainless 18/8 coil
2	Steel tube	19100.0	3-Ferrous	22-St tube/profile
3	Galvanized steel	267400.0	3-Ferrous	21-St sheet galv.
4	Cast Iron	15280.0	3-Ferrous	23-Cast iron
5	Plastics (PP. Polyester. ABS etc.)	7640.0	1-BlkPlastics	4-PP
6	Zinc	7640.0	4-Non-ferrous	32-ZnAl4 cast
7	Aluminium	7640.0	4-Non-ferrous	26-Al sheet/extrusion
8	Copper	15280.0	4-Non-ferrous	30-Cu tube/sheet
9	PVC	764.0	1-BlkPlastics	8-PVC
10	Electronics	10696.0	6-Electronics	98-controller board

Bill of material of Base case WM6

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	441500.0	3-Ferrous	**25-Stainless 18/8 coil**
2	Steel tube	170600.0	3-Ferrous	**22-St tube/profile**
3	Galvanized steel	50100.0	3-Ferrous	**21-St sheet galv.**
4	Cast Iron	80300.0	3-Ferrous	**23-Cast iron**
5	Plastics (PP. Polyester. ABS etc.)	48200.0	1-BlkPlastics	**4-PP**
6	Zinc	20100.0	4-Non-ferrous	**32-ZnAl4 cast**
7	Aluminium	30100.0	4-Non-ferrous	**26-Al sheet/extrusion**
8	Brass	20100.0	0	**31-CuZn38 cast**
9	Copper	30100.0	4-Non-ferrous	**30-Cu tube/sheet**
10	PVC (cables)	2000.0	1-BlkPlastics	**8-PVC**
11	Electronics	60200.0	6-Electronics	**8-PVC**
12	EDPM rubber	20100.0	1-BlkPlastics	**1-LDPE**
13	Glass	10000.0	7-Misc.	**54-Glass for lamps**
14	Polyamid (PA)	20100.0	2-TecPlastics	**11-PA 6**

Bill of material of Base case WM7

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	9600000.0	3-Ferrous	25-Stainless 18/8 coil
2	Galvanized steel	1200000.0	3-Ferrous	21-St sheet galv.
3	Cast iron	600000.0	3-Ferrous	23-Cast iron
4	Copper (cable)	240000.0	4-Non-ferrous	29-Cu wire
5	EPDM rubber	79200.0	1-BlkPlastics	1-LDPE
6	Electronics	120000.0	6-Electronics	98-controller board
7	PE	79200.0	1-BlkPlastics	6-EPS
8	PVC (cables)	79200.0	1-BlkPlastics	8-PVC

Bill of material of Base case D1

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless Steel	34600.0	3-Ferro	25-Stainless 18/8 coil
2	Steel Sheet galvanized	3500.0	3-Ferro	21-St sheet galv.
3	Cast Iron	2400.0	3-Ferro	23-Cast iron
4	Polypropylen (PP)	7700.0	1-BlkPlastics	4-PP
5	Polyamid (PA)	400.0	2-TecPlastics	11-PA 6
6	Acrylonitrile Butadiene Styrene (ABS)	2100.0	1-BlkPlastics	6-EPS
7	Plystyrene (PS)	400.0	1-BlkPlastics	10-ABS
8	Styropor expandable polystyrene (EPS)	450.0	1-BlkPlastics	5-PS
9	Polyvinylchlorid (PVC)	150.0	1-BlkPlastics	8-PVC
10	Plastics others	2500.0	1-BlkPlastics	2-HDPE
11	Aluminium	900.0	4-Non-ferro	26-Al sheet/extrusion
12	Cu wire	2600.0	4-Non-ferro	29-Cu wire
13	Glass for lamps	600.0	7-Misc.	54-Glass for lamps
14	Electronics (control)	1900.0	6-Electronics	98-controller board

Bill of material of Base case D2

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless Steel	32800.0	3-Ferro	25-Stainless 18/8 coil
2	Steel Sheet galvanized	3500.0	3-Ferro	21-St sheet galv.
3	Cast Iron	2800.0	3-Ferro	23-Cast iron
4	Polypropylen (PP)	7200.0	1-BlkPlastics	4-PP
5	Polyamid (PA)	400.0	2-TecPlastics	11-PA 6
6	Acrylonitrile Butadiene Styrene (ABS)	2100.0	1-BlkPlastics	6-EPS
7	Plystyrene (PS)	400.0	1-BlkPlastics	10-ABS
8	Styropor expandable polystyrene (EPS)	450.0	1-BlkPlastics	5-PS
9	Polyvinylchlorid (PVC)	150.0	1-BlkPlastics	8-PVC
10	Plastics others	1500.0	1-BlkPlastics	2-HDPE
11	Aluminium	900.0	4-Non-ferro	26-Al sheet/extrusion
12	Cu wire	2600.0	4-Non-ferro	29-Cu wire
13	Glass for lamps	600.0	7-Misc.	54-Glass for lamps
14	Electronics (control)	1800.0	6-Electronics	98-controller board

