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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

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Task 5: Definition of Base Case

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

The report at hand covers ***professional dishwashers***.

The Task 5 report on *professional washing machines and dryers*
is published separately.

Part: Professional Dishwashers

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1 Introduction

1.1 Objective of Task 5

For this assessment, one or two average European Union (EU) product(s) have to be defined or a representative product category as the "base case" (BC) for the whole of the EU has to be chosen. On this base case most of the environmental and Life Cycle Cost (LCC) analyses will be built throughout the rest of the study. The base case is a conscious abstraction of reality, necessary one for practical reasons (budget, time). Having said that, the question if this abstraction leads to inadmissible conclusions for certain market segments will be addressed in the impact and sensitivity analysis.

In principle, the aim of a base case assessment is to quantify the environmental impacts of a service or product throughout its life. This includes 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 life cycle analysis (LCA).

First, all incoming and outgoing flows of materials and energy are detailed for each step 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 life cycle analysis.

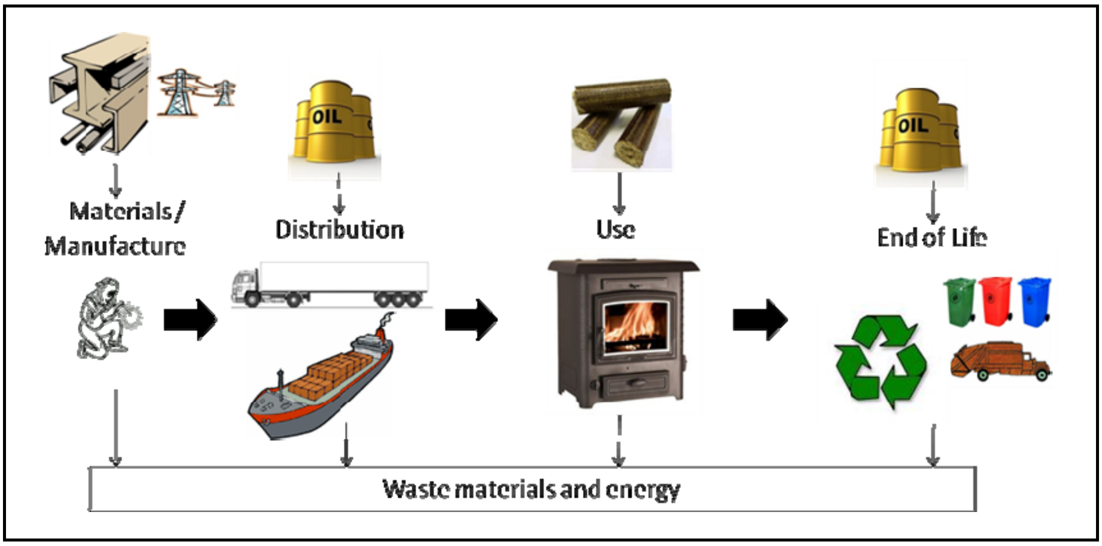

Figure 1 Simplified material flow diagram for life cycle analysis

These material and energy flows are then aggregated over the life time 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 Ecodesign studies. These indicators will be described in more detail later in the report. As the results are presented through several indicators of environmental impact, the 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 dishwashers.

While this study has been completed as comprehensively and accurately as possible, it relies on data which has been extrapolated from literature and stakeholder input. The performance of real appliances can vary substantially from the data provided in this report. This is understood and mitigated to an extent 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 consequently estimated valuable as they represent the best indication to date of the environmental impacts of professional dishwashers 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 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 BAT), 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 dishwashers 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]. This 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 the EcoReport tool.

Definition of base cases

The objective of this subsection is to define and describe the base cases, based on the previous tasks and the information recovered from stakeholders and literature review. The base cases are "a conscious abstraction of reality" and have to cover the wide variety of existing professional dishwashers in order to be as representative of the EU market as possible. Thus, BCs are not necessarily representative of real products. When two products have similar bill of materials and technical parameters, they may be represented by a single BC. The number of base cases is optimized to be small enough to enable a simplified analysis of the market but large enough to deal with the technological spectrum of professional dishwashers.

Although the MEEuP methodology foresees one or two BCs to cover the entire EU market for the products considered in each preparatory study, in this study six BCs emerged for the dishwasher part only. Such a high number of BCs is necessary to appropriately cover the broad range of technical specifications and functionalities of professional dishwashers. Table 1 gives an overview of the six defined base cases which are products that have already been presented in previous tasks.

Discussions on glasswashers have been held during the interim and final stakeholder meetings[2]. It appears that technical parameters of glasswashers and undercounter one-tank dishwashers are very similar: glasswashers can be considered as smaller capacity undercounter one-tank machines. The global economic and environmental outcomes of base case 2 should be similar to the potential results of a thorough and separate analysis of glasswashers (the absolute values would differ but the base case is supposed to be representative of an EU average).

Table 1 Description of the base cases

Base case	Name	Short Description	Average capacity
BC 1	Undercounter water-change	- Manually loaded program automats, undercounter front loaders with water-change operation - Used for dishes, glasses, cutlery, pots, pans, utensils (semi-commercial and commercial applications)	200 dishes/hour
BC 2	Undercounter one-tank	- Manually loaded program automats, undercounter front loaders with one-tank - Used for mainly plates, glasses, cups, cutlery; also includes specialized glasswashers (commercial applications)	550 dishes/hour

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[2] 13th July 2010 in Brussels and 9th December 2010 in Paris cf. http://www.ecowet-commercial.org/meetings.php

Base case	Name	Short Description	Average capacity
BC 3	Hood-type	- Program automats, one-tank pass through dishwashers - Used for mainly plates, glasses, cups, cutlery (commercial applications)	860 dishes/hour
BC 4	Utensil/Pot	- Universal / warewashing / utensil / pot dishwasher, program automat, front loader or pass through - Used for black cookware and large utensils (commercial applications)	0.42 m^2 (rack area) 20 cycles per hour
BC 5	Conveyor-type one-tank	- Conveyor-type (basket transport system or belt conveyor) with one-tank - Used for plates, glasses, cups, cutlery, trays (heavy commercial applications)	1 750 dishes/hour
BC 6	Conveyor-type multi-tank	- Conveyor-type (basket transport system or belt conveyor) with four zones: one pre-wash zone (one-tank), one main wash zone (one-tank), one rinse zone and one drying zone (no tank). - Used for mainly plates, glasses, cups, cutlery, trays (heavy commercial applications)	3 600 dishes/hour

2.2 Inputs in the production phase

Production phase data related to typical EU professional dishwashers consists of the BOM and the sheet metal scrap generated during production. The BOMs have already been presented in Task 4. In Table 2, they are structured according to the different categories of materials (e.g. bulk plastics, ferrous materials)[3] and packaging material is included.

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[3] The full composition can be found in Annex A.

Table 2 Composition of the six base cases, by category of materials (packaging included)

Base case	Unit	1 Bulk Plastics	2 Tech. Plastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7 Misc.	Total
BC 1	g	8 826	1 014	27 266	1 373	0	448	11 769	50 696
	%	17.4	2.0	53.8	2.7	0.0	0.9	23.2	100.0
BC 2	g	8 075	1 500	54 510	5 850	0	500	8 750	79 185
	%	10.2	1.9	68.8	7.4	0.0	0.6	11.1	100.0
BC 3	g	9 465	1 800	98 590	7 700	0	600	17 000	135 155
	%	7.0	1.3	72.9	5.7	0.0	0.4	12.6	100.0
BC 4	g	16 000	4 000	172 000	12 400	0	2 100	19 500	226 000
	%	7.1	1.8	76.1	5.5	0.0	0.9	8.6	100.0
BC 5	g	99 080	6 140	670 210	108 995	0	9 800	79 000	973 225
	%	10.2	0.6	68.9	11.2	0.0	1.0	8.1	100.0
BC 6	g	110 090	18 660	1 042 440	103 700	0	15 400	174 710	1 465 000
	%	7.5	1.3	71.2	7.1	0.0	1.1	11.9	100.0

We notice that all base cases except BC 1 have around 70% of ferrous materials in their BOMs. 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 Ecodesign preparatory studies, its database does not include some materials found in professional dishwashers. These are listed below:

- polybutylene terephthalate (PBT);
- ethylene propylene diene monomer (EPDM) rubber;
- polyoxymethylene (POM);
- chromium;
- cotton (used for acoustic attenuation);
- wood (included in packaging).

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

- EPDM rubber was considered as low density polyethylene (LDPE);
- POM as high density polyethylene (HDPE);
- 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 made of around 60% of LDPE usually. The choices were also supported by preliminary environmental analysis (see

Table 3, 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 3 Life cycle impact assessment of missing individual components (part 1), for 1 kg[4]

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, cotton 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 three 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 1 and the share of these material categories in the total weight of the dishwasher is very low (1% altogether).

A preliminary environmental analysis supports this assumption, by showing that these three materials have impacts in the same order of magnitude as (or smaller than) stainless steel (which represents more than 50% of the mass of BC 1) which justifies the fact that these materials are neglected based on the low mass allocated to them (see Table 4, all results were obtained using the method CML 2 baseline 2000 V2.04). Only for the ozone layer depletion indicator, the three 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.

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[4] All materials from ETH-ESU 96 database

Table 4 Life cycle impact assessment of missing individual components (part 2), for 1 kg[5]

Impact category	Unit	Stainless Steel	PET	Chromium	Cotton
Abiotic depletion	kg Sb eq.	2.35E-02	3.46E-02	1.92E-01	7.92E-02
Acidification	kg SO_2eq.	1.68E-01	9.77E-03	1.02E-01	1.34E-01
Eutrophication	kg PO_4^{3}eq.	1.22E-03	3.00E-03	7.83E-03	2.81E-02
Global warming (GWP100)	kg CO_2eq.	3.68E+00	2.73E+00	2.65E+01	1.20E+01
Ozone layer depletion (ODP)	kg CFC-11 eq.	5.26E-09	1.21E-07	1.85E-06	3.27E-07
Photochemical oxidation	kg C_2H_4	7.22E-03	6.23E-04	5.54E-03	4.10E-03

Regarding the sheet metal scrap percentage generated during the production phase, a rate of **5%** has been assumed, based on 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 5 below.

Table 5 Volume of packaged product for base cases

Base case	Volume of packaged product (in m^3)
BC 1 Undercounter water-change	0.40
BC 2 Undercounter one-tank	0.48
BC 3 Hood-type	1.03
BC 4 Utensil/Pot	4.95
BC 5 One-tank conveyor-type	12.25
BC 6 Multi-tank conveyor-type	16.58

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

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

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[5] All materials from EcoInvent 2.0 database

2.4 Inputs in the use phase

Task 3 has shown that products have different efficiencies whether ideal user behaviour or real-life user behaviour is considered. According to Task 1, no EU or national standard is currently used to measure the energy, water or detergent consumption/efficiency of professional dishwashers. 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. Based on the ideal use, the data takes into account the consumption for initial filling, the consumption in standby mode and the additional consumption through real-life user behaviour (partial workload, deviation from the use of the standard programs and mal-operation, see Task 3).

Besides, all BCs are considered having only cold water input and an electrical heating system as these options are the most commonly found. This ensures that most of the improvement options considered later will be applicable for implementation on the BCs (for instance, a heat pump system is only relevant for a machine with a cold water input). Furthermore, the infrastructure for the alternatives to electrical heating (warm water supply, heating with steam or hot water) is not available in every place.

2.4.1 Electricity consumption

The electricity consumption during the use phase (see Task 3 and 4) is expected to be a major contributor to the environmental impacts of a professional dishwasher. The annual electricity 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 Life Cycle Costs (LCC) of the BCs.

Table 6 presents the annual electricity consumption of the six BCs.

Table 6 Electricity consumption per year for all base cases

Base case	**Total Electricity consumption (in kWh per year)**
BC 1 Undercounter water-change	1 254
BC 2 Undercounter one-tank	5 253
BC 3 Hood-type	8 258
BC 4 Utensil/Pot	8 913
BC 5 One-tank conveyor-type	37 703
BC 6 Multi-tank conveyor-type	102 229

2.4.2 Water consumption

Table 7 presents the annual water consumption of the six base cases (cf. Task 3 and 4).

Table 7 Water consumption per year for all base cases

Base case	**Water consumption (in m^3 per year)**
BC 1 Undercounter water-change	25.92
BC 2 Undercounter one-tank	55.82
BC 3 Hood-type	86.65
BC 4 Utensil/Pot	89.52
BC 5 One-tank conveyor-type	255.68
BC 6 Multi-tank conveyor-type	643.64

2.4.3 Detergent and rinse aid consumption

Table 8 presents the annual detergent consumption of the six base cases (cf. Task 3 and 4).

Table 8 Detergent consumption per year for all base cases

Base case	**Detergent consumption (in kg per year)**
BC 1 Undercounter water-change	87
BC 2 Undercounter one-tank	188
BC 3 Hood-type	292
BC 4 Utensil/Pot	294
BC 5 One-tank conveyor-type	865
BC 6 Multi-tank conveyor-type	2 146

2.4.4 Travelling effort for maintenance and repair over the product life

The number of kilometres travelled for maintenance and repair for one machine was estimated to be proportional to the product price of the appliance, according to discussions during the final stakeholder meeting. 200 km was taken as a basis for BC 2, in order to extrapolate linearly the other figures. Therefore it varies for each BC but the influence of this parameter on the outcomes of the environmental analysis is low. Table 9 presents the input figures by BC.

Table 9 Travelling effort for maintenance and repair over the product life, by base case

Base case	**Number of kilometres**
BC 1 Undercounter water-change	183
BC 2 Undercounter one-tank	200
BC 3 Hood-type	269
BC 4 Utensil/Pot	600
BC 5 One-tank conveyor-type	857
BC 6 Multi-tank conveyor-type	2 571

2.5 Inputs in the end-of-life phase

None of the BCs contains dangerous substances that can be released into the environment during the end-of-life phase, e.g. refrigerant or mercury. 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 rethink. Possible harmful aspects, resistances of bacteria, and missing comprehensive data to allow conclusive risk assessments are the main reasons for the warnings (for more details see also Task 4).

Heat pumps for heat recovery are considered as improvement options so the refrigerants these devices contain will be taken into account in Tasks 6 and 7 only. Reflection of the market in Task 6 supports this consideration: heat pumps are usually not yet applied in smaller dishwasher categories due to lower profitability. With high-throughput machines (conveyor-type), the profitability is better, but pumps for heat recovery are still usually offered only as an option, and not as standard equipment. Therefore, they do not have a significant market share and it is justified that they are not included into the BCs.

It is assumed that an important share of the professional dishwashers' materials are recycled and reused. We assumed that during the end-of-life phase (cf. Task 4):

- 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;

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[6] More information at www.bfr.bund.de

- 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 BCs, 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 calculations of the LCCs were elaborated in Task 2 (in particular product lifetime and product prices, electricity rates, and water and consumables rates). The product prices were estimated with the data aggregation used for the definition of the BCs and based on stakeholders' comments.

Table 10 presents the lifetimes, sales and stock figures and product prices for all six BCs. The installation of the dishwashers is taken into account in the product price so that there are no separate installation costs. The disposal costs were considered to be zero, as the machines are never landfilled but taken care of by recyclers.

Table 10 EcoReport economic inputs of the base cases

Base case	Product lifetime (in years)	Sales (units)	Stock (units)	Product price (in €)	Maintenance costs (in €)
BC 1 Undercounter water-change	12	20 000	207 223	3 200	1 200
BC 2 Undercounter one-tank	8	138 200	1 012 355	3 500	1 540
BC 3 Hood-type	8	65 900	482 728	4 700	2 068
BC 4 Utensil/Pot	8	2 600	19 309	10 500	4 620
BC 5 One-tank conveyor-type	12	6 600	68 425	15 000	6 600
BC 6 Multi-tank conveyor-type	17	1 300	18 015	45 000	19 800

The running costs will be calculated based on the user behaviour and the consumables rates presented in Table 11.

Table 11 Energy, water and consumables rates, by base case

Base case	Electricity rate (Euro/kWh)	Gas rate (Euro/GJ)	Water rate (Euro/m^3)	Detergent/Rinse aid rate (Euro/kg)
BC 1 Undercounter water-change	0.138	11.21	2.64	3.00
BC 2 Undercounter one-tank				
BC 3 Hood-type	0.105	10.01		
BC 4 Utensil/pot				
BC 5 One-tank conveyor-type	0.090	8.79		
BC 6 Multi-tank conveyor-type				

The discount rate was provided by the European Commision: **4%** will be used for all BCs.

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 in environmental efficiency, 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 the BCs all represent products currently sold on the market. The overall improvement ratios (market over stock, during use phase) which are required in EcoReport are used here as correction factors for this parameter. They were calculated from data presented in Task 2 and reminded in Table 12. For each BC, this improvement ratio indicates the difference of global efficiency during the use phase between the new sales and the current stock. We assumed that a representative product of the current stock was "half the product lifetime" old (e.g. 4 years for hood-type dishwashers) and we scaled down (proportionally) the global improvement exposed in Table 12, which is related to a ten years gap. For BC 1, a ratio of 1.00 was considered as manufacturers stated that these products have not really changed in the past decade.

Table 12 Overall improvement ratios for all base cases

Base case	Improvement between ten year old product and new product			Overall improvement ratio
	Energy consumption	Water consumption	Global improvement[7]	
BC 1 Undercounter water-change	-	-	-	1.00
BC 2 Undercounter one-tank	30%	16%	23%	1.09
BC 3 Hood-type	29%	16%	22.5%	1.09
BC 4 Utensil/Pot	29%	20%	24.5%	1.10
BC 5 One-tank conveyor-type	37%	35%	36%	1.22
BC 6 Multi-tank conveyor-type	37%	33%	35%	1.30

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[7] Simple average between energy and water consumptions.

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 base case environmental impact assessment will lead to an identification of basic technological design parameters being of outstanding environmental relevancy[8]. 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, materials and features of the professional dishwashers.

Seventeen environmental indicators are considered in EcoReport. Of these, 13 are relevant to professional dishwashers, while others have none to very little impact:

- Total Gross Energy Requirement, in MJ primary;
- Electricity, in kWh_e;
- 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;
- 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.

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

3.1 Base case 1: Undercounter water-change

Table 13 shows the environmental impacts of an undercounter water-change dishwasher over its whole life cycle. The total energy consumption for the whole life cycle of the BC 1 is 196.5 GJ, of which 159 GJ (i.e. 15.1 MWh_e) electricity.[9]

Table 13 Life Cycle Impact (per unit) of base case 1 – Undercounter water-change

Nr	**Life cycle Impact per product:**							Date	Author		
1	Under counter, water change								BIO		
	Life Cycle phases -->		**PRODUCTION**			**DISTRI-**	**USE**	**END-OF-LIFE***			**TOTAL**
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**8523**			5966	2557	**8523**	**0**
2	TecPlastics	g			**1014**			710	304	**1014**	**0**
3	Ferro	g			**27266**			1363	25903	**27266**	**0**
4	Non-ferro	g			**1302**			65	1237	**1302**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**448**			448	0	**448**	**0**
7	Misc.	g			**11317**			566	10751	**11317**	**0**
	Total weight	g			**49870**			9118	40752	**49870**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	3274	792	**4066**	**496**	**191896**	641	587	**54**	**196511**
9	of which, electricity (in primary MJ)	MJ	592	474	**1066**	**1**	**158015**	0	11	**-11**	**159071**
10	Water (process)	ltr	2246	7	**2253**	**0**	**322392**	0	7	**-7**	**324637**
11	Water (cooling)	ltr	1199	221	**1420**	**0**	**421358**	0	58	**-58**	**422720**
12	Waste, non-haz./ landfill	g	48858	2660	**51518**	**233**	**222449**	3117	41	**3076**	**277276**
13	Waste, hazardous/ incinerated	g	350	0	**350**	**5**	**4414**	6676	6	**6670**	**11439**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	220	44	**265**	**31**	**8390**	48	36	**12**	**8697**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	2043	190	**2233**	**92**	**49402**	98	50	**48**	**51776**
17	Volatile Organic Compounds (VOC)	g	56	0	**56**	**8**	**80**	2	1	**1**	**145**
18	Persistent Organic Pollutants (POP)	ng i-Teq	222	14	**236**	**1**	**1257**	22	0	**22**	**1516**
19	Heavy Metals	mg Ni eq.	3793	32	**3825**	**12**	**3417**	175	0	**175**	**7429**
	PAHs	mg Ni eq.	172	0	**173**	**20**	**474**	0	1	**-1**	**666**
20	Particulate Matter (PM, dust)	g	1844	29	**1874**	**1367**	**2686**	878	2	**876**	**6803**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	2427	0	**2427**	**0**	**1043**	52	0	**52**	**3523**
22	Eutrophication	g PO4	71	0	**72**	**0**	**55965**	3	0	**3**	**56039**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 2 exposes the contribution of each life cycle phase to each impact. The total impact of a category is shown as 100%, but it does not mean that each of the impacts in each category

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

is equally important. The categories are not comparable. Several observations can be made from this analysis:

- Within the production phase, the manufacturing impacts are very small: the maximum contribution is 1% in non-hazardous waste, because of the sheet metal and plastic scrap generated during the manufacturing process. The material extraction and production are responsible for the important contributions of this phase to the quantity of landfilled waste (18%) because of the general metal content, VOC (38%) emissions and PM (27%) because of the bitumen content and HM (51%) and POP (15%) emissions because of the stainless steel contained in the product.
- As expected, the use phase is by far the main contributor to the following impacts: total energy (97.7%) and electricity consumption (99.3%), water for processing (99.3%), non-hazardous waste (80%), greenhouse gases emissions (96%), acidification (95%), POP (83%), PAHs (71%) and eutrophication (99.8%). The water use during the use phase is the main contributor for the water processing impact. The detergent is the source of almost 100% of the eutrophication impact during the use phase, and also makes a slight contribution for waste generation, GWP and POP emissions. The maintenance and repair services are the main reason for the PM and PAHs emissions because of the travels. For the remaining shares, the electricity consumption is the main source for the impacts especially total energy and electricity, GWP and acidification.
- The distribution phase is negligible for all impacts except for PM for which it accounts for around 20% of the total emissions, and for VOC emissions (6%). This is due to the product transportation.
- The end-of-life is also negligible for all impacts except for the generation of hazardous waste (58%) and PM (13%). This is due to the high recycling rate (because of the plastics and metals content) which partly counterbalances the negative impacts of incinerating or landfilling the few non recyclable materials. When the red bar is placed below the x-axis on the figure, it means that the end-of-life actually results in a small credit in the impact category considered: in particular, this is the case for energy and electricity consumption.

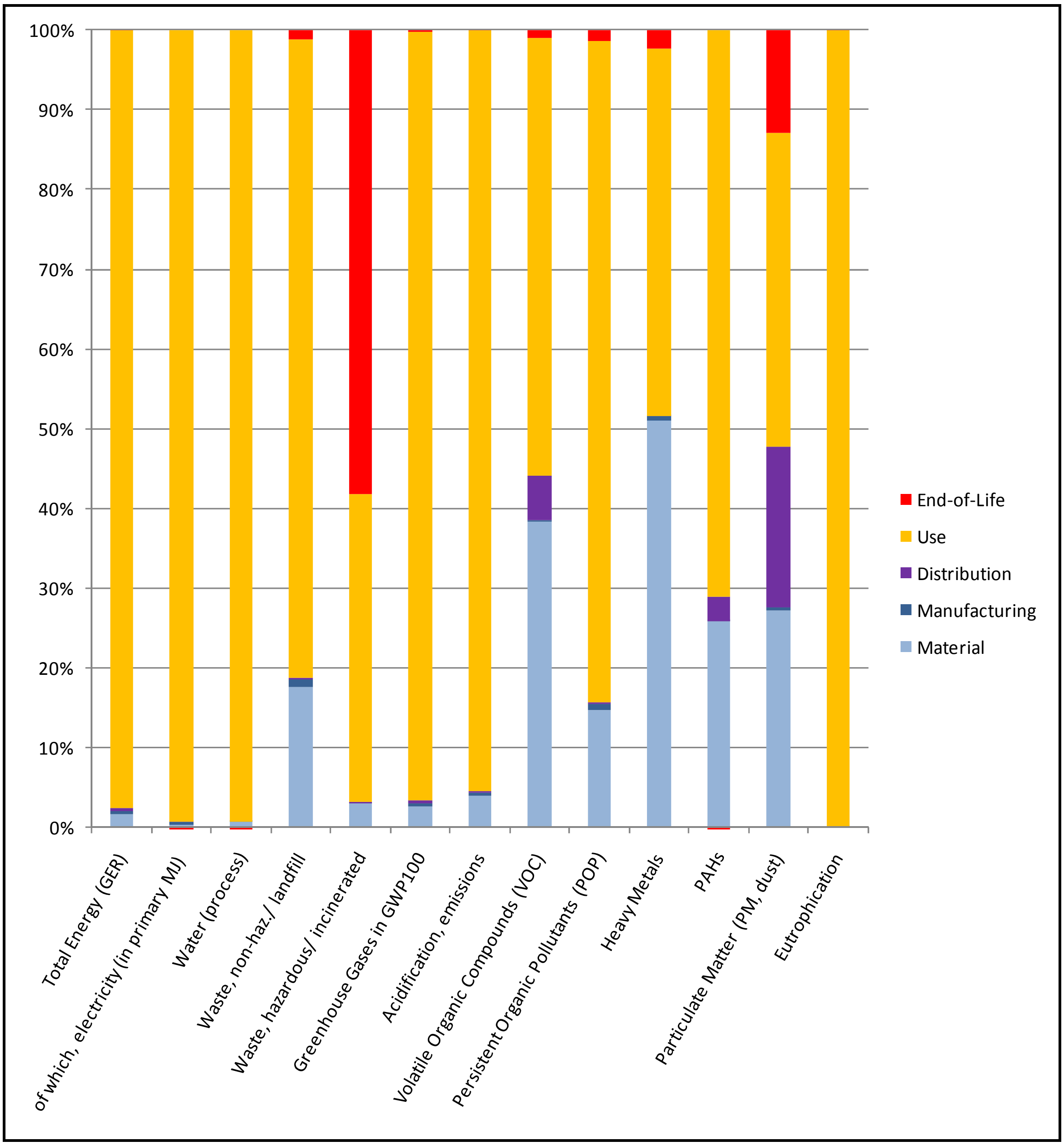

Figure 2 Distribution of environmental impacts of BC 1 per life cycle phase

3.2 Base case 2: Undercounter one-tank

Table 14 shows the environmental impacts of an undercounter one-tank dishwasher over its whole life cycle. The total energy consumption for the whole life cycle of the BC 2 is 497 GJ, of which 443 GJ (i.e. 42.2 MWh$_e$) electricity.

Table 14 Life Cycle Impact (per unit) of base case 2 – Undercounter one-tank

Nr	**Life cycle Impact per product:**								Date	Author	
2	Under counter, one tank									BIO	
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**8075**			5653	2423	**8075**	**0**
2	TecPlastics	g			**1500**			1050	450	**1500**	**0**
3	Ferro	g			**54510**			2726	51785	**54510**	**0**
4	Non-ferro	g			**5850**			293	5558	**5850**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**500**			500	0	**500**	**0**
7	Misc.	g			**8750**			438	8313	**8750**	**0**
	Total weight	g			**79185**			10658	68527	**79185**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	5392	1284	**6676**	**585**	**489932**	740	715	**26**	**497218**
9	of which, electricity (in primary MJ)	MJ	928	766	**1694**	**1**	**441269**	0	11	**-11**	**442954**
10	Water (process)	ltr	4328	11	**4339**	**0**	**477182**	0	7	**-7**	**481514**
11	Water (cooling)	ltr	1410	355	**1765**	**0**	**1176690**	0	58	**-58**	**1178396**
12	Waste, non-haz./ landfill	g	106962	4428	**111389**	**269**	**568526**	4863	41	**4822**	**685007**
13	Waste, hazardous/ incinerated	g	390	0	**390**	**5**	**11281**	6703	6	**6696**	**18373**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	422	72	**494**	**36**	**21399**	55	45	**10**	**21938**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	3905	309	**4214**	**108**	**126177**	112	62	**51**	**130550**
17	Volatile Organic Compounds (VOC)	g	12	0	**12**	**10**	**192**	2	1	**2**	**216**
18	Persistent Organic Pollutants (POP)	ng i-Teq	475	31	**505**	**2**	**3213**	34	0	**34**	**3753**
19	Heavy Metals	mg Ni eq.	7908	72	**7980**	**14**	**8580**	204	0	**204**	**16777**
	PAHs	mg Ni eq.	331	0	**331**	**24**	**1071**	0	1	**-1**	**1426**
20	Particulate Matter (PM, dust)	g	496	48	**544**	**1641**	**4461**	1007	2	**1005**	**7651**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	4965	0	**4966**	**0**	**2895**	61	0	**61**	**7921**
22	Eutrophication	g PO4	136	1	**137**	**0**	**80631**	3	0	**3**	**80771**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

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

- Within the production phase, the manufacturing impacts are very small: the maximum contribution is 0.8% in POP emissions, because of the sheetmetal scrap generated during the manufacturing process. The material extraction and production are responsible for the important contributions of this phase to the quantity of landfilled waste (16%) because of the general metal content, POP (13%) and HM (47%) emissions because of the stainless steel contained in the product and PAH emissions (23%) because of the aluminium parts.

- As expected, the use phase is by far the main contributor to the following impacts: total energy (98.5%) and electricity consumption (99.6%), water for processing (99%), non-hazardous waste (83%), greenhouse gases emissions (97.5%), acidification (97%), POP (86%), PAHs (75%) and eutrophication (99.8%). The water use during the use phase is the main contributor for the water processing impact. The detergent is the source of almost 100% of the eutrophication impact during the use phase, and also makes a slight contribution (around 10%) for waste generation, GWP and POP emissions. The maintenance and repair services are the main reason for the PM emissions because of the travels. For the remaining shares, the electricity consumption is the main source for the impacts, especially total energy and electricity, GWP and acidification.
- The distribution phase is negligible for all impacts except for PM for which it accounts for around 21% of the total emissions, and for VOC emissions (5%). This is due to the product transportation.
- The end-of-life is also negligible for all impacts except for the generation of hazardous waste (36%) and PM (13%). This is due to the high recycling rate (because of the plastics and metals content) which partly counterbalances the negative impacts of incinerating or landfilling the few non recyclable materials. When the red bar is placed below the x-axis on the figure, it means that the end-of-life actually results in a small credit in the impact category considered: in particular, this is the case for energy and electricity consumption.

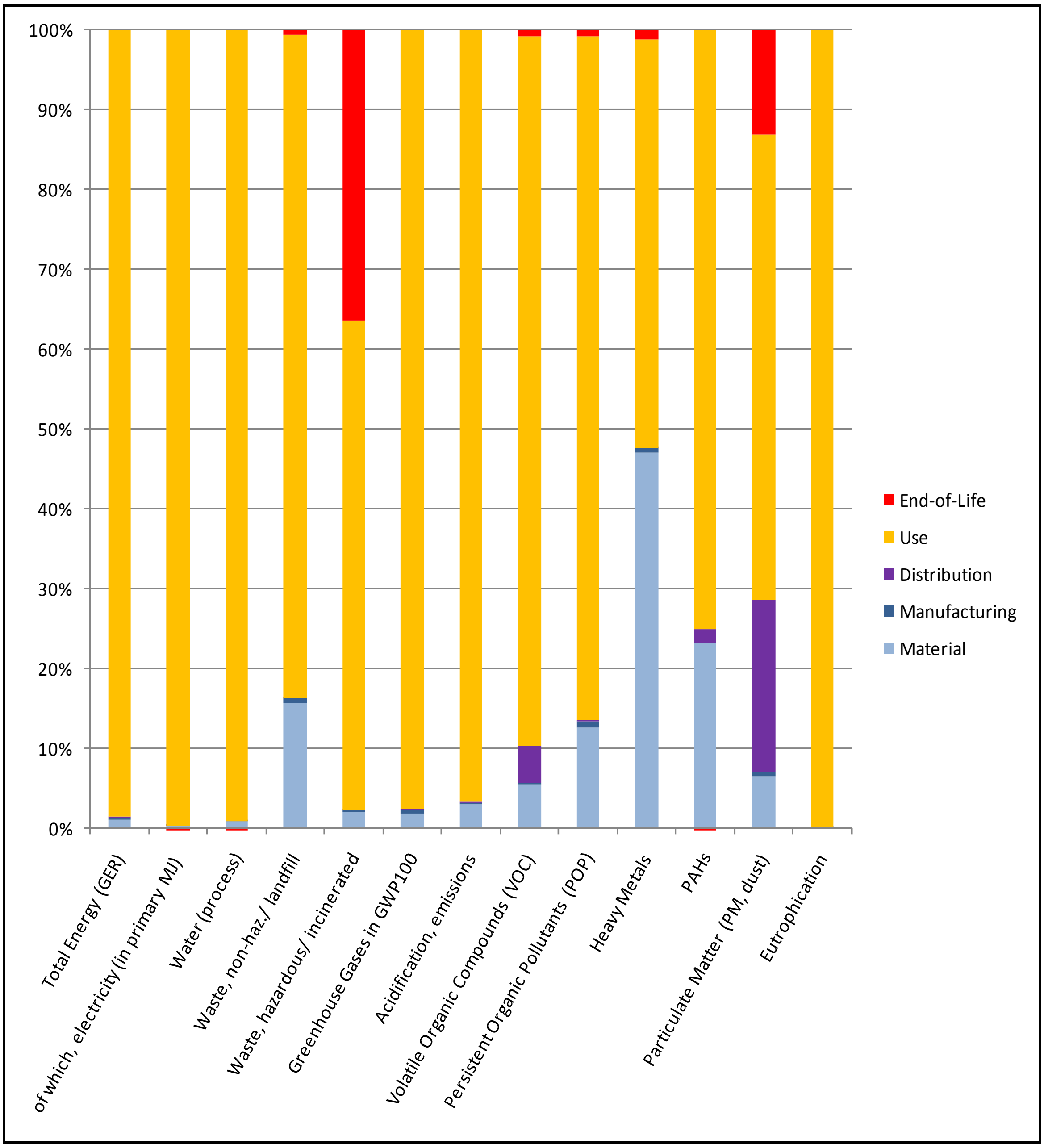

Figure 3 Distribution of environmental impacts of BC 2 per life cycle phase

3.3 Base case 3: Hood-type

Table 15 shows the environmental impacts of a hood-type dishwasher over its whole life cycle. The total energy consumption for the whole life cycle of the BC 3 is 781 GJ, of which 696 GJ (i.e. 66.3 MWh$_e$) electricity. This BC presents a very close impact profile to base case 2, due to their technical and composition similarities.

Table 15 Life Cycle Impact (per unit) of base case 3 – Hood-type

Nr	Life cycle Impact per product:							Date	Author		
3	Hood type								BIO		
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**9465**			6626	2840	**9465**	**0**
2	TecPlastics	g			**1800**			1260	540	**1800**	**0**
3	Ferro	g			**98590**			4930	93661	**98590**	**0**
4	Non-ferro	g			**7700**			385	7315	**7700**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**600**			600	0	**600**	**0**
7	Misc.	g			**17000**			850	16150	**17000**	**0**
	Total weight	g			**135155**			14650	120505	**135155**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	8786	2058	**10844**	**1195**	**769186**	1014	1005	**9**	**781234**
9	of which, electricity (in primary MJ)	MJ	1449	1227	**2676**	**3**	**693699**	0	12	**-12**	**696365**
10	Water (process)	ltr	7750	18	**7768**	**0**	**741302**	0	8	**-8**	**749062**
11	Water (cooling)	ltr	1892	567	**2459**	**0**	**1849817**	0	69	**-69**	**1852207**
12	Waste, non-haz./ landfill	g	170577	7173	**177750**	**519**	**892728**	8296	48	**8247**	**1079244**
13	Waste, hazardous/ incinerated	g	468	0	**468**	**10**	**17712**	7886	8	**7878**	**26068**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	723	115	**838**	**72**	**33592**	76	66	**10**	**34511**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	6682	496	**7178**	**218**	**198119**	153	88	**65**	**205581**
17	Volatile Organic Compounds (VOC)	g	19	1	**20**	**21**	**300**	3	1	**2**	**344**
18	Persistent Organic Pollutants (POP)	ng i-Teq	828	55	**883**	**3**	**5046**	57	0	**57**	**5989**
19	Heavy Metals	mg Ni eq.	14433	128	**14561**	**26**	**13469**	282	0	**282**	**28338**
	PAHs	mg Ni eq.	417	0	**417**	**48**	**1658**	0	1	**-1**	**2122**
20	Particulate Matter (PM, dust)	g	861	76	**937**	**3521**	**6608**	1372	3	**1369**	**12435**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	8891	0	**8891**	**1**	**4562**	83	0	**83**	**13536**
22	Eutrophication	g PO4	238	1	**239**	**0**	**125236**	5	0	**4**	**125479**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

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

- Within the production phase, the manufacturing impacts are very small: the maximum contribution is 0.9% in POP emissions, because of the sheet metal scrap generated during the manufacturing process. The material extraction and production are responsible for the important contributions of this phase to the quantity of landfilled waste (16%) because of the general metal content, POP (14%) and HM (51%) emissions because of the stainless steel contained in the product and PAH emissions (20%) because of the aluminium parts.
- As expected, the use phase is by far the main contributor to the following impacts: total energy (98.5%) and electricity consumption (99.6%), water for processing (99.0%), non-hazardous waste (83%), greenhouse gases emissions (97.3%), acidification (96.3%), POP (84%), PAHs (78%) and eutrophication (99.8%). The water use during the use phase is the main contributor for the water processing impact. The detergent is the source of almost 100% of the eutrophication impact during the use phase, and also makes a slight contribution (around 10%) for waste generation, GWP and POP emissions. The maintenance and repair services are the main reason for the PM emissions because of the travels. For the remaining shares, the electricity consumption is the main source for the impacts, especially total energy and electricity, GWP and acidification.
- The distribution phase is negligible for all impacts except for PM for which it accounts for around 28% of the total emissions, and for VOC emissions (6%). This is due to the product transportation.
- The end-of-life is also negligible for all impacts except for the generation of hazardous waste (30%) and PM (11%). This is due to the high recycling rate (because of the plastics and metals content) which partly counterbalances the negative impacts of incinerating or landfilling the few non recyclable materials. When the red bar is placed below the x-axis on the figure, it means that the end-of-life actually results in a small credit in the impact category considered: in particular, this is the case for energy and electricity consumption.

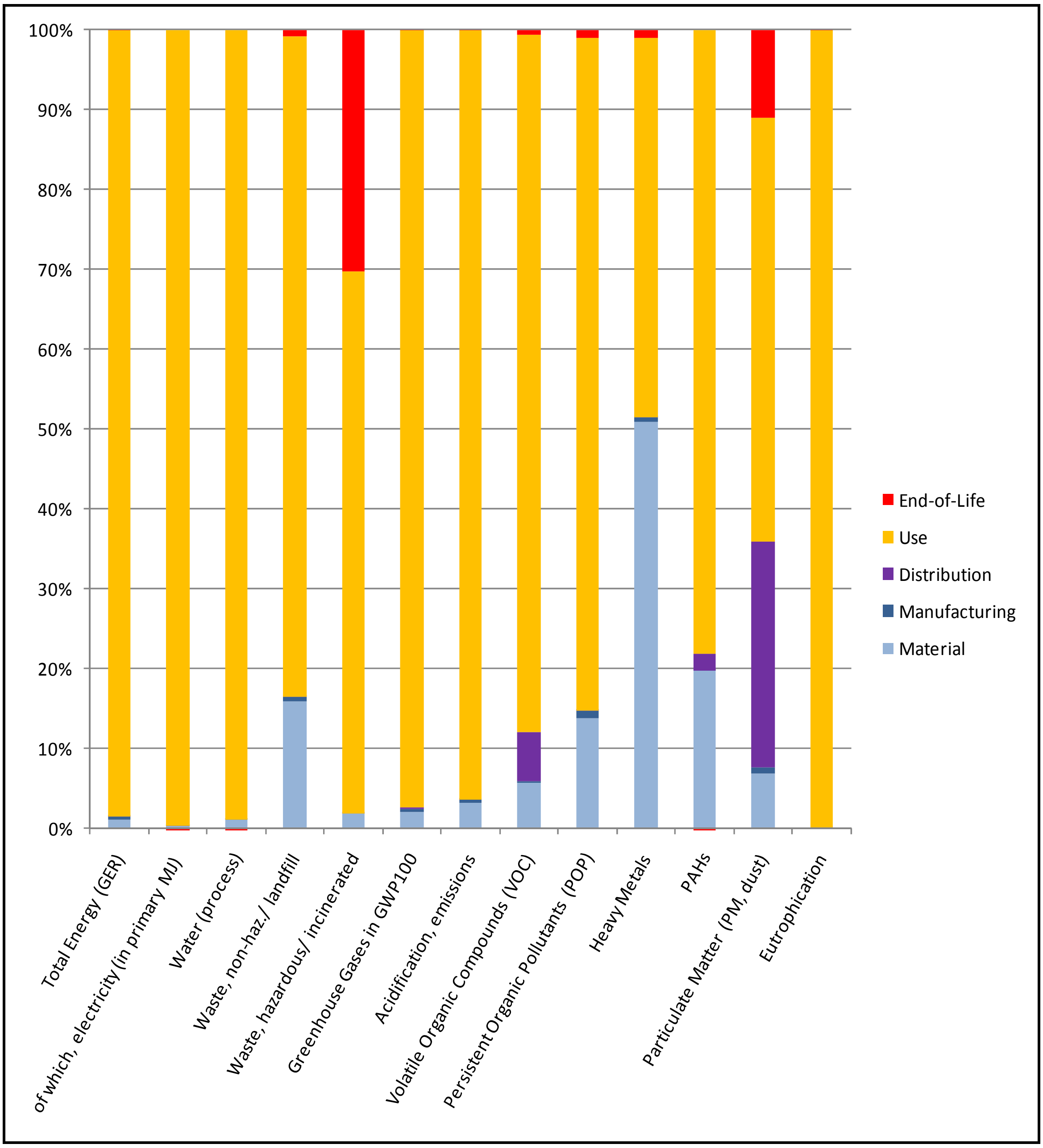

Figure 4 Distribution of environmental impacts of BC 3 per life cycle phase

3.4 Base case 4: Utensil/pot

Table 16 shows the environmental impacts of a utensil/pot dishwasher over its whole life cycle. The total energy consumption for the whole life cycle of the BC 4 is 851 GJ, of which 754 GJ (i.e. 71.8 MWh$_e$) electricity.

Table 16 Life Cycle Impact (per unit) of base case 4 – Utensil/pot

Nr	**Life cycle Impact per product:**							Date	Author		
4	Utensil/Pot								BIO		
	Life Cycle phases -->		**PRODUCTION**			**DISTRI-**	**USE**	**END-OF-LIFE***			**TOTAL**
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**16000**			11200	4800	**16000**	**0**
2	TecPlastics	g			**4000**			2800	1200	**4000**	**0**
3	Ferro	g			**172000**			8600	163400	**172000**	**0**
4	Non-ferro	g			**12400**			620	11780	**12400**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**2100**			2100	0	**2100**	**0**
7	Misc.	g			**19500**			975	18525	**19500**	**0**
	Total weight	g			**226000**			26295	199705	**226000**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	15858	3617	**19475**	**5549**	**825601**	1753	1657	**96**	**850720**
9	of which, electricity (in primary MJ)	MJ	3150	2157	**5306**	**14**	**748745**	0	22	**-22**	**754044**
10	Water (process)	ltr	14090	32	**14121**	**0**	**768006**	0	15	**-15**	**782113**
11	Water (cooling)	ltr	3310	997	**4306**	**0**	**1996555**	0	122	**-122**	**2000740**
12	Waste, non-haz./ landfill	g	284834	12602	**297436**	**2297**	**958311**	13873	86	**13787**	**1271831**
13	Waste, hazardous/ incinerated	g	1518	1	**1518**	**46**	**19002**	14000	14	**13987**	**34552**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1316	202	**1518**	**328**	**36084**	131	107	**23**	**37953**
15	Ozone Depletion, emissions	mg R-11eq.					negligible				
16	Acidification, emissions	g SO2 eq.	12000	872	**12872**	**1002**	**212538**	265	144	**121**	**226533**
17	Volatile Organic Compounds (VOC)	g	43	1	**44**	**102**	**334**	6	2	**4**	**484**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1441	96	**1536**	**13**	**5416**	96	0	**96**	**7061**
19	Heavy Metals	mg Ni eq.	25396	224	**25621**	**117**	**14704**	487	0	**487**	**40928**
	PAHs	mg Ni eq.	719	0	**719**	**220**	**1942**	0	1	**-1**	**2881**
20	Particulate Matter (PM, dust)	g	1518	134	**1652**	**16920**	**9840**	2373	4	**2369**	**30781**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	16005	0	**16006**	**4**	**4987**	144	0	**144**	**21140**
22	Eutrophication	g PO4	412	2	**414**	**0**	**126097**	8	1	**8**	**126518**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

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

- Within the production phase, the manufacturing impacts are very small: the maximum contribution is 1.4% in POP emissions, because of the sheet metal scrap generated during the manufacturing process. The material extraction and production are responsible for the important contributions of this phase to the quantity of landfilled waste (22%) because of the general metal content, POP (20%) and HM (62%) emissions because of the stainless steel contained in the product and PAH emissions (25%) because of the aluminium parts.
- As expected, the use phase is by far the main contributor to the following impacts: total energy (97.0%) and electricity consumption (99.3%), water for processing (98.2%), non-hazardous waste (75%), greenhouse gases emissions (95%), acidification (94%), POP (77%), PAHs (67%) and eutrophication (99.7%). The water use during the use phase is the main contributor for the water processing impact. The detergent is the source of almost 100% of the eutrophication impact during the use phase, and also makes a slight contribution (around 10%) for waste generation, GWP and POP emissions. The maintenance and repair services are the main reason for the PM emissions because of the travels. For the remaining shares, the electricity consumption is the main source for the impacts, especially total energy and electricity, GWP and acidification.
- The distribution phase is negligible for all impacts except for PM for which it accounts for around 55% of the total emissions, and for VOC (21%) and PAHs (8%) emissions. This is due to the product transportation.
- The end-of-life is also negligible for all impacts except for the generation of hazardous waste (40%) and PM (8%). This is due to the high recycling rate (because of the plastics and metals content) which partly counterbalances the negative impacts of incinerating or landfilling the few non recyclable materials. When the red bar is placed below the x-axis on the figure, it means that the end-of-life actually results in a small credit in the impact category considered: in particular, this is the case for energy and electricity consumption.

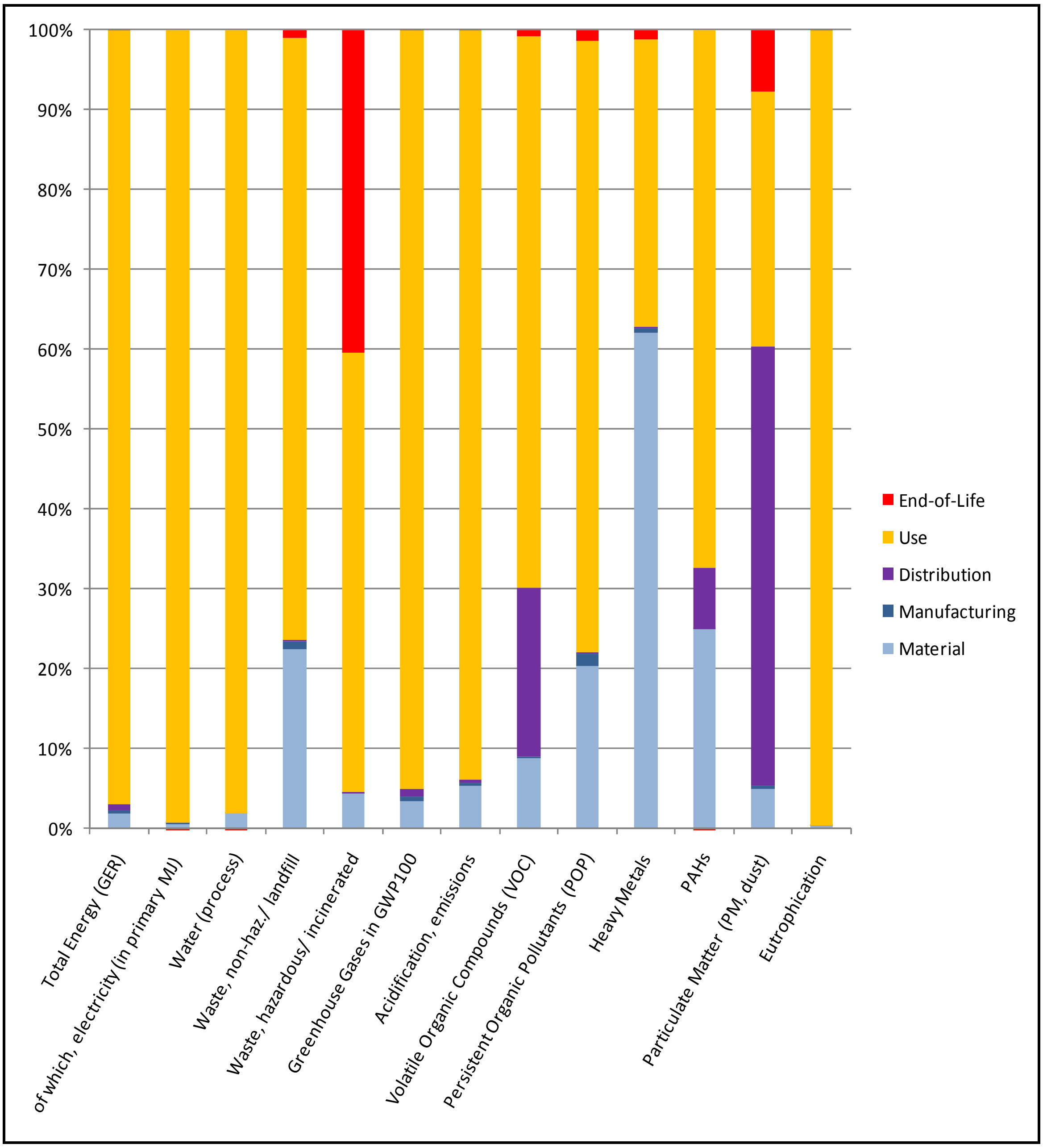

Figure 5 Distribution of environmental impacts of BC 4 per life cycle phase

3.5 Base case 5: Conveyor-type one-tank

Table 17 shows the environmental impacts of a conveyor-type one-tank dishwasher over its whole life cycle. The total energy consumption for the whole life cycle of the BC 5 is 5.19 TJ, of which 4.77 GJ (i.e. 454 MWh$_e$) electricity.

Table 17 Life Cycle Impact (per unit) of base case 5 – Conveyor-type one-tank

Nr	Life cycle Impact per product:							Date	Author		
5	One-tank conveyor-type								BIO		
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	unit									
1	Bulk Plastics	g			99080			69356	29724	99080	0
2	TecPlastics	g			6140			4298	1842	6140	0
3	Ferro	g			670210			33511	636700	670210	0
4	Non-ferro	g			108995			5450	103545	108995	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			9800			9800	0	9800	0
7	Misc.	g			79000			3950	75050	79000	0
	Total weight	g			973225			126364	846861	973225	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	72236	15895	88131	13657	5085707	8487	7817	669	5188164
9	of which, electricity (in primary MJ)	MJ	13195	9484	22679	35	4750805	0	116	-116	4773403
10	Water (process)	ltr	55907	140	56047	0	3393406	0	77	-77	3449377
11	Water (cooling)	ltr	13880	4388	18268	0	12668391	0	642	-642	12686017
12	Waste, non-haz./ landfill	g	1703048	55062	1758111	5610	5910757	59758	451	59307	7733783
13	Waste, hazardous/ incinerated	g	6967	2	6970	111	117191	73656	71	73585	197858
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	5627	887	6514	804	222034	632	497	134	229486
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	55258	3829	59087	2462	1310126	1286	673	613	1372288
17	Volatile Organic Compounds (VOC)	g	167	4	172	253	1949	28	8	20	2394
18	Persistent Organic Pollutants (POP)	ng i-Teq	6009	397	6406	32	33379	413	0	413	40231
19	Heavy Metals	mg Ni eq.	100741	930	101670	284	88663	2345	0	2345	192963
	PAHs	mg Ni eq.	6100	2	6101	542	10520	0	6	-6	17156
20	Particulate Matter (PM, dust)	g	6441	589	7031	41872	35584	11526	22	11504	95990
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	65648	0	65649	9	31287	695	0	695	97639
22	Eutrophication	g PO4	1613	7	1620	0	556540	40	3	37	558197
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

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

- Within the production phase, the manufacturing impacts are very small: the maximum contribution is 1% in POP emissions, because of the sheet metal scrap generated during the manufacturing process. The material extraction and production are responsible for the important contributions of this phase to the quantity of landfilled waste (22%) because of the general metal content, POP (15%) and HM (52%) emissions because of the stainless steel contained in the product and PAH emissions (36%) because of the aluminium parts.
- As expected, the use phase is by far the main contributor to the following impacts: total energy (98%) and electricity consumption (99.5%), water for processing (98.4%), non-hazardous waste (76%), greenhouse gases emissions (97%), acidification (95%), POP (83%), PAHs (61%) and eutrophication (99.7%). The water use during the use phase is the main contributor for the water processing impact. The detergent is the source of almost 100% of the eutrophication impact during the use phase, and also makes a slight contribution (around 7%) for waste generation, GWP and POP emissions. The maintenance and repair services represent “only” 25% of the PM emissions in the use phase (in comparison with previous base cases) because of the travels. For the remaining shares, the electricity consumption is the main source for the impacts, especially total energy and electricity, GWP, acidification and POP emissions.
- The distribution phase is negligible for all impacts except for PM for which it accounts for around 44% of the total emissions, and for VOC (11%) and PAHs (3%) emissions. This is due to the product transportation.
- The end-of-life is also negligible for all impacts except for the generation of hazardous waste (37%) and PM (12%). This is due to the high recycling rate (because of the plastics and metals content) which partly counterbalances the negative impacts of incinerating or landfilling the few non recyclable materials. When the red bar is placed below the x-axis on the figure, it means that the end-of-life actually results in a small credit in the impact category considered: in particular, this is the case for energy and electricity consumption.

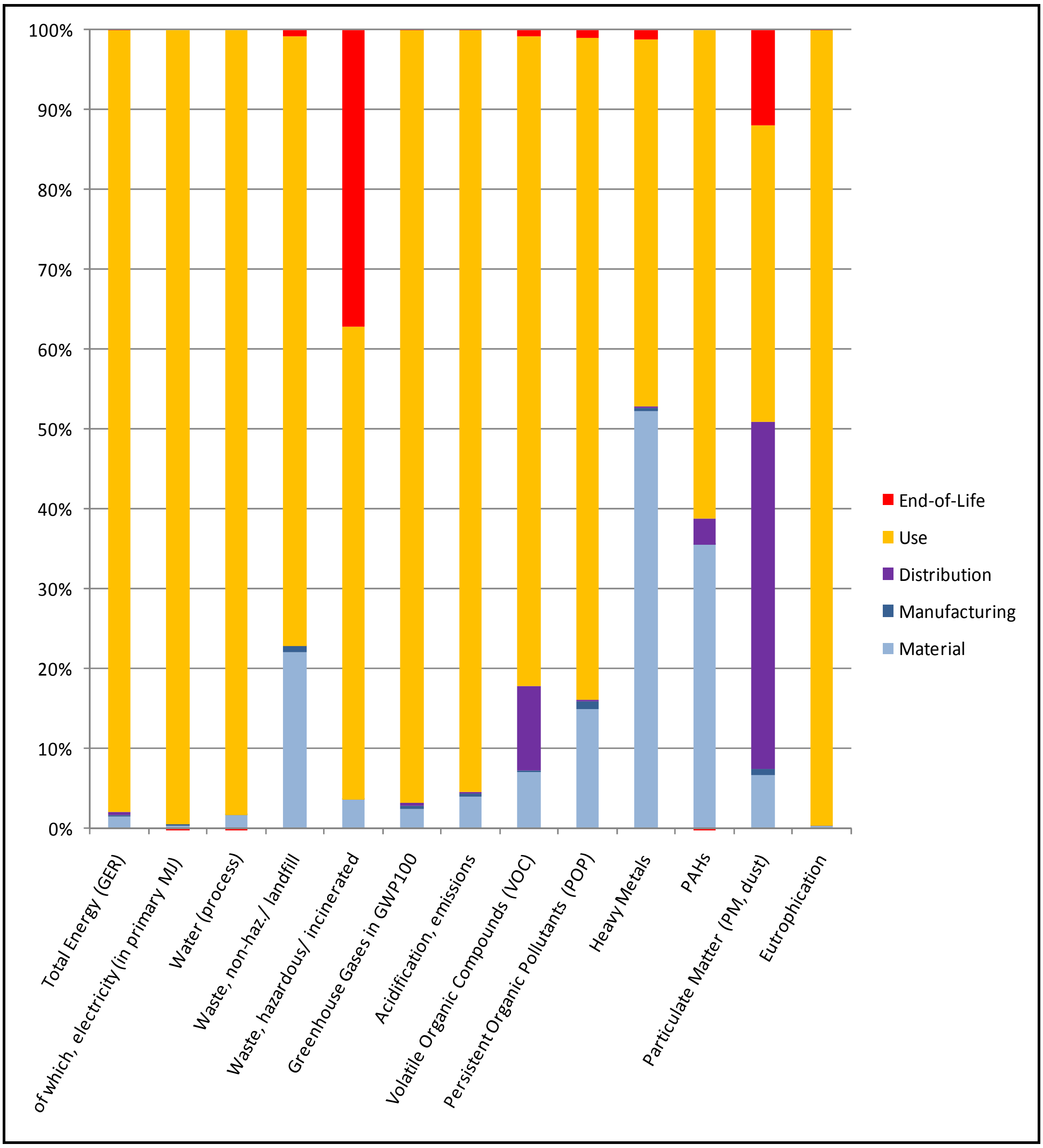

Figure 6 Distribution of environmental impacts of BC 5 per life cycle phase

3.6 Base case 6: Conveyor-type multi-tank

Table 18 shows the environmental impacts of a conveyor-type multi-tank dishwasher over its whole life cycle. The total energy consumption for the whole life cycle of the BC 6 is 19.6 TJ, of which 18.3 TJ (i.e. 1.74 GWh$_e$) electricity.

Table 18 Life Cycle Impact (per unit) of base case 6 – Conveyor-type multi-tank

Nr	Life cycle Impact per product:							Date	Author		
6	Multi-tank conveyor-type								BIO		
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**110090**			77063	33027	**110090**	**0**
2	TecPlastics	g			**18660**			13062	5598	**18660**	**0**
3	Ferro	g			**1042440**			52122	990318	**1042440**	**0**
4	Non-ferro	g			**103700**			5185	98515	**103700**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**15400**			15400	0	**15400**	**0**
7	Misc.	g			**174710**			8736	165975	**174710**	**0**
	Total weight	g			**1465000**			171568	1293433	**1465000**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	103175	22392	**125567**	**18466**	**19422834**	11321	11047	**274**	**19567140**
9	of which, electricity (in primary MJ)	MJ	20506	13355	**33861**	**47**	**18248215**	1	143	**-142**	**18281981**
10	Water (process)	ltr	86267	197	**86464**	**0**	**12187151**	0	94	**-94**	**12273521**
11	Water (cooling)	ltr	19750	6173	**25924**	**0**	**48661263**	0	785	**-785**	**48686402**
12	Waste, non-haz./ landfill	g	1962298	77932	**2040230**	**7574**	**22531445**	89925	552	**89373**	**24668623**
13	Waste, hazardous/ incinerated	g	10890	3	**10893**	**151**	**447497**	90127	87	**90041**	**548581**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	8280	1250	**9530**	**1087**	**847850**	843	719	**124**	**858591**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	76199	5396	**81595**	**3328**	**5002741**	1711	962	**749**	**5088412**
17	Volatile Organic Compounds (VOC)	g	262	6	**269**	**342**	**7415**	39	12	**26**	**8052**
18	Persistent Organic Pollutants (POP)	ng i-Teq	8986	586	**9573**	**43**	**127356**	621	0	**621**	**137592**
19	Heavy Metals	mg Ni eq.	152879	1374	**154253**	**384**	**335974**	3143	0	**3143**	**493755**
	PAHs	mg Ni eq.	6282	2	**6284**	**732**	**39648**	0	8	**-8**	**46657**
20	Particulate Matter (PM, dust)	g	9431	830	**10261**	**56672**	**129563**	15323	29	**15294**	**211790**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	97876	1	**97876**	**12**	**118636**	928	0	**928**	**217453**
22	Eutrophication	g PO4	2484	10	**2494**	**0**	**1956057**	53	3	**50**	**1958601**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

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

- Within the production phase, the manufacturing impacts are very small: the maximum contribution is 0.4% in POP emissions, because of the sheet metal scrap generated during the manufacturing process. The material extraction and production are responsible for the contributions of this phase to the quantity of landfilled waste (8%) because of the general metal content, POP (7%) and HM (31%) emissions because of the stainless steel contained in the product and PAH emissions (13%) because of the aluminium parts.
- As expected, the use phase is by far the main contributor to the following impacts: total energy (99.3%) and electricity consumption (99.8%), water for processing (99.3%), non-hazardous waste (91%), greenhouse gases emissions (98.8%), acidification (98.3%), POP (93%), PAHs (85%) and eutrophication (99.9%). The water use during the use phase is the main contributor for the water processing impact. The detergent is the source of almost 100% of the eutrophication impact during the use phase, and also makes a slight contribution (around 7%) for waste generation, GWP and POP emissions. The maintenance and repair services represent “only” 8% of the PM emissions in the use phase (in comparison with previous base cases) because of the travels. For the remaining shares, the electricity consumption is the main source for the impacts, especially total energy and electricity, GWP, acidification and POP emissions.
- The distribution phase is negligible for all impacts except for PM for which it accounts for around 27% of the total emissions and for VOC (4%) emissions. This is due to the product transportation.
- The end-of-life is also negligible for all impacts except for the generation of hazardous waste (16%) and PM (7%). This is due to the high recycling rate (because of the plastics and metals content) which partly counterbalances the negative impacts of incinerating or landfilling the few non recyclable materials. When the red bar is placed below the x-axis on the figure, it means that the end-of-life actually results in a small credit in the impact category considered: in particular, this is the case for energy and electricity consumption.

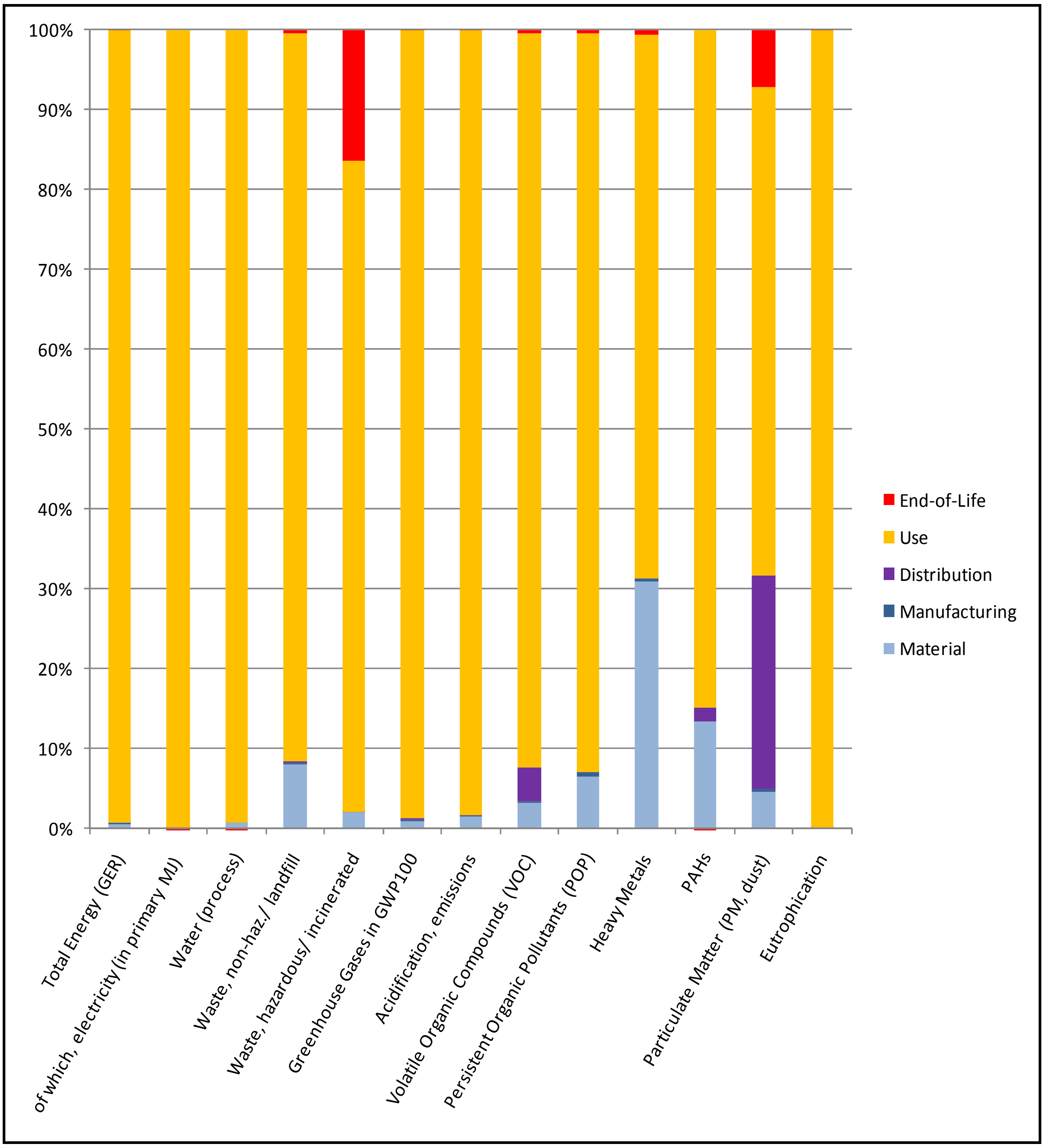

Figure 7 Distribution of environmental impacts of BC 6 per life cycle phase

3.7 Conclusions

The results of the impact assessment are very similar for the six BCs, not in absolute values but in predominance of certain key elements on the environmental impacts:

- The production phase impacts are mostly due to the stainless steel and the aluminium content of the professional dishwashers. The use of these materials however seems necessary so that it is not expected that improvement options enable to lower significantly the impacts due to this life cycle phase.
- The use phase is the main contributing phase for most environmental indicators, especially energy consumption (and electricity consumption, always over 97% of the total impacts), GWP and acidification. The contribution of this phase is mainly due to the amount of electricity needed to run the appliances during the whole lifetime. Besides, the high detergent consumption induces eutrophication impacts and the water consumption obviously results in use of water. Therefore, improvement options enabling energy, water and detergent savings in operation will be the most effective options in reducing the environmental impact of professional dishwashers.
- The distribution is always negligible except for the emissions of particulate matter, which are due to the transportation of the appliances, which is inevitable. Manufacturing lighter machines would reduce this impact but is not considered as a priority option (and manufacturers probably already optimise this aspect as it directly influences their logistic costs).
- The end-of-life mainly contributes significantly 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. On the contrary, the possible implementation of heat pumps (containing refrigerant) in more efficient products may result in additional impacts.

Looking at the results of the Ecodesign preparatory study on domestic washing machines and dishwashers (Lot 14 for DG TREN), the environmental analysis of the base cases shows many similarities. Concerning emissions, the use phase is also the main contributor for greenhouse gases, acidification and VOC. 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). Energy consumption and water use are also identified as the most relevant elements in the use phase. The main difference lies in the fact that the contribution of the use phase is globally more important in the case of professional dishwashers, at the expenses of the other phases.

This results from the fact that professional appliances are used more intensively than household appliances.

4 Base case life cycle costs

The result of the procurement process should be the cheapest dishwasher, having the lowest total cost of ownership, taking into account the consumables expenditure and optimised for a given application.

Table 19 exposes the details of the LCC over the lifetime for each base case (see assumed lifetime of base cases in Table 20).[10] Installation costs and end-of-life costs were estimated to be zero in Task 2 and are not displayed in the table.

Table 19 EcoReport outcomes of the LCC calculations of the six base cases

Item	**Base case**					
	1	**2**	**3**	**4**	**5**	**6**
Product price (Euro)	3 200	3 500	4 700	10 500	15 000	45 000
Repair and maintenance costs (Euro)	939	1 296	1 740	3 888	5 162	14 169
Electricity cost (Euro)	1 624	4 881	5 838	6 301	31 846	111 932
Water cost (Euro)	642	992	1 540	1 591	6 335	20 672
Detergent/Rinse aid cost (Euro)	2 450	3 797	5 898	5 938	24 354	78 323
Life Cycle Cost (Euro)	**8 854**	**14 466**	**19 716**	**28 219**	**82 697**	**270 096**

Figure 8 shows the contribution of the product price and the resources and consumables costs for the six base cases LCC.

For BC 1 and BC 4, the product price represents 36-37% of the global LCC. For BC 2 and BC 3, the product price only accounts for 24% and gets an even smaller share for heavy duty appliances (18% for BC 5 and 17% for BC 6). This phenomenon makes sense as the lifetimes are longer, resulting in larger total costs for consumables and resources. Repair and maintenance follow the same evolution as they were estimated through a percentage of the product price. For the resources and consumables shares, the opposite happens: electricity only represent 18% for BC 1 and 22% for BC 4, while it reaches 39% for BC 5 and 41% for BC 6. The detergent share is comprised between 21% and 30% for all base cases and the share for water is less variable (between 6% and 8%). BC 1 is the only base case for which

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[10] Annual costs being discounted taking into account the discount rate of 4%.

the detergent costs are significantly more important than the electricity costs (they are similar for BC 3 and BC 4).

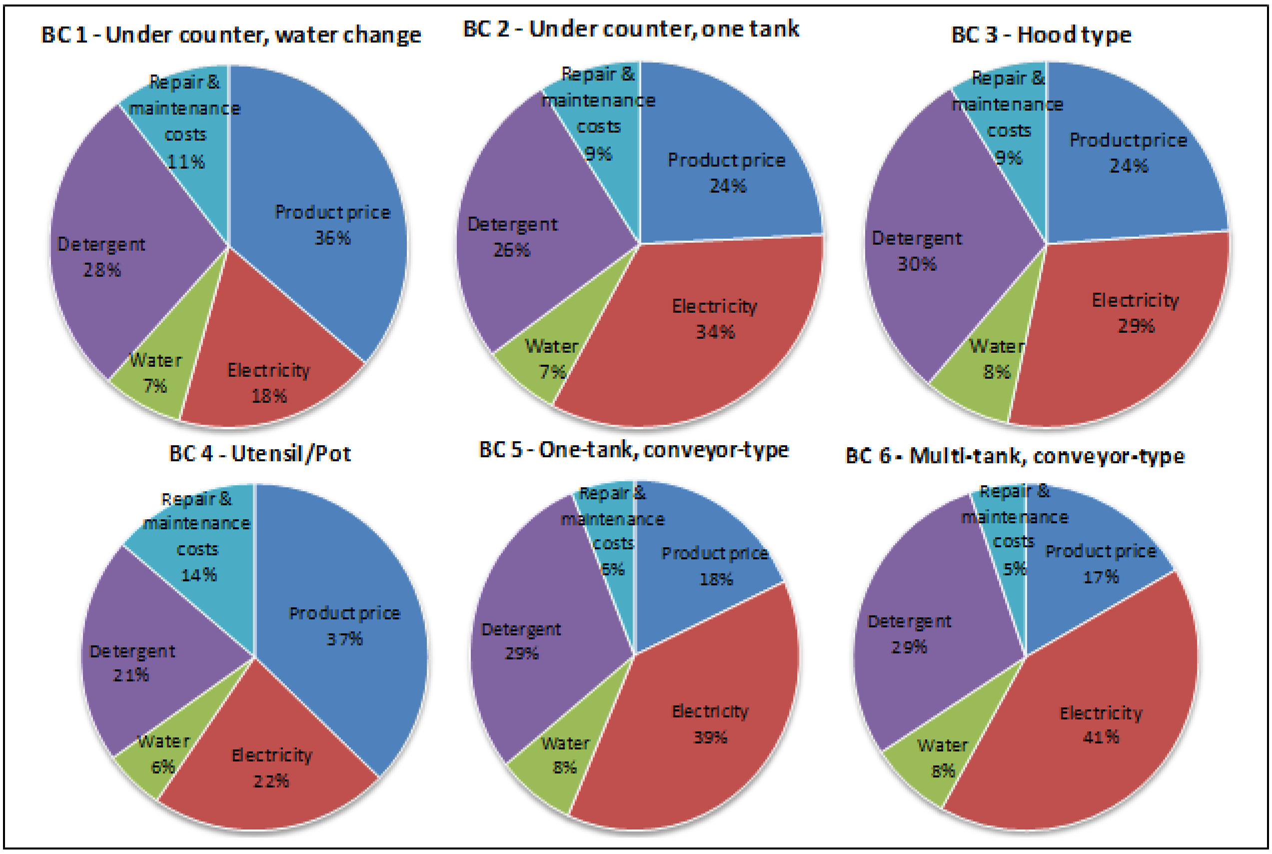

Figure 8 Breakdown of base cases' LCC

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. impacts and LCC of the stock).

5.1 Market data

Table 20 displays the market data of the six BCs in EU-27 in 2009.

Table 20 Market and technical data for all base cases in 2009

Base case	Lifetime (years)	Annual sales (units/year)	EU stock (units)
BC 1 Undercounter water-change	12	20 000	207 223
BC 2 Undercounter one-tank	8	138 200	1 012 355
BC 3 Hood-type	8	65 900	482 728
BC 4 Utensil/Pot	8	2 600	19 309
BC 5 One-tank conveyor-type	12	6 600	68 425
BC 6 Multi-tank conveyor-type	17	1 300	18 015

5.2 Life Cycle Environmental Impacts

Table 21 shows the total environmental impacts in 2009 of all professional dishwashers in stock in EU-27, based on the extrapolation of the base cases impacts (all have the same impacts as the base case of their category). Thus, these figures include the production and distribution impacts of the products sold in 2009, the use phase impacts of the stock products being used during 2009 and the end-of-life impacts of the products being discarded that same year.

Table 21 Environmental impacts of the EU-27 stock in 2009 for all base cases

Environmental Impact	Base case						Total
	1	2	3	4	5	6	
Total Energy (GER) (in PJ)	3.4	68.6	51.4	2.3	36.1	26.9	188.6
of which electricity (in TWh)	0.3	5.8	4.4	0.2	3.2	2.4	16.2
Water process (in million m^3)	5.6	66.4	49.3	2.1	24.0	16.9	164.3
Waste, non-hazardous/landfill (in kt)	4.9	94.5	71.0	3.4	53.2	33.8	260.8
Waste, hazardous/ incinerated (in kt)	0.22	2.54	1.72	0.09	1.35	0.75	6.7
Emissions to air							
Greenhouse Gas in GWP100 (in Mt CO_2eq.)	0.15	3.03	2.27	0.10	1.59	1.18	8.3
Acidification, emissions (in kt SO_2eq.)	0.9	18.0	13.5	0.6	9.5	7.0	49.6
Volatile Organic Compounds (VOC) (in kt)	0.003	0.030	0.023	0.001	0.016	0.011	0.1
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.03	0.52	0.39	0.02	0.28	0.19	1.4
Heavy Metals (in ton Ni eq.)	0.14	2.32	1.87	0.11	1.31	0.67	6.4
PAHs (in ton Ni eq.)	0.01	0.20	0.14	0.01	0.12	0.06	0.5
Particulate Matter (PM, dust) (in kt)	0.13	1.06	0.82	0.08	0.65	0.29	3.0
Emissions to water							
Eutrophication (in kt PO_4)	0.97	11.14	8.25	0.34	3.88	2.70	27.3

Summary of environmental impacts of BCs as a percentage of total impact are presented in Figure 9. As the figure shows, undercounter one-tank dishwashers have the greatest impacts within the sector and represent the major share of the total stock. The share of these appliances remains relatively constant, between 35% (for PM) and 41% for eutrophication and water. Hood-type dishwashers, representing 27% of the total stock, also account for a large share of the impacts, between 26% (for PAHs) and 30% for eutrophication and water. Undercounter water-change dishwashers have a very low share for all indicators (always below 4%) despite a share of 11% of the total stock. The low stock of utensil/pot dishwashers and their relatively low capacity explain the negligible share of this base case in the total impacts (less than 1%). Finally, heavy duty appliances (BC 5 and BC 6) represent together around 30-35% of the environmental impacts even if fewer appliances are used in comparison with other types.

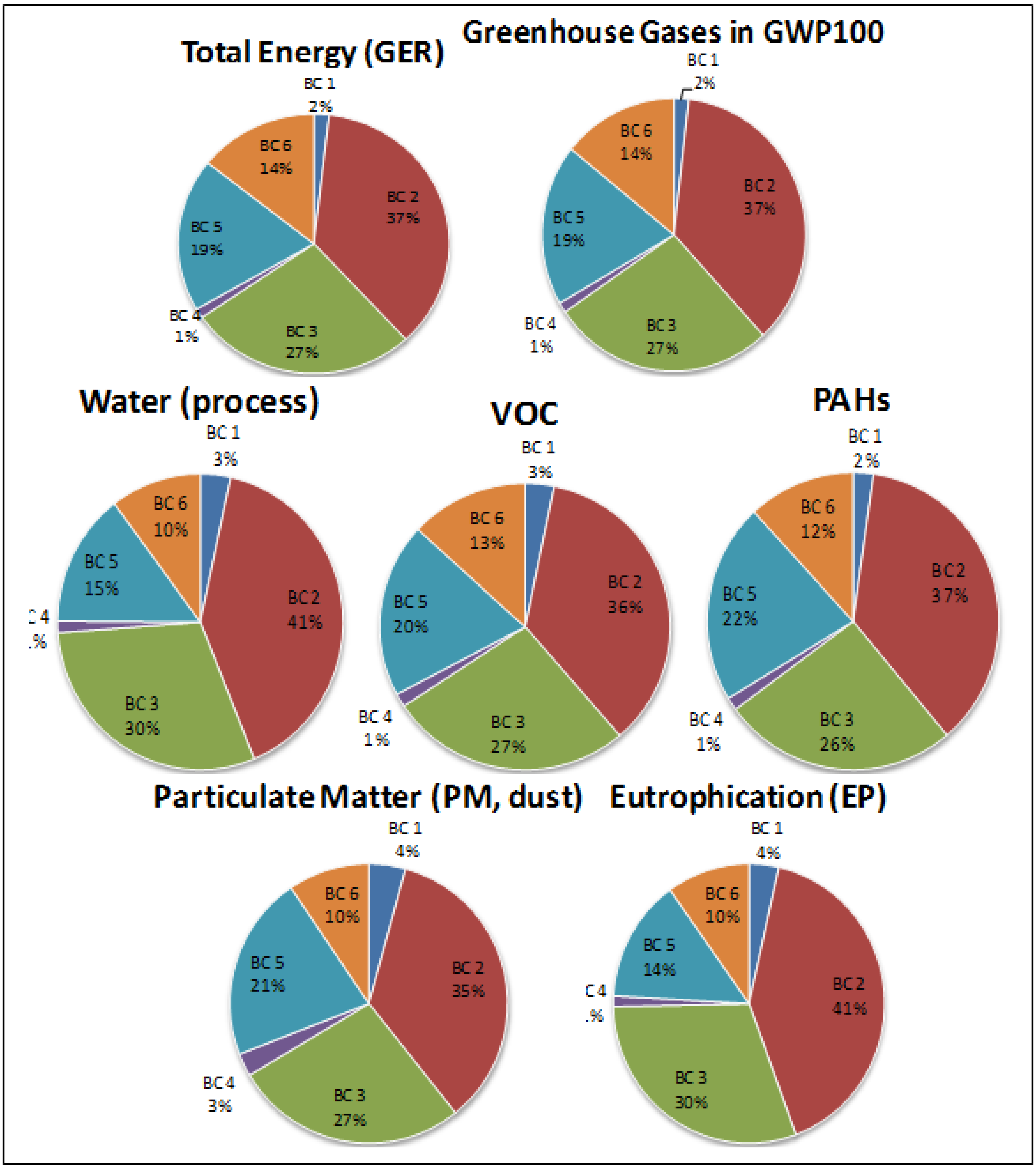

Figure 9 Base cases' share of the environmental impacts of the stock in 2009

Figure 10 focuses on the shares of the electricity consumption. They are similar to other impacts as BC 2 represents 36% of the total electricity consumption of the professional dishwashers stock, BC 3 accounts for 27% of the total and BC 5 and 6 for 34% together. The total electricity consumption of professional dishwashers is about 16.2 TWh which represents around 0.57% of the EU-27 total electricity consumption.[11]

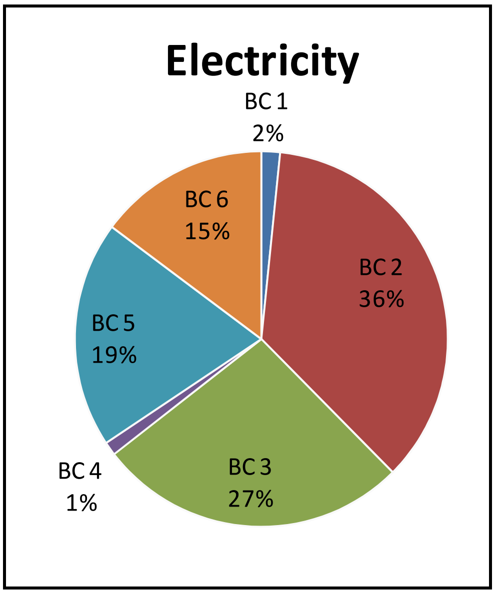

Figure 10 Base cases' share of the electricity consumption of the stock in 2009

No other estimations of the overall impacts of EU professional dishwashers were found in the literature. An American study[12] however estimated the baseline energy use (but other environmental impacts were not assessed). These results are presented in Table 22.

Table 22 Energy consumption of professional dishwashers in the USA, 2008[13]

Category	Primary Energy consumption (TBtu)[14]	Primary Energy consumption (PJ)
Undercounter	5.2	5.5
Conveyor	115.0	121.9
Door type	21.9	23.2
Flight type	18.9	20.0
Total	**161.0**	**170.7**

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[11] Source Eurostat: EU27 electricity consumption in 2007 = 244 million toe = 2 837 TWh.

[12] Navigant Consulting (2009), *Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances*, for US Department of Energy.

[13] Navigant Consulting (2009), *Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances*, for US Department of Energy.

[14] Conversion factor: 1 Btu = 1060 kJ

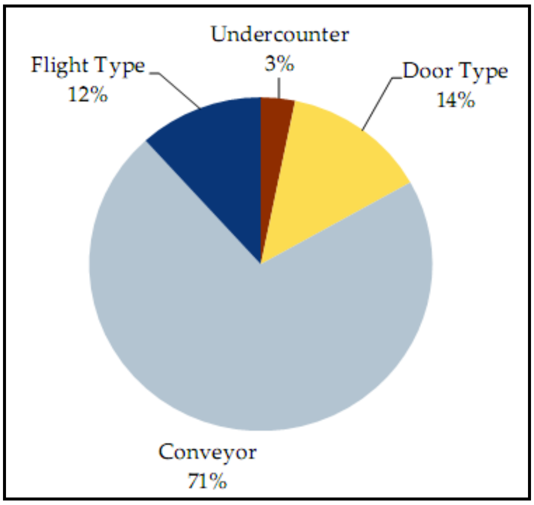

Figure 11 Professional Dishwashers Primary Energy Consumption by Washer Type, in the USA, 2008 [13]

These results are in accordance: while the EU-27 (with a population of around 500 million inhabitants and a GDP of $ 16 447 259[15]) has an annual primary energy consumption of 234.0 PJ for professional dishwashers, the US (with a population of 310 million inhabitants and a GDP of $ 14 256 275[15]), has an annual consumption of 170.7 PJ for the same sector.

However, important differences can be seen on Figure 11, as conveyor dishwashers are expected to represent 71% of the total consumption in the US, while only 36% in EU-27. Undercounter dishwashers also have a much smaller share in the US than in the EU (3% vs. 37%). This difference may come from the specificities of the market structure as it seems that the sales of conveyor-type dishwashers represent a more important share of the total sales in the US than in the EU-27.

5.3 Life Cycle Costs

Regarding the total consumer expenditure in 2009 related to the six BCs, about 36% of the total costs are due to electricity consumption, 8% to water consumption and 27% to detergent consumption while product prices represent 21% of this total. The distribution per base case is given in Figure 12 and details on consumer expenditure are presented in Table 23.

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[15] International Monetary Fund, 2009

Table 23 Total Annual Consumer expenditure in EU-27 in 2009

Environmental Impact	Base case						Total
	1	**2**	**3**	**4**	**5**	**6**	
EU-27 sales (in thousand units)	20	138.2	65.9	2.6	6.6	1.3	234.6
Share of the EU-27 sales	8.5%	58.9%	28.1%	1.1%	2.8%	0.6%	100%
Product Price (in million Euro)	64	484	310	27	99	59	1 042
Electricity (in million Euro)	36	800	456	20	283	215	1 811
Water (in million Euro)	14	163	120	5	56	40	398
Detergent (in million Euro)	54	571	423	17	178	116	1 358
Repair and maintenance costs (in million Euro)	21	195	125	11	38	21	410
Total (in million Euro)	189	2 212	1 434	80	654	451	5 020

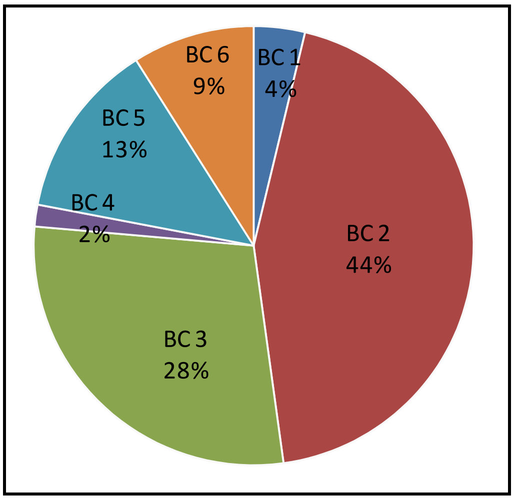


Figure 12 Base cases' share of the total consumer expenditure in 2009

The contributions to the total consumer expenditure are slightly different from the ones to the environmental impacts. Total consumer expenditure in 2009 related to undercounter one-tank dishwashers represents 44% of the total. Hood-types are the next highest with 28% and third come conveyor-type appliances accounting for 13% (one-tank) and 9% (multi-tank) of the total consumer expenditure. Total consumer expenditure does not take into account possible benefits received for materials at disposal.

6 EU-27 total system impact

During operation, professional dishwashers produce heat which is transferred to the water first and partially to the dishes afterwards. This heat (and residual moisture) can then be transferred to the room if the machine has no specific heat recovery option implemented. The environmental impacts of this heat transfer can be positive as well as negative, depending on several parameters:

- The climate: If the room needs to be heated, the dishwasher will complement the heating system. On the contrary, if the room needs to be cooled (it is usually the case for kitchens with warm and humid atmosphere), operating a dishwasher will require additional energy consumption from the ventilation/air conditioning system. A dishwasher with a heat recovery system or a heat pump will reduce the energy consumption of the dishwasher itself on the one hand, and also spares the extra work needed from the ventilation system in comparison with a basic dishwasher on the other hand.
- The energy source of the dishwasher and of the heating system: electricity needs to be produced from a primary energy, generally with low efficiency. If the dishwasher only uses electricity as energy source, the central heating system will be much more efficient and heating the room indirectly thanks to the dishwasher 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 dishwasher is installed has also an influence on the possible options to reduce the energy consumption of the system. The base cases are all considered with only cold water supply and 100% electric heating. However, the implementation of warm water supply (see Task 7) or the use of another energy source (e.g. gas which, however, is not very common for professional dishwashers) normally enable to reduce the use of primary energy (and lower many environmental impacts) even if it does not reduce the final energy needed at the level of the machine: the heat required and contained in the water remains the same.

7 Conclusions

The environmental impacts assessment carried out with the EcoReport tool for each base case shows that the use phase is by far the most impacting stage of the life cycle in terms of energy consumption, water consumption, greenhouse gases emissions and eutrophication. Therefore, the analysis of the improvement potential in Task 7 will mainly focus on technologies that reduce the electricity, water and detergent consumption during the use phase.

Because of their large amount of appliances in total stock, the undercounter one-tank dishwashers are responsible for about 40% of the overall impacts due to professional dishwashers in EU. They also represent 44% of the annual consumer expenditure as their range of price is very wide. Hood-type dishwashers and conveyor-type dishwashers also significantly contribute to the total environmental impacts and expenditure while undercounter water-change and utensil/pot dishwashers account for minor shares.

Task 6 will examine the improvement options of professional dishwashers considered as best available technologies, in an attempt to improve upon the base cases. Based on the life cycle analysis made in this task, these options mainly focus on the reduction of energy, water and detergent consumption of the dishwashers during the use phase.

8 Annex

8.1 Detailed bills of materials of the six base cases

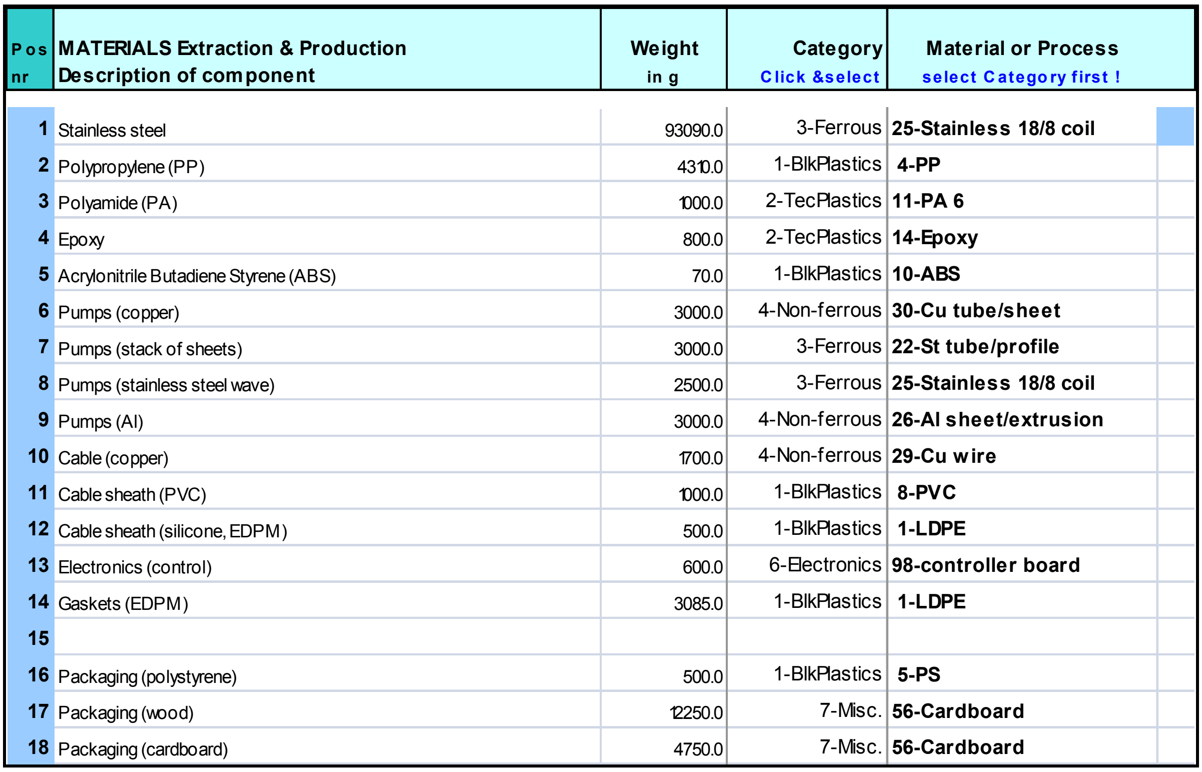
Bill of material of Base case 1

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless Steel	24560.0	3-Ferro	25-Stainless 18/8 coil
2	Steel Sheet galvanized	403.0	3-Ferro	21-St sheet galv.
3	Cast Iron	2303.0	3-Ferro	23-Cast iron
4	Polypropylene (PP)	4980.0	1-BlkPlastics	4-PP
5	Polyamid (PA)	399.0	2-TecPlastics	11-PA 6
6	Polymethylmetacrylate (PMMA)	6.0	2-TecPlastics	13-PMMA
7	Acrylonitrile Butadiene Styrene (ABS)	751.0	1-BlkPlastics	10-ABS
8	Plystyrene (PS)	512.0	1-BlkPlastics	5-PS
9	Styropor expandable polystyrene (EPS)	40.0	1-BlkPlastics	6-EPS
10	Polybutylene Terephthalate (PBT)	35.0		
11	Polyvinylchlorid (PVC)	403.0	1-BlkPlastics	8-PVC
12	EPDM-rubber	524.0	1-BlkPlastics	1-LDPE
13	POM	230.0	1-BlkPlastics	2-HDPE
14	PE	187.0	1-BlkPlastics	2-HDPE
15	Plastics others	268.0		
16	Aluminium	273.0	4-Non-ferro	26-Al sheet/extrusion
17	Cu wire	1006.0	4-Non-ferro	29-Cu wire
18	CuZn38 cast	23.0	4-Non-ferro	31-CuZn38 cast
19	Chromium	71.0		
20	Bitumen	6089.0	7-Misc.	55-Bitumen
21	Concrete	1263.0	7-Misc.	58-Concrete
22	Cotton	452.0		
23	Epoxy	609.0	2-TecPlastics	14-Epoxy
24	Wood	2034.0	7-Misc.	56-Cardboard
25	others (Paper)	285.0	7-Misc.	57-Office paper
26	Electronics (control)	448.0	6-Electronics	98-controller board
27	Packaging (EPS)	724.0	1-BlkPlastics	6-EPS
28	Packaging (PE foil)	172.0	1-BlkPlastics	2-HDPE
29	Packaging (Wood)	1011.0	7-Misc.	56-Cardboard
30	Packaging (cardboard)	635.0	7-Misc.	56-Cardboard

Bill of material of Base case 2

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	49760.0	3-Ferro	**25-Stainless 18/8 coil**
2	Polypropylene (PP)	4565.0	1-BlkPlastics	**4-PP**
3	Polyamide (PA)	500.0	2-TecPlastics	**11-PA 6**
4	Epoxy	1000.0	2-TecPlastics	**14-Epoxy**
5	Acrylonitrile Butadiene Styrene (ABS)	70.0	1-BlkPlastics	**10-ABS**
6	Pumps (copper)	2500.0	4-Non-ferro	**30-Cu tube/sheet**
7	Pumps (stack of sheets)	2500.0	3-Ferro	**22-St tube/profile**
8	Pumps (stainless steel wave)	2250.0	3-Ferro	**25-Stainless 18/8 coil**
9	Pumps (Al)	2250.0	4-Non-ferro	**26-Al sheet/extrusion**
10	Cable (copper)	1100.0	4-Non-ferro	**29-Cu wire**
11	Cable sheath (PVC)	600.0	1-BlkPlastics	**8-PVC**
12	Cable sheath (silicone, EDPM)	300.0	1-BlkPlastics	**1-LDPE**
13	Electronics (control)	500.0	6-Electronics	**98-controller board**
14	Gaskets (EDPM)	2040.0	1-BlkPlastics	**1-LDPE**
15				
16	Packaging (polystyrene)	500.0	1-BlkPlastics	**5-PS**
17	Packaging (wood)	6000.0	7-Misc.	**56-Cardboard**
18	Packaging (cardboard)	2750.0	7-Misc.	**56-Cardboard**

Bill of material of Base case 3



Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	93090.0	3-Ferrous	**25-Stainless 18/8 coil**
2	Polypropylene (PP)	4310.0	1-BlkPlastics	**4-PP**
3	Polyamide (PA)	1000.0	2-TecPlastics	**11-PA 6**
4	Epoxy	800.0	2-TecPlastics	**14-Epoxy**
5	Acrylonitrile Butadiene Styrene (ABS)	70.0	1-BlkPlastics	**10-ABS**
6	Pumps (copper)	3000.0	4-Non-ferrous	**30-Cu tube/sheet**
7	Pumps (stack of sheets)	3000.0	3-Ferrous	**22-St tube/profile**
8	Pumps (stainless steel wave)	2500.0	3-Ferrous	**25-Stainless 18/8 coil**
9	Pumps (Al)	3000.0	4-Non-ferrous	**26-Al sheet/extrusion**
10	Cable (copper)	1700.0	4-Non-ferrous	**29-Cu wire**
11	Cable sheath (PVC)	1000.0	1-BlkPlastics	**8-PVC**
12	Cable sheath (silicone, EDPM)	500.0	1-BlkPlastics	**1-LDPE**
13	Electronics (control)	600.0	6-Electronics	**98-controller board**
14	Gaskets (EDPM)	3085.0	1-BlkPlastics	**1-LDPE**
15				
16	Packaging (polystyrene)	500.0	1-BlkPlastics	**5-PS**
17	Packaging (wood)	12250.0	7-Misc.	**56-Cardboard**
18	Packaging (cardboard)	4750.0	7-Misc.	**56-Cardboard**

Bill of material of Base case 4

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	165000.0	3-Ferrous	**25-Stainless 18/8 coil**
2	Polypropylene (PP)	3000.0	1-BlkPlastics	**4-PP**
3	Polyamide (PA)	4000.0	2-TecPlastics	**11-PA 6**
4	Epoxy	0.0	2-TecPlastics	**14-Epoxy**
5	Ethylene Propylene Dien M-class rubber (EPDM)	4000.0	1-BlkPlastics	**1-LDPE**
6	Acrylonitrile Butadiene Styrene (ABS)	0.0	1-BlkPlastics	**10-ABS**
7	Pumps (copper)	5000.0	4-Non-ferrous	**30-Cu tube/sheet**
8	Pumps (stack of sheets)	4000.0	3-Ferrous	**22-St tube/profile**
9	Pumps (stainless steel wave)	3000.0	3-Ferrous	**25-Stainless 18/8 coil**
10	Pumps (Al)	5000.0	4-Non-ferrous	**26-Al sheet/extrusion**
11	Cable (copper)	2400.0	4-Non-ferrous	**29-Cu wire**
12	Cable sheath (PVC)	1400.0	1-BlkPlastics	**8-PVC**
13	Cable sheath (silicone, EDPM)	1100.0	1-BlkPlastics	**1-LDPE**
14	Electronics (control)	2100.0	6-Electronics	**98-controller board**
15	Gaskets, etc. (EDPM)	6000.0	1-BlkPlastics	**1-LDPE**
16				
17	Packaging (polystyrene)	500.0	1-BlkPlastics	**5-PS**
18	Packaging (wood)	16000.0	7-Misc.	**56-Cardboard**
19	Packaging (cardboard)	3500.0	7-Misc.	**56-Cardboard**

Bill of material of Base case 5

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	642250.0	3-Ferrous	**25-Stainless 18/8 coil**
2	Polypropylene (PP)	55500.0	1-BlkPlastics	**4-PP**
3	Polyamide (PA)	6140.0	2-TecPlastics	**11-PA 6**
4	Polyvinyl chloride (PVC)	4600.0	1-BlkPlastics	**8-PVC**
5	Polystyrene (PS)	4430.0	1-BlkPlastics	**5-PS**
6	Acrylonitrile Butadiene Styrene (ABS)	5000.0	1-BlkPlastics	**10-ABS**
7	Pumps (copper)	16825.0	4-Non-ferrous	**30-Cu tube/sheet**
8	Pumps (stack of sheets)	15625.0	3-Ferrous	**22-St tube/profile**
9	Pumps (stainless steel wave)	12335.0	3-Ferrous	**25-Stainless 18/8 coil**
10	Pumps (Al)	17470.0	4-Non-ferrous	**26-Al sheet/extrusion**
11	Condenser (AL)	4720.0	4-Non-ferrous	**26-Al sheet/extrusion**
12	Condenser (Cu)	7080.0	4-Non-ferrous	**30-Cu tube/sheet**
13	Ventilator, fan (AL)	17440.0	4-Non-ferrous	**26-Al sheet/extrusion**
14	Ventilator, fan (Cu)	10160.0	4-Non-ferrous	**30-Cu tube/sheet**
15	Drive motor (AL)	4000.0	4-Non-ferrous	**26-Al sheet/extrusion**
16	Drive motor (Cu)	5000.0	4-Non-ferrous	**30-Cu tube/sheet**
17	Cable (copper)	16300.0	4-Non-ferrous	**29-Cu wire**
18	Cable sheath (PVC)	8640.0	1-BlkPlastics	**8-PVC**
19	Cable sheath (silicone, EDPM)	5170.0	1-BlkPlastics	**1-LDPE**
20	Electric contactor (copper)	10000.0	4-Non-ferrous	**29-Cu wire**
21	Electronics (control)	9800.0	6-Electronics	**98-controller board**
22	Gaskets (EDPM)	12800.0	1-BlkPlastics	**1-LDPE**
23				
24	Packaging (polystyrene)	2940.0	1-BlkPlastics	**5-PS**
25	Packaging (wood)	63500.0	7-Misc.	**56-Cardboard**
26	Packaging (cardboard)	15500.0	7-Misc.	**56-Cardboard**

Bill of material of Base case 6

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless steel	980000.0	3-Ferrous	**25-Stainless 18/8 coil**
2	Polypropylene (PP)	58000.0	1-BlkPlastics	**4-PP**
3	Polyamide (PA)	18660.0	2-TecPlastics	**11-PA 6**
4	Epoxy	0.0	2-TecPlastics	**14-Epoxy**
5	Ethylene Propylene Dien M-class rubber (EPDM)	12000.0	1-BlkPlastics	**1-LDPE**
6	Acrylonitrile Butadiene Styrene (ABS)	0.0	1-BlkPlastics	**10-ABS**
7	Pumps (copper)	39020.0	4-Non-ferrous	**30-Cu tube/sheet**
8	Pumps (stack of sheets)	37070.0	3-Ferrous	**22-St tube/profile**
9	Pumps (stainless steel wave)	25370.0	3-Ferrous	**25-Stainless 18/8 coil**
10	Pumps (Al)	44880.0	4-Non-ferrous	**26-Al sheet/extrusion**
11	Cable (copper)	19800.0	4-Non-ferrous	**29-Cu wire**
12	Cable sheath (PVC)	11440.0	1-BlkPlastics	**8-PVC**
13	Cable sheath (silicone, EDPM)	8360.0	1-BlkPlastics	**1-LDPE**
14	Electronics (control)	15400.0	6-Electronics	**98-controller board**
15	Gaskets, etc. (EDPM)	15000.0	1-BlkPlastics	**1-LDPE**
16				
17	Packaging (polystyrene)	5290.0	1-BlkPlastics	**5-PS**
18	Packaging (wood)	14180.0	7-Misc.	**56-Cardboard**
19	Packaging (cardboard)	33530.0	7-Misc.	**56-Cardboard**

8.2 Stakeholder feedback to draft versions of Task 5

Please note that the feedback refers to prior draft versions of Task 5 report; thus the indicated numerations of chapters, tables, figures or pages might have changed.

Feedback		Comment
JRC IPTS		
	In general the Draft Task 5 of the Professional Dishwashers Report makes a good impression. It is very well structured, transparent and clearly presented in line with the MEEUP methodology. We consider that significant improvements on the environmental assessment of the base cases are feasible if the study could reach a greater level of detail (i.e. it could be more precise, and/or could contain a longer components/substance list in the EcoReport in order to capture the differences among the base cases). Moreover, we would like to emphasise a significant aspect in the calculation of the overall environmental performance of the EU product group stock in which correction factors are used. These corrections result in higher absolute values. Neither the decision of using correction factors is substantiated nor is the determination of them evidence-based. These values are highly relevant when implementing measures are considered. In particular, following the consultant approach, products which have average environmental performance seem compared to the stock as environmental sound solutions. This calculation should be made and presented in a different form ensuring transparency and being evidence based.	Thank you for your valuable comments. See reply below
	In Draft Task 5, the environmental impact results of the six product base cases as elaborated in the EcoReport tool do not seem to have significant differences in terms of predominance of certain elements (see Section 5.2.7 Conclusions, page 33). The analysis ends up focusing mainly on the energy and consumables during the use phase. We consider that such results indicate that the analysis needs to go into greater detail so that the product's ecodesign differences can be captured. At this point it should also be emphasised that such outcomes unveil restrictions of the EcoReport tool.	Indeed limitations of the EcoReport (especially for the material database) are estimated to be partly responsible for this similarity between the six base cases analysis. However, the base cases are not fundamentally different from a technical point of view and the fact that the hot spots are the same does not seem unexpected for the project team.
	The assumptions made for the product group end-of-life phase with incineration and recycling rates of 100 % for plastics and metals respectively are considered overestimated. A rate of landfill disposal should be presented.	Considered in revision, see reply below
	In the computation of the overall environmental assessment of the product group, EU stock correction factors regarding the performance of new and older products are used. The use of these correction factors results in higher overall environmental impact values of the total product group. The relevance of these values directly affects the calculation of the environmental savings potential when implementing measures are determined and allows appliances with average environmental performances to seem like environmentally-sound solutions. This calculation should be clarified and substantiated.	See reply below

Feedback		Comment
Section 5.1.2 page 8	Specific materials of product components were not available in the database of the EcoReport tool. Therefore, a few materials were approximated by using other materials of the database whereas others were ignored. In order to substantiate the approximations made, it is considered supportive to provide and illustrate the similarities of the life cycle environmental performance of these material pairs. This could be possible by using available LCA databases and respective LCIA methods. Moreover, the environmental performance of the materials that were not approximated (in this case, it was chromium, cotton and polybutylene terephtalate (PBT)) should also be provided and compared with the environmental performance of other components investigated. This is necessary in order to further substantiate any decision regarding their exclusion from the investigation. The components' share of the total weight of the dishwasher should not be the only reason substantiating their exclusion. If high environmental relevance of these components is confirmed, then a dataset could be added as new entry in the database of the EcoReport.	Preliminary environmental analyses have been added to the report to complement such assumptions. Besides, the project team would like to add that it is estimated more relevant (when the material is not of outstanding importance in the BOM) to make assumptions on closest materials available in the EcoReport database, rather than add "homemade" impacts for a new category in EcoReport (problem of consistency between different datasets).
Section 5.1.4.1	The number of kilometres travelled for maintenance and repair of one machine over its product lifetime is time-dependent. Thus, the assumption made of 1000 km should be transformed in x km/year in order to better time dependant real life conditions.	Considered in revision due to new stakeholder input at final stakeholder meeting
Section 5.1.5	After the product use, the metal parts of professional dishwashers are assumed to have recycling rates of 100 %. Respectively the incineration rates of the plastic parts were also assumed to reach 100 %. Both values are not considered realistic. These rates need refinement which would additionally take into account the geographical variation among the Member States (please see also the comments above).	The text has been corrected: the intended meaning of the sentence was that 100% of the recovered metals and plastics are recycled or incinerated. Post WEEE and post ROHS conditions are assumed within MEEuP and the assumed default value of non-recovered products in a post-WEEE scenario is 5%. In particular, the standard recycling rate for metals and TV glass is set at 95%, assumption under which the recycling benefits of metals (defined with MEEuP) are valid. The same rate will be considered for the recovery of all types of material (5% of the BOM goes to landfill).
Section 5.1.5	Professional dishwashers with pumps for heat recovery are not considered within the base cases with the justification that they are BAT appliances. These kinds of dishwashers are indeed considered to be BAT; nevertheless, this does not necessarily exclude them from being taken into account in the base case. The base case is defined as a conscious abstraction of reality which should represent an average product in the market. Therefore, as long as dishwashers with heat recovery pumps have a significant market share, then they should be included in the base cases.	Description of the market according to this option was tentatively made in draft Task 2 but the lack of data (according to manufacturers, such records do not exist) has led the team to consider the base case as a basic product, with the option of heat pump being entirely BAT. Reflection of the market during the course of Task 6

Feedback		**Comment**
		has supported this assumption: heat pumps are usually not yet applied in smaller DW categories due to lower profitability. With high-throughput machines of categories 5 and 6, the profitability is better, but still pumps for heat recovery are usually offered only as optional, not as standard equipment. Therefore, they do not have a significant market share and it is justified that they are not included into the base cases.
Section 5.1.6 (Point 3)	According to the consultant, the professional dishwasher's environmental efficiency differs largely when new products and older ones are compared. As the environmental assessment is based on 'base cases currently sold in the market' the consultant proposes the use of correction factors in order to avoid underestimation of the overall environmental assessment of the product group stock. This decision needs to be justified in more detail. Moreover, if these correction factors are considered necessary then their determination should rely on scientific evidence and not on simply assumptions and/or estimations of stakeholders. The graphical presentation of the lines of environmental performance of the product stock over time (past and future) as calculated with and without correction would clarify the importance of this issue (e.g. on the y axis the environmental performance values and on the x axis the years). We would like to draw attention to the fact that with the implementation of these correction factors, the overall environmental performance of the product stock seems to be higher compared with the calculation without correction. This could directly affect the phase of implementing measures proposal because with the current calculation, significant environmental savings can also be allocated to products which are of average performance. This takes place because the environmental performance is compared with the performance of the product group stock which is 'corrected' thus with higher absolute values.	This is not an initiative from the team but a required input of the EcoReport tool: Overall Improvement Ratio (Stock vs. New), Use Phase. It is indeed expected to take into account the fact that in the current stock, the products are less efficient than the currently sold products. For all product categories, this input was estimated from data presented in Task 2, as specified in the text and reminded in the table.
Section 5.1.4.1	Reference should be provided on the values given in Table 9 'Overall improvements ratios for all base cases'.	Added in revision.
Section 5.2.7	In the conclusion chapter, a discussion on the similarities and differences between domestic and professional dishwashers should be added.	Added in revision.
Section 5.4.2	It is considered necessary to identify the environmental hot spots of each base case and their respective contribution to the overall life cycle product performance. For instance one hot spot is electricity consumption which is responsible for base case 1 for x % of eutrophication potential and y % of VOC, etc. Furthermore, another hot spot is material A as it contributes respectively to y % of the total overall value of heavy metals, etc. That way it would be easier to identify the focus areas of BAT and implementing measures.	The project team believes that this is what is currently presented in sections 3.1 to 3.6 3.7 summarises these hot spots.

Feedback		**Comment**
Hobart		
Section 2.4.4	**Travelling effort for maintenance and repair:** 1000 km over the product lifetime seems to be not applicable for all six categories. The effort for maintenance and repair is more or less related to the complexity of the particular machine. There is also a relation based on the usage of a particular machine (i.e. cycles per day, operating hours per day, care handling etc.). Thus, lower category machines need less maintenance and repair than upper categories and consequently accordant kilometres. Note: Data for different categories are not available.	Considered in revision due to new stakeholder input at final stakeholder meeting
Granuldisk		
5.1.4.2	The water consumption in pre-soak and pre-wash prior to the washing in the machine is not included in Table 5. For Base Case 4 Utensil/Pot washers, this consumption can't be neglected since it's much higher than the water consumption in the machine (5 to 8 times higher). For utensil- and pot-washers using granule technology this consumption will be avoided! Granule technology = A mechanical cleaning process where plastic granules and water are blasting the pots and pans clean without using pre-soaking and scrubbing. Water consumption in pre-soak/-wash process MUST be included at least in BC4.	Please refer to the discussion in Task 6 (BAT) for this point: In order to give incentive to reduce the overall water consumption of dishwashing, the inclusion of the whole process from dirty to clean (including the pre-soak and pre-cleaning phase) would be rather desirable for all dishwasher categories, with special focus on utensil / pot dishwashers. However, the water consumption for pre-cleaning is strongly dependent on the specific user behaviour and cannot be influenced by the technology of the dishwashing machine itself. Further, there is no standard measurement method and thus no reliable data to record the average consumption through external pre-cleaning of the wash ware for the different dishwasher categories. Finally, as we already excluded all manually process steps outside the dishwashing machines from the scope of this study as stated in Task 1, we didn't include the consumption of the pre-soak / pre-cleaning phase into the calculation of base cases at all.
5.1.4.3	As 30 % of the total detergent consumption is used in the pre-wash process it's necessary to include this in the total detergent consumption. For utensil- and pot-washers using granule technology this consumption will be avoided as no pre-soak or pre-wash is needed. Granule technology = A mechanical cleaning process where plastic granules and water are blasting the pots and pans clean without using pre-soaking and scrubbing. Detergent consumption in pre-soak/-wash process MUST be included at least in BC4.	
5.1.4.1	Hot water is used for pre-soak and pre-wash. The energy for heating this water is not included either! For utensil- and pot-washers using granule technology this consumption will be avoided as no pre-soak or pre-wash is needed. Granule technology = A mechanical cleaning process where plastic granules and water are blasting the pots and pans clean without using pre-soaking and scrubbing	