Bill of material of Base case D3

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Steel	4350.0	3-Ferro	25-Stainless 18/8 coil
2	Steel sheet galvanized	108750.0	3-Ferro	21-St sheet galv.
3	Plastics (PP. Polyester. ABS etc.)	2175.0	1-BlkPlastics	4-PP
4	Aluminium	20300.0	4-Non-ferro	26-Al sheet/extrusion
5	Copper	1450.0	4-Non-ferro	30-Cu tube/sheet
6	PVC	145.0	1-BlkPlastics	8-PVC
7	Electronics	3045.0	6-Electronics	98-controller board
8	EDPM	1450.0	1-BlkPlastics	1-LDPE
9	Other	3480.0	7-Misc.	54-Glass for lamps

Bill of material of Base case D4

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	12240.0	3-Ferro	25-Stainless 18/8 coil
2	Galvanized steel	107100.0	3-Ferro	21-St sheet galv.
3	Steel	7650.0	3-Ferro	22-St tube/profile
4	Cast Iron	6120.0	3-Ferro	23-Cast iron
5	Plastics (PP. Polyester. ABS etc.)	3820.0	1-BlkPlastics	4-PP
6	Aluminium	3060.0	4-Non-ferro	6-EPS
7	Copper	6120.0	4-Non-ferro	10-ABS
8	PVC	300.0	1-BlkPlastics	5-PS
9	Electronics	4600.0	6-Electronics	8-PVC
10	Glass	1990.0	7-Misc.	2-HDPE

Bill of material of Base case D5

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	24400.0	3-Ferro	25-Stainless 18/8 coil
2	Galvanized steel	243600.0	3-Ferro	21-St sheet galv.
3	Steel	17400.0	3-Ferro	22-St tube/profile
4	Cast Iron	13900.0	3-Ferro	23-Cast iron
5	Plastics (PP. Polyester. ABS etc.)	12200.0	1-BlkPlastics	4-PP
6	Aluminium	6950.0	4-Non-ferro	26-Al sheet/extrusion
7	Copper	13900.0	4-Non-ferro	30-Cu tube/sheet
8	PVC	700.0	1-BlkPlastics	8-PVC
9	Electronics	10400.0	6-Electronics	98-controller board
10	Glass	4550.0	7-Misc.	54-Glass for lamps

Bill of material of Base case D6

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	52150.0	3-Ferro	**25-Stainless 18/8 coil**
2	Galvanized steel	521500.0	3-Ferro	**21-St sheet galv.**
3	Steel	37250.0	3-Ferro	**23-Cast iron**
4	Cast Iron	29800.0	3-Ferro	**23-Cast iron**
5	Plastics (PP. Polyester. ABS etc.)	26100.0	1-BlkPlastics	**4-PP**
6	Aluminium	14900.0	4-Non-ferro	**26-Al sheet/extrusion**
7	Copper	29800.0	4-Non-ferro	**30-Cu tube/sheet**
8	PVC	1500.0	1-BlkPlastics	**8-PVC**
9	Electronics	22350.0	6-Electronics	**98-controller board**
10	Glass	9650.0	7-Misc.	**54-Glass for lamps**

Bill of material of Base case D7

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless Steel	16600.0	3-Ferro	**25-Stainless 18/8 coil**
2	Steel	2826600.0	3-Ferro	**21-St sheet galv.**
3	Cast Iron	6650.0	3-Ferro	**23-Cast iron**
4	Copper	6650.0	4-Non-ferro	**30-Cu tube/sheet**
5	EPDM rubber	3325.0	1-BlkPlastics	**1-LDPE**
6	PE	3325.0	1-BlkPlastics	**6-EPS**
7	Electronics	3325.0	6-Electronics	**98-controller board**
8	PVC (cables)	3325.0	1-BlkPlastics	**8-PVC**

8.2 Additional questionnaire to stakeholders

The additional questionnaire for the final report is provided separately in the following document:

EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls