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Ecodesign Requirements of EuPs (III)

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Lot 22
Domestic and commercial ovens (electric, gas, microwave), including when incorporated in cookers

Task 5: Definition of Base-case

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Contents

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5. TASK 5 – DEFINITION OF BASE-CASE

The purpose of this task is:

- Selection of the average EU representative model or construction of average EU model characteristics from several important product subcategories in the product group
- Definition of Standard Base-case, i.e. the environmental impact, functionality and Life Cycle Costs for a reference year measured according to harmonised test standards (that would also be used for compliance testing).
- Definition of Real-life Base-case, i.e. the (estimated) environmental impact, functionality and Life Cycle Cost in real-life for a reference year with actual consumer behaviour and ambient conditions.

The Base-case is a conscious abstraction of reality, necessary 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.

The description of the Base-cases is the synthesis of the results of Tasks 1 to 4. Most of the environmental and life cycle cost analysis are built on these Base-cases throughout the rest of the study and it serves as the point-of-reference for Task 6 (technical analysis of BAT), Task 7 (improvement potential), and Task 8 (policy analysis).

The environmental and cost impact analysis is carried out using the EcoReport tool, which is part of the MEEuP methodology, required by the European Commission for undertaking preparatory studies for the Ecodesign Directive. The results of the environmental impact assessment presents the total primary energy consumed over the product life cycle. 1 kWh of electricity (final energy) is converted into 10.5 MJ (primary energy). The conversion factor is therefore 2.92, and not 2.5 as described in Annex II of the Energy Service Directive. This factor being used for the environmental impact assessment does not imply that the same factor will be used in future legislation.

5.1. PRODUCT-SPECIFIC INPUTS

This section describes the technical analysis of typical domestic and commercial ovens 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 5.2.

5.1.1. Definition of Base-cases

The objective of this section is to define and describe the Base-cases, based on the previous tasks and the information recovered from the stakeholders and the literature review. The Base-cases are "a conscious abstraction of reality" and have to cover the wide variety of existing products in order to be as representative of the European market as possible. Therefore, the number of Base-cases is optimised to be small enough to enable a simplified analysis of the market but large enough to deal with the technological spectrum of products.

The appliances covered by Lot 22 are very diverse in how they are designed and how they are used. The definition of Base-cases had to take into account this diversity, but the MEEuP methodology requires the number of Base-cases to be low. As a result, some appliances that are under the scope of this study will not be covered by the Base-cases. This is particularly the case for some designs of commercial ovens, which energy consumption at the EU level was considered too low to be included as Base-case. The following paragraphs detail the choice of the Base-cases presented in Table 5-1.

- **Average product in stock**

In DG ENER Lot 22 study, the Base-case is defined as the average product in stock although the MEEuP methodology recommends the use of the average product sold. Indeed, for products with long lifetime, such as ovens, using the average product in stock is more relevant as it better illustrates the current consumption levels and gives a more reliable indication of potential savings.

Therefore, the "Overall Improvement ratio" parameter, available in EcoReport, was set at 1. For clarification, the average product sold will be presented in Task 7, together with the improvement options.

- **Commercial sector**

Ovens used in the commercial sector are different from those found in the domestic sector, in terms of technology as well as user behaviour. Different designs and functionalities are available to meet specific needs of the commercial sector. The sales volumes of some types of appliances, such as rack ovens, are low, and even if there is an improvement potential in energy efficiency, the savings at the EU level would be low.

Concerning microwave ovens (MWO), which are used in many foodservice outlets, little information was available. The technical differences between domestic and commercial MWO were considered small enough not to merit two Base-cases. The outcomes of this study regarding domestic microwave ovens will be applicable to commercial microwave ovens.

[1] Necessary input into EcoReport

As a result, only combi-steam ovens were included as Base-cases for restaurant ovens. In fact, they represent most of the commercial ovens sold on the EU market in 2007 (see Task 2).

Separation between appliances using different energy sources

Appliances of the same category using different energy sources will be treated in separate Base-cases.

At the present time, the standard test procedures to measure the energy consumption of electric and gas ovens are different. Although both of them are based on the principle of heating a brick, the test protocols are not identical. Therefore, it is currently not possible to make a rigorous comparison of the results from the two standards, even by converting final energy consumptions into primary energy consumptions.

A Base-case for each energy source will result in assessing the improvement potential and pinpointing the Best Available Technology separately for each Base-case. However, a separation between energy sources at this stage of the study will have not influence in any way the recommendations that will be made in Task 8, or on the implementing measures that will be adopted by the European Commission. The aim of this preparatory study is to provide the European Commission the necessary knowledge to set up implementing measures. Having implementing measures covering all appliances whatever their energy source or specific implementing measures for each type of appliance is a political decision that will be made by the European Commission later in the legislative process.

Synthesis

Although the MEEuP methodology foresees one or two Base-cases (BCs) to cover the entire EU market for the products considered in each preparatory study, ten BCs emerged for ovens. Such a high number of BCs is necessary to appropriately cover the broad range of technical specifications and functionalities of ovens. Table 5-1 gives an overview of the ten Base-cases, for which characteristics were discussed and agreed with relevant stakeholders.

Table 5-1: Description of the Base-cases

Base-case	Configuration	Capacity	Self-cleaning	Total power
Domestic ovens				
BC1 – Domestic electric oven	Built-in independent	54 L*	None	3,570 W
BC2 – Domestic gas oven	Free-standing dependant (used in cooker)	58 L*	None	10,500 W**
BC3 – Domestic microwave oven	Free-standing independent	18 L	None	1,150 W
Restaurant ovens				
BC4 – Commercial electric combi-steamer	Free-standing	10 GN 1/1	Chemical	19,000 W
BC5 - Commercial gas combi-steamer	Free-standing	10 GN 1/1	Chemical	NG : 22,000 W Elec.: 800 W
Bakery ovens				*BSA: Baking surface area*
BC6 – Commercial in-store convection oven	Free-standing	BSA: 1m²	None	11,500 W
BC7 – Commercial electric deck oven	Free-standing	BSA: 4.5 m²	None	62,000 W
BC8 – Commercial gas deck oven	Free-standing	BSA: 4.5 m²	None	NG: 80,000 W Elec.: 2,000 W
BC9 – Commercial electric rack oven	Free-standing	BSA: 7.5 m²	None	70,000 W
BC10 – Commercial gas rack oven	Free-standing	BSA: 7.5 m²	None	NG: 85,000 W Elec: 6,400 W

* In line with Figures 4-6 and 4-7, presented in Task 4.
** BC2 is a cooker. Thus the total power includes the hobs as well as the oven. This power is however only indicative and the energy consumption considered in the environmental impact assessment will only take into account the oven's energy consumption.

5.1.2. DOMESTIC APPLIANCES

5.1.2.1. INPUTS IN THE PRODUCTION PHASE

Production phase data related to typical ovens consists of the Bill of Materials (BOM) and the sheet metal scrap generated during the manufacturing phase. The BOMs have already been presented in Task 4.

- **Material equivalents**

Because the EcoReport was initially designed as a simple and generic tool for all Ecodesign preparatory studies, its database does not include some materials found in domestic ovens. The list of those materials is presented in Table 5-2. The equivalences were mainly based on assumptions made in previous Ecodesign preparatory studies.

Table 5-2: Material found in domestic appliances covered by Lot 22 not included in EcoReport

Material[2]	Detail	BC	Weight	Percentage of the total weight	Most similar material available
Tempered glass	Door's glass in domestic ovens	BC1 BC2	4.1 kg 3.8 kg	13.4% 11.1%	54-Glass for lamps
Borosilicate glass	Turntable of domestic microwave ovens	BC3	0.65 kg	4.8%	54-Glass for lamps
Enamel coating	Coating used in convection ovens	BC1 BC2	< 0.2 kg < 0.2 kg	< 0.6% < 0.6%	54-Glass for lamps
Incoloy steel alloy	nickel-iron-chromium alloy with additions of molybdenum, copper and titanium used in heating resistances	BC1	1.2 kg	3.9%	25 – Stainless 18/8
PTFE and PPS		BC3	0.025 kg	0.2%	11-PA6
PPO and POM		BC3	0.04 kg	0.3%	11-PA6
Silicone	Used in joints	BC1 BC2	0.05 kg 0.05 kg	0.2% 0.1%	16 – Flex PUR
Frigolit	Bulk plastic used in packaging for microwave ovens.	BC3	0.215 kg	1.6%	6-EPS

[2] PTFE: Polytetrafluoroethylene
PPS: Polyphenylene sulfide
PPO: Polyphenylene oxide
POM: Polyoxymethylene (polyacetal)

Weight distribution

In Table 5-3, the weight distribution according to material categories is presented. It is important to notice that Base-case 2 is a gas cooker, and thus its BOM refers to the complete appliance, including not only the oven but also the hob.

Table 5-3: Composition of the three domestic Base-cases, by category of materials

Base-case	Weight	1 Bulk Plastics	2 Tech. Plastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7 Misc.[3]	Total
Base-case 1: Domestic electric oven	in g	194	500	24,375	235	0	125	5,430	30,858
	in %	1%	2%	79%	1%	0%	0%	18%	
Base-case 2: Domestic gas oven	in g	50	424	35,857	2,938	0	0	10,798	50,067
	in %	0%	1%	72%	6%	0%	0%	22%	
Base-case 3: Domestic microwave oven	in g	1,077	41	6,978	2,340	216	533	2,361	13,546
	in %	8%	0%	52%	17%	2%	4%	17%	

The complete BOMs should include more coatings. However, the enamelled coatings used in BC1 and BC2 are not available in EcoReport. Coatings in EcoReport are epoxy-based, and thus are inadequate to model enamelled coatings. Consequently, these coatings were not considered.

As all domestic Base-cases have a high proportion of ferrous materials in their BOM, environmental impacts of the production and manufacturing phases are expected to be mainly due to this category of materials. BC3 has also a high proportion of materials under the category 7-Misc, mainly cardboard (for the packaging) and glassy materials. However, EcoReport provides only a few glassy materials (18-E-glass fiber and 54-Glass for lamps). Thus, the approximations which had to be made to fill the BOMs could bias the environmental analysis.

Regarding the sheet metal scrap percentage generated during the manufacturing phase, a rate of 5% has been assumed for all Base-cases.

5.1.2.2. 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, based on the findings of task 4, are exposed in Table 5-4 below.

[3] Including the material "Glass for lamps"

Table 5-4: Volume of packaged product for domestic Base-cases

Base-case	Volume of packaged product (in m^3)
BC1: Domestic electric oven	0.292
BC2: Domestic gas oven	0.439
BC3: Domestic microwave oven	0.092

BC2 has the biggest package volume, because this is a cooker, and not just the oven.

Two other pieces of information are required in this section:

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

These parameters are used in EcoReport to modify the impacts of the distribution phase. Consumer electronics and installed appliances have a specific distribution phase. None of the three domestic base cases are consumer electronics or installed appliances.

5.1.2.3. Inputs in the use phase

- **Energy consumption**

The energy consumption during the use phase is expected to be a major contributor to the environmental impacts of an oven. The annual energy 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 Base-cases.

Table 5-5: Energy consumption for each domestic Base-case

Base-case	On-mode			Standby mode	
	Consumption per cycle (kWh)	Number of cycle per year	Duration of a cycle	Consumption per hour (Wh)	Number of hours per year
BC1: Domestic electric oven	1.1[4]	110	55 min	2	8660
BC2: Domestic gas oven	1.67	111	55 min	0	0
BC3: Domestic microwave oven	0.056	1200	2 min 36 s	2.2	8708

The energy consumption per cycle and the number of cycle per year was taken from Table 3-11 in the Task 3 report. The electricity consumption for defining the energy label is based on the brick test, but with a margin of 10% + 0.04 kWh. Such a tolerance could result in a difference between the actual performance and the energy label

[4] This value represents the Base-case 1, i.e. the average product in stock. Please note that in Task 7, the average product that is currently sold (identified as Option 0) is introduced with a 0.84 kWh/cycle energy consumption.

performance of up to 15%. This would imply that an oven's energy consumption could be 15% higher than the value determined by the wet brick test. Moreover, the value on the label is based on the most efficient functionality of an oven, which is not always used in practice.

The calculation of the impacts of gas consumption in EcoReport was intended to be applied to building heating systems. Consequently, an "Avg. Heat Power Output" is required. To input the gas consumption in the tool, "69-Gas, atmospheric" was selected as fuel, with an efficiency of 86.0%. The "heat output" parameter was calculated to have an energy input of 1.67 kWh with an efficiency of 86.0%, which is 1.44 kWh.

The standby consumption was estimated at 3W for the domestic electric oven and 2.2W for the microwave oven. In accordance with Regulation 1275/2008/EC, the equipment sold in the EU after December 2009 should meet the following requirements:

- Power consumption in off mode must be 1 Watt or less;
- Power consumption in standby mode which allows reactivation must be 1 Watt or less;
- Power consumption in standby mode which allows reactivation and displays information (such as a clock) must be 2 Watts or less.

Ovens are covered by this regulation. However, Base-cases are representative of the appliances already in stock in the EU. Thus, the electricity consumption in standby-mode is higher than these requirements. Further, for the gas oven Base-case, the standby electric consumption is not relevant as this BC (including in a cooker) does not have a timer.

Number of kilometres over the product life for maintenance and repair

For all Base-cases, the number of kilometres travelled for maintenance and repair for one oven is given in Table 5-6.

Table 5-6: Number of kilometre over the product life for maintenance and repair of domestic products

Base-case	Number of kilometres over the product life
BC1: Domestic electric oven	15
BC2: Domestic gas oven	15
BC3: Domestic microwave oven	0

Users were considered to replace their microwave oven when it is no longer working, so there is no maintenance on this type of appliances, and thus no travel over the product lifetime. For ovens, as no stakeholder was able to provide this information, the number of kilometres travelled used in previous preparatory studies concerning household appliances[5] was used.

5.1.2.4. Inputs in the end-of-life phase

It is assumed that an important share of the ovens' materials is recycled and reused.

- **Domestic electric and gas ovens**

2% by weight of BC1 and BC2 was assumed not to be recovered (go to landfill) during the end-of-life phase.

Indeed, in principle, almost all materials in the electric and gas ovens' composition are recovered and follow one of the following options:

- Metals are 100% recycled;
- Paper, cardboard, and plastics are 100% incinerated or thermally recycled (benefits of energy recovery);
- Hazardous waste consists only of electronic components, which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

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

- Re-use, closed loop recycling: 15 %
- Material (or mechanical) recycling: 83 %
- Thermal recycling: 2 %.

- **Domestic microwave oven**

For BC3, stakeholders estimated that 15% to 20% was going to landfill. 18% was the figure used in EcoReport. Also, they considered plastics are treated as follows at end-of-life:

- Re-use, closed loop recycling: 95 %
- Material (or mechanical) recycling: 2 %
- Thermal recycling: 3 %.

5.1.2.5. Economic inputs

Economic data used for the calculations of the Life Cycle Costs (LCC) were elaborated in Task 2 (product lifetime, product prices, energy rates, etc.). Table 5-7 presents the lifetimes, sales and stock figures (which are used to assess environmental and economic impacts at EU level) and product prices for all three domestic Base-cases. It is considered that consumers are not charged with any installation or disposal costs.

[5] See Preparatory Study for Eco-design Requirements of EuPs – Lot 13: Domestic refrigerators & Freezers: www.ecocold-domestic.org/index.php?option=com_docman&task=doc_download&gid=122&Itemid=40

Table 5-7: EcoReport economic inputs of the domestic Base-cases

Base-case	Product Lifetime (in years)	Sales for the year 2007 (units)	Stock for the year 2008 (units)	Product price (in €)	Maintenance costs (in €)
BC1: Domestic electric oven	19	8,990,000	145,000,000	493	0
BC2: Domestic gas oven	19	2,180,000	50,000,000	330	0
BC3: Domestic microwave oven	8	13,870,000	125,000,000	117	0

In addition, Table 5-8 presents the energy rates used for each Base-case.

Table 5-8: Energy rates, by Base-case

Base-case	Electricity rate (€/kWh)	Natural gas rate (€/GJ)
BC1: Domestic electric oven	0.1658	
BC2: Domestic gas oven		16.21
BC3: Domestic microwave oven	0.1658	

Further, the discount rate (4%) was provided by the EC and is the same for all Base-cases. The overall improvement ratios (market over stock) were assumed to be 1. For each Base-case, this improvement ratio indicates the difference of global efficiency during the use phase between the new sales and the current stock.

5.1.3. COMMERCIAL APPLIANCES USED IN RESTAURANTS

5.1.3.1. INPUTS IN THE PRODUCTION PHASE

- **Material equivalent**

Table 5-9 presents the material used in EcoReport to replace some of the material found in restaurant ovens that were not available.

Table 5-9: Material found in restaurant ovens covered by Lot 22 not included in EcoReport[6]

Material	Detail	BC	Weight	Percentage of the total weight	Most similar material available
Silicate glass	Door's glass in commercial ovens	BC4 BC5	9 kg 9 kg	6.6% 5.8%	54-Glass for lamps
Glass wool	Insulation of commercial ovens	BC4 BC5	8 kg 8 kg	5.9% 5.2%	7-Misc *(as in ENER Lots 1 and 2)*
Incoloy steel alloy	Nickel-iron-chromium alloy with additions of molybdenum, copper and titanium used in heating resistances	BC4 BC5	9 kg 26 kg	6.6% 16.8%	25- Stainless 18/8
Silicone polymer	Used in door seal of domestic convection ovens.	BC4 BC5	2.4 kg 2.4 kg	1.8% 1.5%	16-Flex PUR

- **Weight distribution**

Table 5-10: Composition of the two combi-steamer Base-cases, by category of materials

Base-case	Weight	1 Bulk Plastics	2 Tech. Plastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7 Misc.	Total
Base-case 4: Commercial eletric combi-steamer	in g	800	8,200	104,000	3,900	0	1,600	17,000	135,500
	in %	1%	6%	77%	3%	0%	1%	13%	
Base-case 5: Commercial gas combi-steamer	in g	800	8,200	121,000	5,900	0	1,600	9,000	146,500
	in %	1%	6%	83%	4%	0%	1%	6%	

[6] The correspondence between materials was mainly based on the hypothesis made for previous Ecodesign Preparatory studies.

5.1.3.2. 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 presented in Table 5-11 below.

Table 5-11: Volume of packaged product for combi-steamer Base-cases

Base-case	Volume of packaged product (in m^3)
BC4: Commercial electric combi-steamer	1.1
BC5: Commercial gas combi-steamer	1.1

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

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

5.1.3.3. Inputs in the use phase

Energy consumption

The energy consumption during the use phase is expected to be a major contributor to the environmental impacts of an oven. The annual energy 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 Base-cases.

Table 5-12: Energy consumption for the combi-steamer Base-cases

	BC4: Commercial electric combi-steamer	BC5: Commercial gas combi-steamer
On-mode		
Electricity consumption per cycle (kWh)	4.2	0.4
Gas consumption per cycle (kWh)		5.4
Number of cycles per year	1872	1872
Duration of a cycle (minutes)	40	40
Standby mode		
Electricity consumption per hour	1.5	0.6
Gas consumption per hour		1.9
Number of hours in standby	936	936

Water consumption

Commercial combi-steamers consume water to produce steam during the cooking process. Most combi-steamers also have an automatic cleaning functionality, but it is difficult for manufacturers to quantify the use frequency of this feature. Therefore, it was assumed that BC4 and BC5 were consuming 10 litres of water per cooking cycle, which represents 18.72 cubic meters per year. The consumption due to the cleaning process was neglected.

Number of kilometres over the product life

For all combi-steamer Base-cases, the number of kilometres travelled for maintenance and repair is given in Table 5-13. This data was collected among stakeholders using a questionnaire.

Table 5-13: Number of kilometre over the product life for combi-steamer Base-cases

Base-case	Number of kilometres over the product life
BC4: Commercial electric combi-steamer	1600
BC5: Commercial gas combi-steamer	1600

5.1.3.4. Inputs in the end-of-life phase

It is assumed that an important share of the ovens' materials is recycled and reused.

For BC4 and BC5, respectively 0.8% and 0.7% of their weight was assumed not to be recovered (go to landfill) during the end-of-life phase.

Indeed, in principle, almost all materials in the electric and gas ovens' composition are recovered and follow one of the following options:

- Metals are 100% recycled;
- Paper, cardboard, and plastics are 100% incinerated or thermally recycled (benefits of energy recovery);
- Hazardous waste consists only of electronic components, which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

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

- Re-use, closed loop recycling: 0 %
- Material (or mechanical) recycling: 5 %
- Thermal recycling: 95 %.

5.1.3.5. Economic inputs

Economic data used for the calculations of the Life Cycle Costs (LCC) were elaborated in Task 2 (product lifetime and product prices, energy rates, water and consumables rates). The product prices were based on stakeholders' feedback and brochures.

Table 5-14 presents the lifetimes, sales and stock figures (which are used to assess environmental and economic impacts at EU level) and product prices for the commercial Base-cases. The installation and the disposal costs were considered to be null, as the machines are rarely sent to landfill but taken care of by recyclers.

Table 5-14: EcoReport economic inputs of the combi-steamer Base-cases

	BC4: Commercial electric combi-steamer	BC5: Commercial gas combi-steamer
Product life (in years)	10	10
Sales 2007 (units)	41,000	9,200
Stock 2007 (units)	400,000	80,000
Product price (€)	11,900	13,200
Installation costs (€)	200	300
Maintenance costs (€)	700	900

Table 5-15 presents the energy and water rates, for each combi-steamer Base-case.

Table 5-15: Energy and water rate, by combi-steamer Base-case

Base-case	Electricity rate (€/kWh)	Natural gas rate (€/GJ)	Water rate (€/m^3)
BC4: Commercial electric combi-steamer	0.1554		2.64
BC5: Commercial gas combi-steamer	0.1554	14.81	2.64

Further, the discount rate (4%) was provided by the EC and is the same for all Base-cases. The overall improvement ratios (market over stock) were assumed to be 1. For each Base-case, this improvement ratio indicates the difference of global efficiency during the use phase between the new sales and the current stock.

5.1.4. Commercial appliances used in Bakeries

5.1.4.1. Inputs in the production phase

Bakery ovens are mainly made out of ferrous metals. A big share of the weight is also due to insulation material (counted in 7-Misc.). For Base-cases 7 and 8, decks are also an important share of the total weight.

The gas deck oven is much heavier than the electric version. The equipment specific to gas can explain part of the additional weight. It is also likely that more work has been done by manufacturers to reduce the weight of electric ovens compared to gas ovens.

Table 5-16: Composition of the bakery Base-cases, by category of materials

Base-case	Weight	1 Bulk Plastics	2 Tech. Plastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7 Misc.	Total
Base-case 6: Bakery in-store convection oven	In g	0	60	78,200	0	0	800	30,000	109,060
	In %	*0%*	*0%*	*72%*	*0%*	*0%*	*1%*	*28%*	*100%*
Base-case 7: Electric deck oven	in g	5,000	10,300	1,080,800	9,500	0	1,800	677,000	1,784,400
	in %	*0%*	*1%*	*61%*	*1%*	*0%*	*0%*	*38%*	*100%*
Base-case 8: Gas deck oven	in g	6,500	6,500	2,014,800	5,500	0	1,000	746,000	2,780,300
	in %	*0%*	*0%*	*72%*	*0%*	*0%*	*0%*	*27%*	*100%*
Base-case 9: Electric rack oven	in g	4,000	4,130	855,815	8,980	0	2,000	145,000	1,019,925
	in %	*0%*	*0%*	*84%*	*1%*	*0.0%*	*0%*	*14%*	*100.0%*
Base-case 10: Gas rack oven	in g	4,000	4,130	880,315	8,980	0	2,000	145,000	1,044,425
	in %	*0%*	*0%*	*84%*	*1%*	*0%*	*0%*	*14%*	*100.0%*

5.1.4.2. Inputs in the distribution phase

Table 5-17: Volume of packed product for bakery Base-cases

Base-case	Volume of packaged product (in m^3)
BC6: Bakery in-store convection oven	0.5
BC7: Electric deck oven	14.9
BC8: Gas deck oven	14.9
BC9: Electric rack oven	7.0
BC10: Gas rack oven	7.0

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

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

5.1.4.3. Inputs in the use phase

- **Energy and water consumption**

The energy consumption during the use phase is expected to be a major contributor to the environmental impacts of an oven. The annual energy 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 Base-cases.

Table 5-18: Energy consumption for the bakery Base-cases (BC6 to BC8)

	BC6: Bakery in-store convection oven	BC7: Electric deck oven	BC8: Gas deck oven
On-mode			
Electricity consumption per cycle (kWh)	2.5	25.2	0.8
Gas consumption per cycle (kWh)	-	-	32.8
Water consumption per cycle (litres)	0.5	6	6
Number of cycles per year	5000	1872	1872
Duration of a cycle (minutes)	30	60	60

Table 5-19: Energy consumption for the bakery Base-cases (BC9 and BC10)

	BC9: Electric rack oven	BC10: Gas rack oven
On-mode		
Electricity consumption per hour (kWh)	25.5	2
Gas consumption per hour (kWh)		28
Water consumption per hour (litres)	5	5
Number of hours per year	2700	2700
Standby mode		
Electricity consumption per hour (kWh)	7.5	1.7
Gas consumption per hour (kWh)		9.15
Number of hours per year in standby	300	300

- **Water consumption**

The water consumption of in-store convection ovens is around 0.5 litre per cycle, which represents 2.5 m^3 of water per year.

Deck ovens are consuming water to produce the steam necessary to bake bread. The consumption per hour of baking will be estimated to 6 litres, which represents 11.2 m^3 of water per year.

For rack ovens, it was assumed that they were consuming 1.65 litres of water per cycle. With 3 cycles per hour, and 2700 hours, this represents an annual water consumption of 13.5 m^3.

Number of kilometres over the product life

For all bakery Base-cases, the number of kilometres travelled for maintenance and repair is given in Table 5-13. This data was collected among stakeholders using a questionnaire.

Table 5-20: Number of kilometre over the product life for bakery Base-cases

Base-case	Number of kilometres over the product life
BC6: Bakery in-store convection oven	1,600
BC7: Electric deck oven	2,000
BC8: Gas deck oven	2,500
BC9: Electric rack oven	2,500
BC10: Gas rack oven	3,000

Information was provided by different stakeholders for in-store convection ovens, deck ovens and rack ovens. They are estimated assuming an oven is serviced once a year all along its lifetime.

5.1.4.4. Inputs in the end-of-life phase

It is assumed that an important share of the ovens' materials is recycled and reused. Indeed, in principle, almost all materials in the electric and gas ovens' composition are recovered and follow one of the following options:

- Metals are 100% recycled;
- Paper, cardboard, and plastics are 100% incinerated or thermally recycled (benefits of energy recovery);
- 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 end-of-life management options were estimated for all Base-cases, based on stakeholders' feedback, and are presented in Table 5-21:

Table 5-21: End-of-life management options for bakery Base-cases

	BC6: Bakery in-store convection oven	BC7, BC8, BC9 and BC10
Product		
Fraction of the product which is not recovered	2%	1%
PWB easy to disassemble	YES	YES
Plastics		
Re-use, closed-loop recycling	1%	0%
Material (or mechanical) recycling	9%	5%
Thermal recycling	90%	95%

5.1.4.5. Economic inputs

Economic data used for the calculations of the Life Cycle Costs (LCC) were elaborated in Task 2 (product lifetime and product prices, energy rates, water and consumables rates). The product prices were based on stakeholders' feedback and brochures.

Table 5-22 presents the lifetimes, sales and stock figures (which are used to assess environmental and economic impacts at EU level) and product prices for the bakery Base-cases. The installation and the disposal costs were considered to be null, as the machines are rarely sent to landfill but taken care of by recyclers.

Table 5-22: EcoReport economic inputs of the commercial Base-cases

	BC6: Bakery in-store convection oven	BC7: Electric deck oven	BC8: Gas deck oven	BC9: Electric rack oven	BC10: Gas rack oven
Product life (in years)	8	15	15	10	10
Sales 2007 (units)	10,625	4,500	1,900	3,000	4,500
Stock 2007 (units)	85,000	53,000	43,000	30,000	45,000
Product price (€)	10,000	35,000	35,000	15,000	15,000
Installation costs (€)	400	*Included in purchase price*	*Included in purchase price*	1,800	2,000
Maintenance	2,500	6,000	8,000	3,650	5,475

	BC6: Bakery in-store convection oven	BC7: Electric deck oven	BC8: Gas deck oven	BC9: Electric rack oven	BC10: Gas rack oven
costs (€)					

Table 5-25 presents the energy rate, for each bakery Base-case. End-of-life costs or benefits were neglected. Indeed, some ovens are sold on the second-end market, while others are taken care of by specialised companies for recycling.

Table 5-23: Energy and water rate, by commercial Base-case

Base-case	Electricity rate (€/kWh)	Natural gas rate (€/GJ)
BC6: Bakery in-store convection oven	0.1554	
BC7: Electric deck oven	0.1554	
BC8: Gas deck oven	0.1554	14.81
BC9: Electric rack oven	0.1554	
BC10: Gas rack oven	0.1554	14.81

Further, the discount rate (4%) was provided by the EC and is the same for all Base-cases. The overall improvement ratios (market over stock) were assumed to be 1. For each Base-case, this improvement ratio indicates the difference of global efficiency during the use phase between the new sales and the current stock.

5.2. BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The aim of this subtask is to assess the environmental impacts 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[7]. These parameters will be listed as they will serve as an important input to the identification of ecodesign options.

The assessment results are tracked back to the main contributing components, materials and features of the domestic and commercial ovens.

5.2.1. DOMESTIC APPLIANCES

5.2.1.1. BASE-CASE 1: DOMESTIC ELECTRIC OVEN

Table 5-24 shows the environmental impacts of a domestic electric oven over its whole life cycle. The total primary energy consumption for the whole life cycle of the Base-case 1 is 31.0 GJ, of which 29.7 GJ comes from the electricity consumption (equivalent to 2.83 MWh final energy).

Table 5-24: Life Cycle Impact (per unit) of Base-case 1

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	970	250	**1220**	**448**	**32826**	48	35	**12**	**34506**
9	of which, electricity (in primary MJ)	MJ	229	149	**378**	**1**	**32782**	0	3	**-3**	**33158**
10	Water (process)	ltr	246	2	**248**	**0**	**2188**	0	2	**-2**	**2434**
11	Water (cooling)	ltr	179	69	**248**	**0**	**87410**	0	15	**-15**	**87643**
12	Waste, non-haz./ landfill	g	36475	884	**37359**	**242**	**38378**	759	10	**749**	**76728**
13	Waste, hazardous/ incinerated	g	88	0	**88**	**5**	**756**	14	2	**12**	**862**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	73	14	**87**	**28**	**1434**	4	1	**3**	**1551**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	350	60	**410**	**84**	**8447**	8	2	**6**	**8947**
17	Volatile Organic Compounds (VOC)	g	4	0	**4**	**6**	**13**	0	0	**0**	**23**
18	Persistent Organic Pollutants (POP)	ng i-Teq	473	8	**481**	**1**	**220**	5	0	**5**	**707**

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

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
19	Heavy Metals	mg Ni eq.	278	18	**296**	**12**	**573**	14	0	**14**	**895**
	PAHs	mg Ni eq.	19	0	**19**	**16**	**73**	0	0	**0**	**107**
20	Particulate Matter (PM, dust)	g	64	9	**73**	**999**	**313**	77	0	**76**	**1461**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	238	0	**238**	**0**	**214**	4	0	**4**	**456**
22	Eutrophication	g PO4	7	0	**7**	**0**	**1**	0	0	**0**	**8**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-1 exposes the contribution of each life cycle phase to each environmental impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for the following categories :
  - Waste, non-hazardous / landfill: 47.5% (mainly due to the galvanised steel used for the body)
  - Persistent Organic Pollutants (POP) to the air: 66.9% (mainly due to the galvanized steel used for the casing)
  - Heavy metals emissions to water: 52.3% (mainly due to the stainless steel used for the heating elements)
  - Eutrophication: 84.2% (mainly due to the stainless steel used for the heating elements)

  and contributes for the categories:
  - Heavy metals emissions to the air: 31.1% (mainly due to the stainless steel used for the heating elements)
- **Manufacturing** is not impacting any of the categories (less than 2.0%)
- **Distribution** is dominating in the case of Particulate matter to the air, with 68.3% and contributes to Volatile Organic Compounds (VOC) emissions to the air, with 26.1%.[8]
- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 95.1%
  - Electricity: 98.9%
  - Water (process): 89.9%
  - Waste, hazardous / incinerated: 87.8%
  - Greenhouse gases: 92.4%
  - Acidification (emissions to air): 94.4%
  - Volatile Organic Compounds (VOC): 55.4%
  - Heavy metals emissions to the air: 64.0%

[8] The high contribution of the distribution phase can be explained by the assumption related to transport in trucks from the retailer's central warehouse to the shop. The EcoReport tool does not allow specifying means of transport ant distances between the production place of the oven and retailer's central warehouse; only the volume of the product is taken into consideration to assess environmental impacts of the transport. Nevertheless, according to the MEEuP methodology (section 5.3.6, page 96), a mix of means of transport (trucking, rail, sear freight and air freight) with assumptions on distances is used for all Base-cases. This assumption could be considered as disadvantageous for appliances mainly produced in Europe.

- PAHs (emissions to the air): 68.0%

and contributes in the case of:

- Waste, non-hazardous /landfill: 50.0%
- Persistent Organic Pollutants (POP): 31.1%
- Heavy metals emissions to water: 46.9%

- **End-of-life** is not contributing to more than 5.2% of the total environmental impacts.

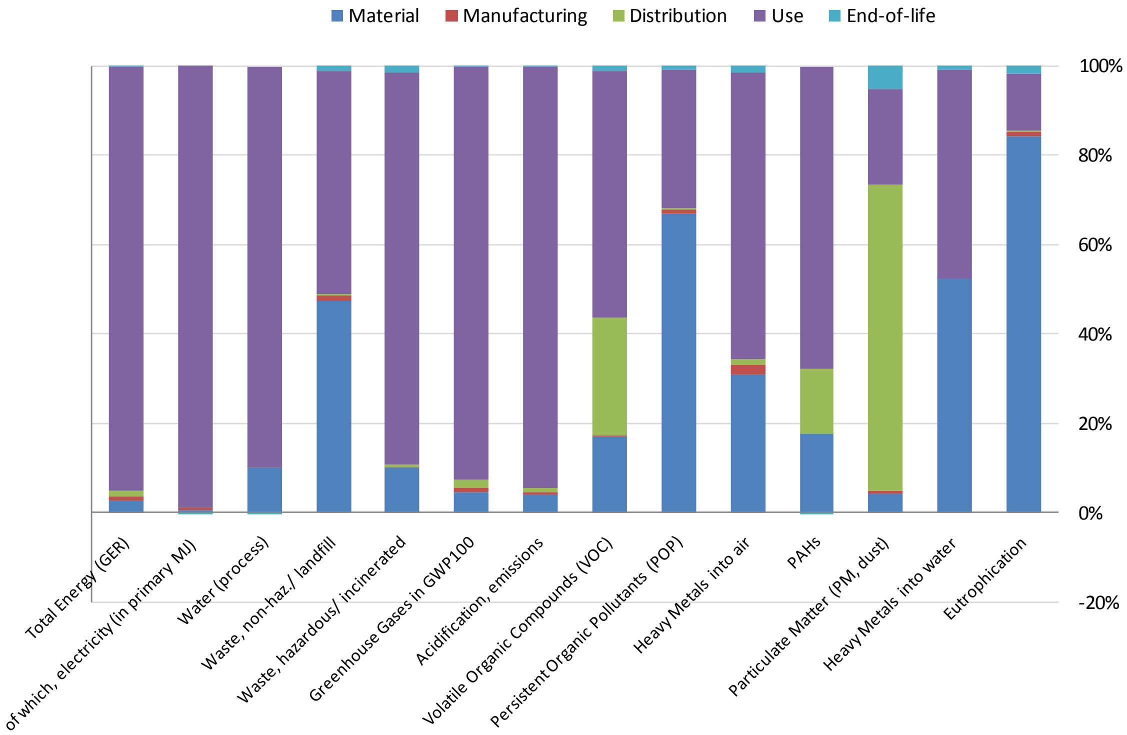

Figure 5-1: Distribution of environmental impacts of BC 1 per life cycle phase

5.2.1.2. Base-case 2: Domestic Gas Oven

Table 5-25 shows the environmental impacts of a domestic gas oven over its whole life cycle. The total primary energy consumption for the whole life cycle of the Base-case 2 is 15.2 GJ, of which 254 MJ comes from the electricity consumption (equivalent to 24.2 kWh final energy).

Table 5-25: Life Cycle Impact (per unit) of Base-case 2

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1358	300	**1659**	**647**	**13591**	72	24	**48**	**15945**
9	of which, electricity (in primary MJ)	MJ	189	179	**368**	**1**	**4**	0	2	**-2**	**371**
10	Water (process)	ltr	225	3	**228**	**0**	**2**	0	1	**-1**	**229**
11	Water (cooling)	ltr	95	82	**177**	**0**	**2**	0	10	**-10**	**169**
12	Waste, non-haz./ landfill	g	57542	1064	**58606**	**339**	**586**	1229	7	**1222**	**60753**
13	Waste, hazardous/ incinerated	g	10	0	**10**	**7**	**0**	10	1	**8**	**26**
	Emissions (Air)										

14	Greenhouse Gases in GWP100	kg CO2 eq.	102	17	**119**	**40**	**752**	5	1	**5**	**916**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	395	72	**468**	**120**	**225**	11	1	**10**	**823**
17	Volatile Organic Compounds (VOC)	g	5	0	**5**	**9**	**10**	0	0	**0**	**25**
18	Persistent Organic Pollutants (POP)	ng i-Teq	785	9	**794**	**2**	**8**	8	0	**8**	**812**
19	Heavy Metals	mg Ni eq.	313	22	**335**	**17**	**11**	21	0	**21**	**384**
	PAHs	mg Ni eq.	105	0	**105**	**22**	**9**	0	0	**0**	**136**
20	Particulate Matter (PM, dust)	g	93	11	**105**	**1501**	**137**	104	0	**104**	**1847**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	142	0	**142**	**1**	**1**	6	0	**6**	**150**
22	Eutrophication	g PO4	3	0	**3**	**0**	**0**	0	0	**0**	**4**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-2 exposes the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for the following categories :
  - Electricity consumption: 51.0% (mainly due to the steel used for the casing and the glass used for the door)
  - Water (process): 98.4% (mainly due to the glass used for the door)
  - Waste, non-hazardous /landfill: 94.7% (mainly due to the steel used for the casing)
  - Persistent Organic Pollutants (POP): 96.6% (mainly due to the steel used for the casing)
  - Heavy metals emissions to the air: 81.5% (mainly due to the steel used for the casing and the brass used in elements in contact with gas)
  - PAHs (emissions to the air): 77.1% (mainly due to the aluminium used for the door handle)
  - Heavy metals emissions to water: 94.9% (mainly due to the steel used for the casing)
  - Eutrophication: 87.3% (due to most metals and tec. plastics)

  and contributes for the categories:
  - Waste, hazardous / incinerated: 40.4% (mainly due to PA-6)
  - Acidification, emissions: 48.0% (due to most metals)
- **Manufacturing** is the phase where 48.2% of the electricity is consumed, but the overall energy consumption of the manufacturing phase is only 1.9% of the total energy consumption.
- **Distribution** is not dominant for the category:
  - Particulate Matter (PM, dust): 81.3%

  and contributes to:
  - Waste, hazardous / incinerated: 26.2%
  - Volatile Organic Compounds (VOC) emissions to the air: 36.6%

- **The use phase** impacts are dominating the total environmental impacts in the case of :
    - Total Energy (GER): 85.2%
    - Greenhouse gases: 82.2%

  and contributes in the case of:
    - Acidification, emissions: 27.4%
    - Volatile Organic Compounds (VOC): 41.8%
- **End-of-life** is contributing to the category:
    - Waste, hazardous / incinerated: 32.8% (this was not the case for BC1 as the majority of this impact came from the electricity consumption during the use phase. For gas ovens, the use phase is less significant. Therefore, in relative terms, the share of the end-of-life phase is greater even if in absolute terms the impact from this stage is quite similar for both Base-cases (12g for BC1 and 26g for BC2)

It is important to notice that this oven has no electric component and thus no standby energy consumption. Including a 3W standby consumption like for Base-case 1 would increase the Total Energy consumption to 20.4 GJ (of which 5.4 GJ electricity), which is still more than 30% lower than the total energy consumption of Base-case 1.

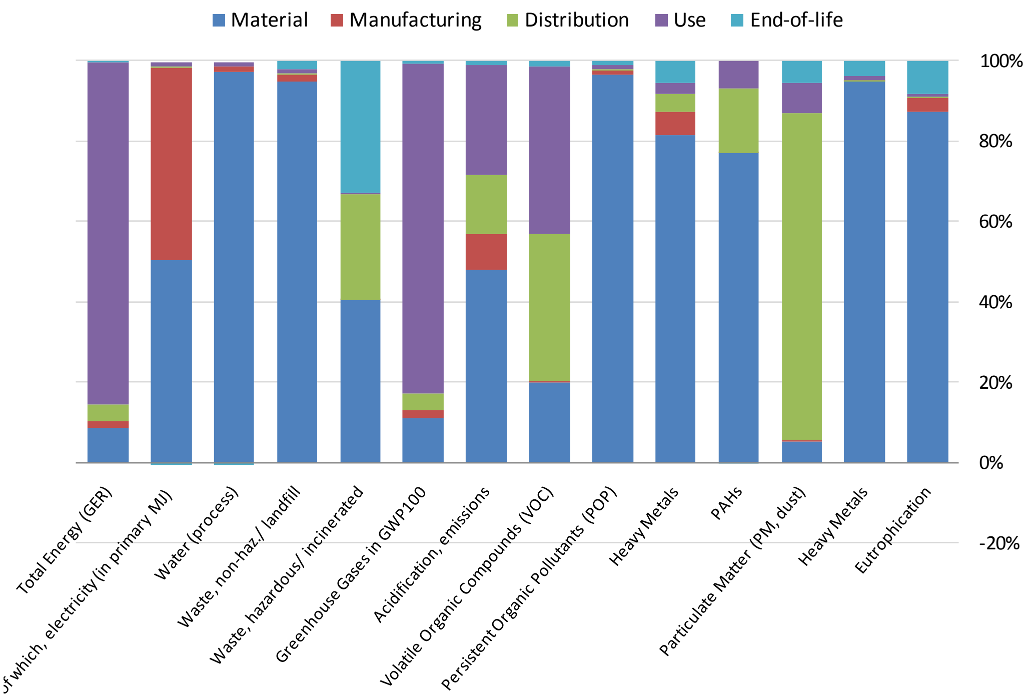

Figure 5-2: Distribution of environmental impacts of BC 2 per life cycle phase

5.2.1.3. Base-case 3: Domestic Microwave Oven

Table 5-26 shows the environmental impacts of a domestic microwave oven over its whole life cycle. The total primary energy consumption for the whole life cycle of the Base-case 2 is 13.3 GJ, of which 12.0 GJ comes from the electricity consumption (equivalent to 1.14 MWh final energy).

Table 5-26: Life Cycle Impact (per unit) of Base-case 3

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1118	187	**1305**	**176**	**7267**	182	74	**107**	**8855**
9	of which, electricity (in primary MJ)	MJ	280	99	**379**	**0**	**7258**	0	16	**-16**	**7622**
10	Water (process)	ltr	328	3	**331**	**0**	**487**	0	13	**-13**	**805**
11	Water (cooling)	ltr	274	52	**325**	**0**	**19347**	0	34	**-34**	**19639**
12	Waste, non-haz./ landfill	g	52840	591	**53431**	**112**	**8945**	2993	51	**2942**	**65429**
13	Waste, hazardous/ incinerated	g	241	1	**242**	**2**	**170**	117	14	**103**	**516**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	68	11	**79**	**12**	**317**	14	3	**11**	**419**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	816	48	**864**	**35**	**1877**	28	12	**16**	**2791**
17	Volatile Organic Compounds (VOC)	g	4	1	**4**	**2**	**3**	1	0	**1**	**10**
18	Persistent Organic Pollutants (POP)	ng i-Teq	231	4	**235**	**1**	**50**	21	0	**20**	**306**
19	Heavy Metals	mg Ni eq.	249	10	**258**	**6**	**127**	52	1	**51**	**442**
	PAHs	mg Ni eq.	89	0	**89**	**7**	**15**	0	1	**-1**	**110**
20	Particulate Matter (PM, dust)	g	48	9	**57**	**315**	**40**	260	1	**259**	**671**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	193	0	**193**	**0**	**49**	15	6	**9**	**251**
22	Eutrophication	g PO4	6	0	**6**	**0**	**0**	1	0	**1**	**7**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

Figure 5-3 exposes the contribution of each life cycle phase to each impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for the following categories :
    - Waste, non-hazardous /landfill: 80.8% (mainly due to the copper used in the transformer)
    - Persistent Organic Pollutants (POP): 75.4% (mainly due to the steel used for casing and the ferrite in the transformer)
    - Heavy metals emissions to the air: 56.2% (mainly due to the copper and the ferrite used in the transformer)
    - PAHs (emissions to the air): 80.9% (mainly due to the capacitor)
    - Heavy metals emissions to water: 76.9% (mainly due to the electronic components)
    - Eutrophication: 83.6% (mainly due to the electronic components)

  and contributes for the categories:
    - Water (process) : 40.7% (mainly due to the electronic components)
    - Waste, hazardous / incinerated: 46.7% (mainly due to the electronic components)
    - Acidification, emissions: 29.2% (mainly due to the copper used in the transformer)

- Volatile Organic Compounds (VOC): 36.8% (mainly due to the electronic components)

- **Manufacturing** is not significantly contributing to any category (less than 5.9%)
- **Distribution** is not dominant in any category but contributes to:
  - Particulate Matter (PM, dust): 46.9%
  - Volatile Organic Compounds (VOC): 20.6%
- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 82.1%
  - Electricity: 95.2%
  - Water (process): 60.5%
  - Greenhouse gases: 75.7%
  - Acidification (emissions to air): 67.2%

  and contributes in the case of:
  - Waste, hazardous / incinerated: 32.9%
  - Volatile Organic Compounds (VOC): 29.1%
  - Persistent Organic Pollutants (POP): 16.3%
  - Heavy metals emissions to the air: 28.7%
  - Heavy metals emissions to water: 19.4%
- **End-of-life** is contributing to the category:
  - Particulate Matter (PM, dust): 38.6% (due to the fact that 18% of the product goes to landfill)

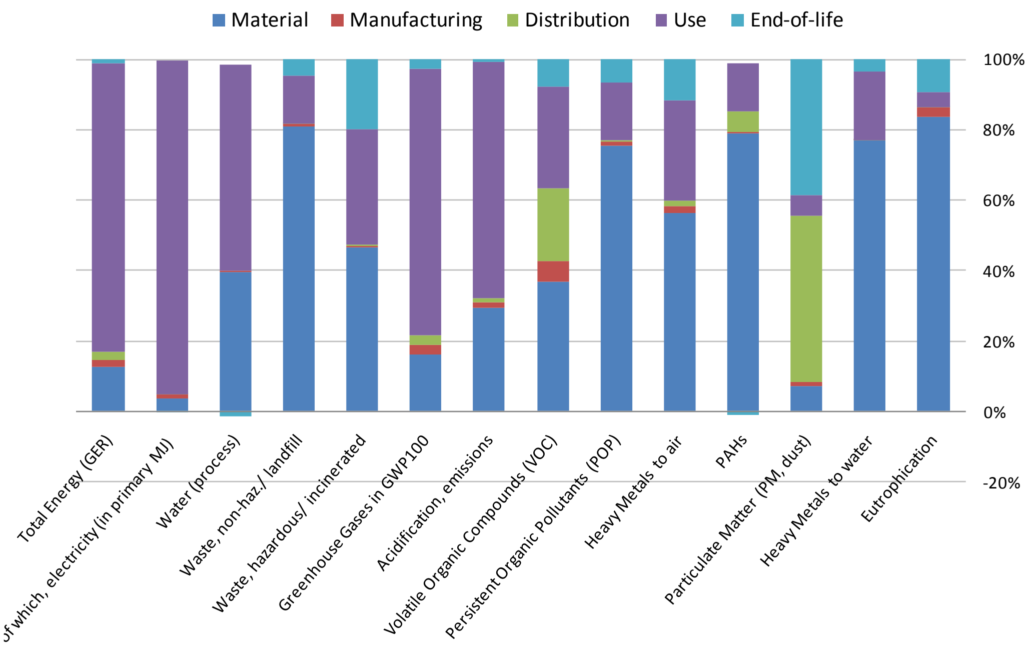

Figure 5-3: Distribution of environmental impacts of BC 3 per life cycle phase

5.2.1.4. CONCLUSIONS

The contribution of each life cycle phase to the indicators is widely varying depending on the Base-case. However, some trends common to all domestic Base-cases can be highlighted. The use phase is by far, and as expected, the main contributor to the energy consumption and greenhouse gases emissions. Non-hazardous waste is mainly produced during the material acquisition phase, which is also the most impacting phase regarding persistent organic pollutants emissions to the air and eutrophication. Particulate matter is emitted mainly during the distribution phase, and the end-of-life is not dominating any category.

The energy consumption of BC2 is significantly lower than BC1's one. However, the two Base-cases offer different functionalities. BC2 is a basic model, with no electronic component, where BC1 is programmable and consume electricity in standby mode, due to the timer. BC2's use phase has a significant contribution to 4 categories, whereas 11 categories are impacted by the use phase of BC1 and BC3.

5.2.2. Commercial appliances used in restaurants

5.2.2.1. Base-case 4: Commercial electric combi-steamer

Table 5-27 shows the environmental impacts of a commercial electric combi-steamer over its whole life cycle. The total primary energy consumption for the whole life cycle of Base-case 4 is 989.4 GJ, of which 976.4 GJ comes from the electricity consumption (equivalent to 93.0 MWh of final energy).

Table 5-27: Life Cycle Impact (per unit) of Base-case 4

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	9236	2018	**11253**	**1273**	**976937**	652	740	**-88**	**989376**
9	of which, electricity (in primary MJ)	MJ	2164	1203	**3367**	**3**	**973006**	0	2	**-2**	**976374**
10	Water (process)	ltr	8877	18	**8895**	**0**	**252154**	0	1	**-1**	**261048**
11	Water (cooling)	ltr	3098	555	**3654**	**0**	**2594629**	0	9	**-9**	**2598273**
12	Waste, non-haz./ landfill	g	167944	7068	**175012**	**550**	**1129858**	1330	6	**1324**	**1306744**
13	Waste, hazardous/ incinerated	g	1239	0	**1239**	**11**	**22433**	8550	1	**8549**	**32232**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	811	113	**924**	**76**	**42767**	49	54	**-5**	**43761**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	7398	486	**7885**	**232**	**250917**	97	68	**29**	**259063**
17	Volatile Organic Compounds (VOC)	g	25	1	**26**	**23**	**429**	2	1	**1**	**478**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1013	56	**1069**	**3**	**6388**	9	0	**9**	**7470**
19	Heavy Metals	mg Ni eq.	15116	132	**15248**	**28**	**17677**	176	0	**176**	**33129**
	PAHs	mg Ni eq.	229	0	**229**	**51**	**2751**	0	0	**0**	**3031**
20	Particulate Matter (PM, dust)	g	916	75	**991**	**3760**	**19473**	834	1	**833**	**25058**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	9585	0	**9585**	**1**	**6369**	55	0	**55**	**16010**
22	Eutrophication	g PO4	267	1	**267**	**0**	**33**	3	0	**3**	**303**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-4 exposes the contribution of each life cycle phase to each environmental impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for the following categories :
    - Heavy metals emissions to water: 59.9% (mainly due to the stainless steel)
    - Eutrophication: 87.8% (mainly due to the stainless steel)

  and contributes for the categories:
    - Heavy metals emissions to the air: 45.6% (mainly due to the stainless steel used for the heating elements)
- **Manufacturing** is not impacting any of the categories (less than 0.8%)

- **Distribution** contributes to Particulate matter (PM, dust) emissions to the air, with 15.0%.
- **The use phase** impacts are dominating the total environmental impacts in the case of :
    - Total Energy (GER): 98.7%
    - Electricity: 99.7%
    - Water (process): 96.6%
    - Waste, non-hazardous /landfill: 86.4%
    - Waste, hazardous / incinerated: 69.6%
    - Greenhouse gases: 97.7%
    - Acidification (emissions to air): 96.8%
    - Volatile Organic Compounds (VOC): 89.7%
    - Persistent Organic Pollutants (POP): 85.5%
    - Heavy metals emissions to the air: 53.3%
    - PAHs (emissions to the air): 90.7%
    - Particulate matter (PM, dust) emissions to the air: 77.7%

  and contributes in the case of:
    - Heavy metals emissions to water: 39.8%
- **End-of-life** contributes to Waste, hazardous / incinerated, with 26.5%, due to the fact the 8.5 kg of plastics which are incinerated.

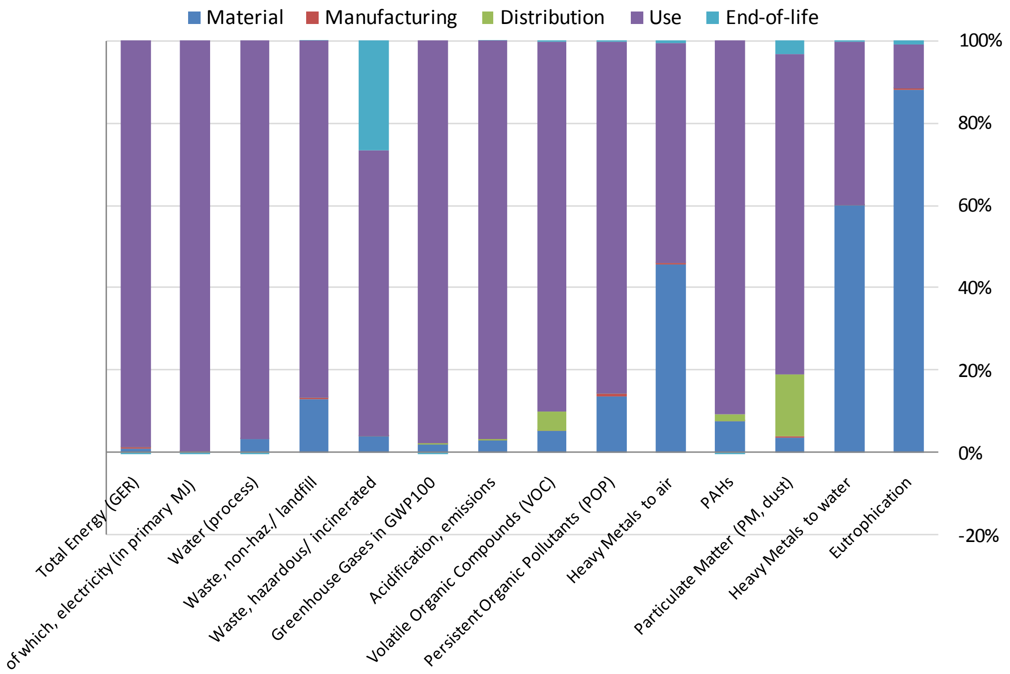

Figure 5-4: Distribution of environmental impacts of BC 4 per life cycle phase

5.2.2.2. Base-case 5: Commercial gas combi-steamer

Table 5-28 shows the environmental impacts of a commercial gas combi-steamer over its whole life cycle. The total energy consumption for the whole life cycle of Base-case 5 is 611.0 GJ, of which 141.3 GJ of primary energy comes from the electricity consumption (equivalent to 13.5 MWh of final energy).

Table 5-28: Life cycle Impact (per unit) of Base-case 5

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	10401	2298	**12699**	**1273**	**597219**	652	806	**-154**	**611038**
9	of which, electricity (in primary MJ)	MJ	2329	1370	**3698**	**3**	**137629**	0	2	**-2**	**141329**
10	Water (process)	ltr	10165	20	**10185**	**0**	**196475**	0	1	**-1**	**206659**
11	Water (cooling)	ltr	3242	632	**3874**	**0**	**366951**	0	9	**-9**	**370816**
12	Waste, non-haz./ landfill	g	186444	8068	**194512**	**550**	**161477**	1327	6	**1321**	**357860**
13	Waste, hazardous/ incinerated	g	1239	0	**1239**	**11**	**3183**	8550	1	**8549**	**12982**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	923	128	**1052**	**76**	**31504**	49	59	**-10**	**32622**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	8382	554	**8936**	**232**	**43154**	97	74	**23**	**52345**
17	Volatile Organic Compounds (VOC)	g	27	1	**28**	**23**	**446**	2	1	**1**	**498**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1211	65	**1277**	**3**	**915**	9	0	**9**	**2204**
19	Heavy Metals	mg Ni eq.	17639	153	**17792**	**28**	**3371**	176	0	**176**	**21367**
	PAHs	mg Ni eq.	265	0	**265**	**51**	**1118**	0	0	**0**	**1434**
20	Particulate Matter (PM, dust)	g	1059	85	**1144**	**3760**	**15008**	834	1	**833**	**20745**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	11066	0	**11066**	**1**	**998**	55	0	**55**	**12119**
22	Eutrophication	g PO4	306	1	**307**	**0**	**7**	3	0	**3**	**318**

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

- **Material acquisition** is predominant in the total environmental impact for the following categories :
  - Waste, non-hazardous /landfill: 52.1%
  - Persistent Organic Pollutants (POP): 54.9% (mainly due to stainless steel)
  - Heavy metals emissions to the air: 82.5% (mainly due to stainless steel)
  - Heavy metals emissions to water: 91.3% (mainly due to stainless steel)
  - Eutrophication: 96.4% (mainly due to stainless steel)

  and contributes for the categories:
  - Acidification (emissions to air): 16.0%
  - PAHs (emissions to the air): 18.5%
- **Manufacturing** is not impacting any of the categories (less than 3.0%)
- **Distribution** contributes to Particulate matter (PM, dust) emissions to the air, with 18.1%.

- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 97.7%
  - Electricity: 97.4%
  - Water (process): 95.1%
  - Greenhouse gases: 96.5%
  - Acidification (emissions to air): 82.4%
  - Volatile Organic Compounds (VOC): 89.6%
  - PAHs (emissions to the air): 78.0%
  - Particulate matter (PM, dust) emissions to the air: 72.3%

  and contributes in the case of:
  - Waste, non-hazardous /landfill: 45.1%
  - Waste, hazardous / incinerated: 24.5%
  - Persistent Organic Pollutants (POP): 41.5%
  - Heavy metals emissions to the air: 15.8%

- **End-of-life** is predominant for the indicator Waste, hazardous / incinerated, with 65.8%, due to the 8.5 kg of plastics which are incinerated.

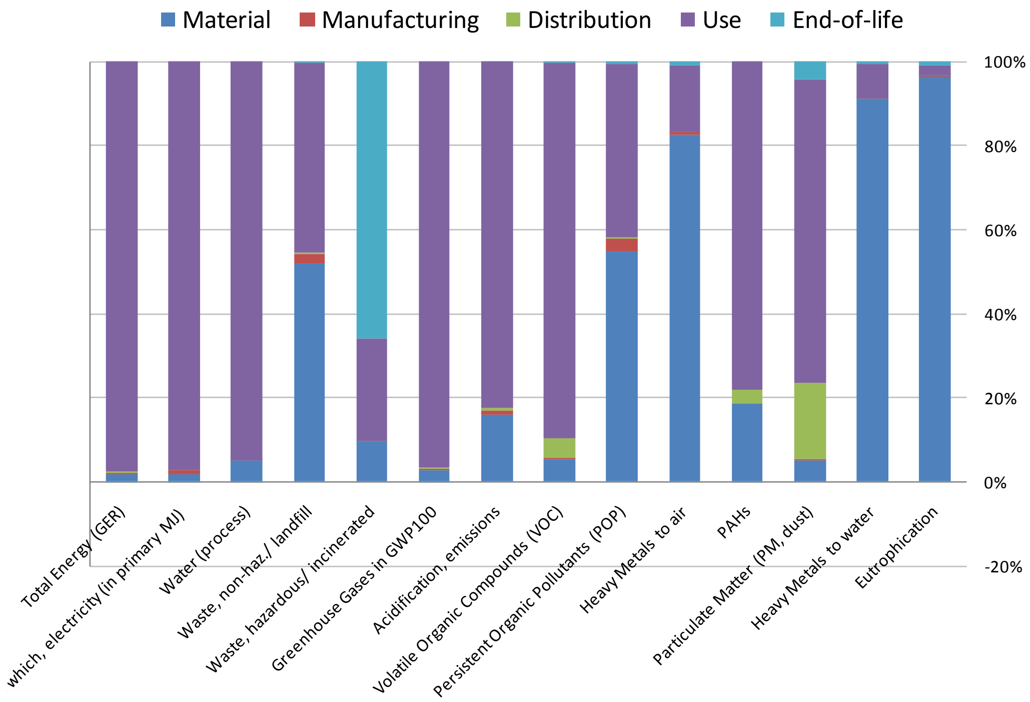

Figure 5-5: Distribution of environmental impacts of BC 5 per life cycle phase

5.2.2.3. CONCLUSIONS

For both combi-steamer Base-cases, the use phase is predominant for most indicators (12 out of 14 for the BC4, 8 out of 14 for BC5). Impacts on water occur at the material extraction phase. The same weight of incinerated waste is generated during end-of-life for BC4 and BC5, but this phase is more significant for BC5 as less waste is generated during its use phase.

Most of BC4's impacts are due to the electricity production. As BC5 generates heat directly from gas, less electricity is needed during the use phase. Therefore, BC5 have lower impacts for every indicators, except for VOC emissions (mainly due to the use phase) and Eutrophication (due to additional stainless steel in the gas combi-steamer).

5.2.3. COMMERCIAL APPLIANCES USED IN BAKERIES

5.2.3.1. BASE-CASE 6: COMMERCIAL IN-STORE CONVECTION OVEN

Table 5-29 shows the environmental impacts of a bakery in-store oven over its whole life cycle. The total primary energy consumption for the whole life cycle of Base-case 6 is 1062.9 GJ, of which 1051.2 GJ comes from the electricity consumption (equivalent to 100.1 MWh of final energy).

Table 5-29: Life Cycle Impact (per unit) of Base-case 6

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	2467	43	**2511**	**607**	**1053876**	153	3	**149**	**1057143**
9	of which, electricity (in primary MJ)	MJ	1146	26	**1172**	**1**	**1050012**	0	0	**0**	**1051185**
10	Water (process)	ltr	824	0	**825**	**0**	**90008**	0	0	**0**	**90833**
11	Water (cooling)	ltr	124	12	**136**	**0**	**2800001**	0	0	**0**	**2800137**
12	Waste, non-haz./ landfill	g	64833	154	**64987**	**278**	**1218065**	2674	0	**2674**	**1286005**
13	Waste, hazardous/ incinerated	g	530	0	**530**	**6**	**24200**	54	0	**54**	**24790**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	182	2	**184**	**37**	**46121**	11	0	**11**	**46353**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	841	10	**852**	**112**	**270681**	22	0	**22**	**271667**
17	Volatile Organic Compounds (VOC)	g	14	0	**14**	**10**	**458**	1	0	**1**	**483**
18	Persistent Organic Pollutants (POP)	ng i-Teq	934	1	**936**	**2**	**6892**	18	0	**18**	**7847**
19	Heavy Metals	mg Ni eq.	644	3	**647**	**14**	**18853**	45	0	**45**	**19559**
	PAHs	mg Ni eq.	52	0	**52**	**25**	**2901**	0	0	**0**	**2978**
20	Particulate Matter (PM, dust)	g	116	2	**118**	**1709**	**19888**	199	0	**199**	**21914**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	611	0	**611**	**0**	**6776**	13	0	**13**	**7400**
22	Eutrophication	g PO4	13	0	**13**	**0**	**32**	1	0	**1**	**46**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-6 exposes the contribution of each life cycle phase to each environmental impact. It is clear that the use phase dominates all environmental impacts.

- **Material acquisition** contributes to eutrophication, with 28.3% (mainly due to stainless steel and electronic components)
- **Manufacturing** is not impacting any of the categories (less than 0.03%)
- **Distribution** has a negligible impact on all of the categories (less than 7.8%)
- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 99.7%
  - Electricity: 99.9%
  - Water (process): 98.8%
  - Waste, non-hazardous /landfill: 94.7%

- Waste, hazardous / incinerated: 97.6%
- Greenhouse gases: 99.5%
- Acidification (emissions to air): 99.6%
- Volatile Organic Compounds (VOC): 95.6%
- Persistent Organic Pollutants (POP): 87.8%
- Heavy metals emissions to the air: 96.6%
- PAHs (emissions to the air): 98.2%
- Particulate matter (PM, dust) emissions to the air: 95.3%
- Heavy metals emissions to water: 91.6%
- Eutrophication: 70.1%

- **End-of-life** is not impacting any of the categories (less than 1.6%)

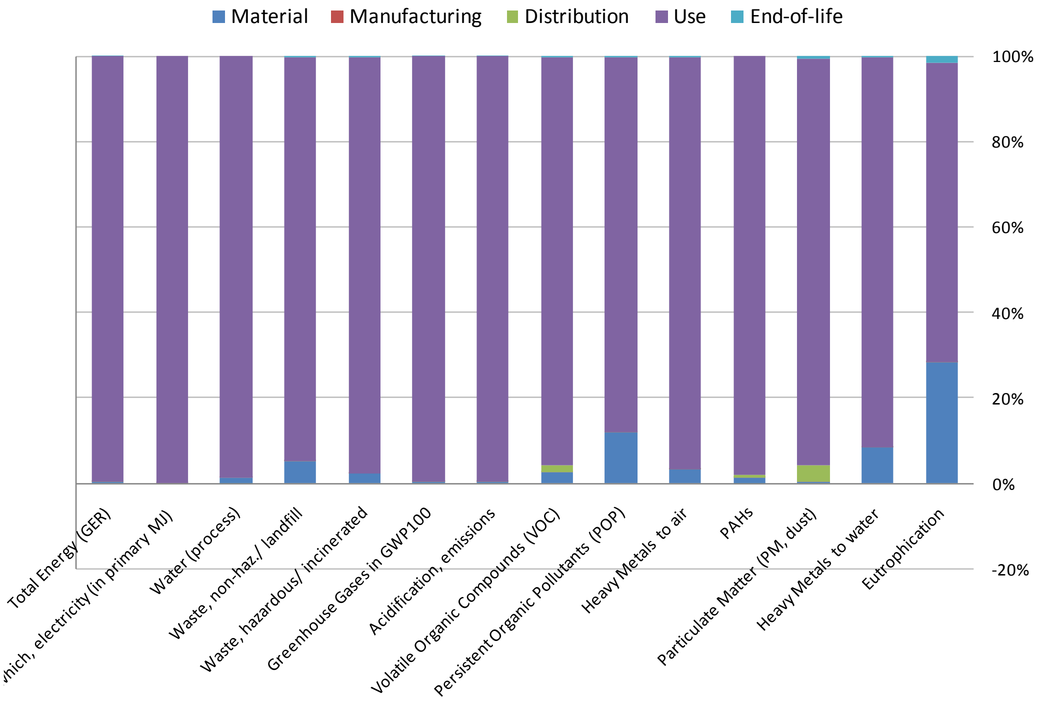

Figure 5-6: Distribution of environmental impacts of BC 6 per life cycle phase

5.2.3.2. Base-case 7: Electric deck oven

Table 5-30 shows the environmental impacts of an electric deck oven over its whole life cycle. The total primary energy consumption for the whole life cycle of Base-case 7 is 7.51 TJ, of which 7.44 TJ comes from the electricity consumption (equivalent to 708 MWh of final energy).

Table 5-30: Life cycle impact (per unit) of Base-case 7

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	44213	14156	**58369**	**16600**	**7435367**	1806	1802	**4**	**7510341**
9	of which, electricity (in primary MJ)	MJ	5915	8230	**14146**	**42**	**7430109**	0	3	**-3**	**7444295**
10	Water (process)	ltr	25682	114	**25796**	**0**	**663589**	0	2	**-2**	**689384**
11	Water (cooling)	ltr	6402	3588	**9990**	**0**	**19813348**	0	15	**-15**	**19823323**
12	Waste, non-haz./ landfill	g	1551142	62473	**1613615**	**6812**	**8630764**	14768	11	**14757**	**10265948**
13	Waste, hazardous/ incinerated	g	329	8	**336**	**135**	**171212**	14535	2	**14533**	**186217**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	3960	803	**4762**	**977**	**324659**	135	132	**2**	**330401**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	26712	3478	**30190**	**2992**	**1913891**	267	167	**100**	**1947174**
17	Volatile Organic Compounds (VOC)	g	141	12	**153**	**308**	**2878**	6	2	**3**	**3342**
18	Persistent Organic Pollutants (POP)	ng i-Teq	18087	1368	**19455**	**39**	**48895**	102	0	**102**	**68490**
19	Heavy Metals	mg Ni eq.	51975	3203	**55178**	**345**	**129062**	504	0	**504**	**185090**
	PAHs	mg Ni eq.	254	1	**255**	**658**	**15680**	0	0	**0**	**16593**
20	Particulate Matter (PM, dust)	g	4314	532	**4846**	**50930**	**58553**	2326	3	**2323**	**116651**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	31509	2	**31511**	**11**	**48221**	151	0	**151**	**79894**
22	Eutrophication	g PO4	882	5	**887**	**0**	**237**	9	0	**9**	**1133**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-7 exposes the contribution of each life cycle phase to each environmental impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for Eutrophication, with 77.8% of the total impact (mainly due to the stainless steel), and contributes to:
  - Waste, non-hazardous /landfill: 15.1%
  - Persistent Organic Pollutants (POP): 26.4% (mainly due to galvanised steel)
  - Heavy metals emissions to the air: 28.1% (mainly due to the stainless steel)
  - Heavy metals emissions to water: 39.4% (mainly due to the stainless steel)
- **Manufacturing** is not impacting any of the categories (less than 2.0%)

- **Distribution** contributes to Particulate matter (PM, dust) emissions to the air, with 43.7%.

- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 99.0%
  - Electricity: 99.8%
  - Water (process): 96.3%
  - Waste, non-hazardous /landfill: 84.1%
  - Waste, hazardous / incinerated: 91.9%
  - Greenhouse gases: 98.3%
  - Acidification (emissions to air): 98.3%
  - Volatile Organic Compounds (VOC): 86.0%
  - Persistent Organic Pollutants (POP): 71.4%
  - Heavy metals emissions to the air: 69.7%
  - PAHs (emissions to the air): 94.4%
  - Particulate matter (PM, dust) emissions to the air: 50.2%
  - Heavy metals emissions to water: 60.4%

  and contributes in the case of:
  - Heavy metals emissions to water: 21.0%

- **End-of-life**: 7.8% of hazardous or incinerated wastes are produced during the end-of-life, the other impacts of this phase are negligible.

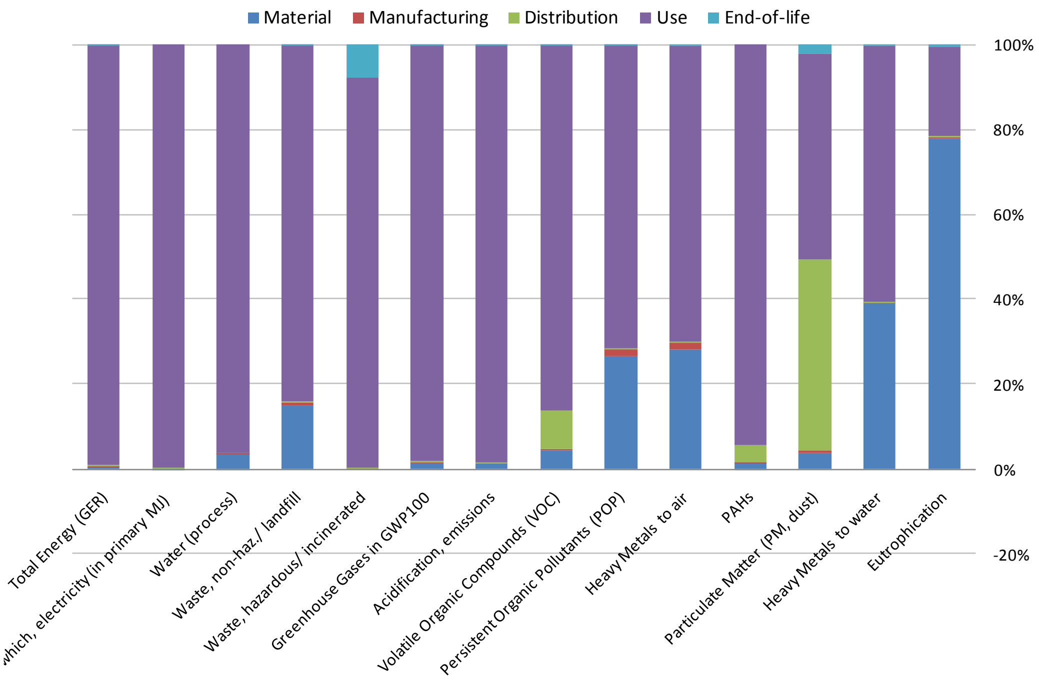

Figure 5-7: Distribution of environmental impacts of BC 7 per life cycle phase

5.2.3.3. Base-case 8: Gas deck oven

Table 5-31 shows the environmental impacts of a gas deck oven over its whole life cycle. The total primary energy consumption for the whole life cycle of Base-case 8 is 3,855 GJ, of which 252 GJ comes from the electricity consumption (equivalent to 24 MWh of final energy).

Table 5-31: Life cycle impact (per unit) of Base-case 8

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	53865	11899	**65764**	**16600**	**3773567**	2165	1731	**434**	**3856365**
9	of which, electricity (in primary MJ)	MJ	8913	6882	**15794**	**42**	**236030**	0	2	**-2**	**251864**
10	Water (process)	ltr	29818	94	**29913**	**0**	**184024**	0	2	**-2**	**213935**
11	Water (cooling)	ltr	7644	2963	**10607**	**0**	**629098**	0	13	**-13**	**639692**
12	Waste, non-haz./ landfill	g	1750757	54742	**1805499**	**6812**	**291537**	23853	9	**23844**	**2127692**
13	Waste, hazardous/ incinerated	g	205	7	**212**	**135**	**5437**	12350	1	**12349**	**18134**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	4921	677	**5598**	**977**	**206036**	161	127	**34**	**212646**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	30231	2935	**33166**	**2992**	**118388**	319	161	**159**	**154704**
17	Volatile Organic Compounds (VOC)	g	248	11	**259**	**308**	**2760**	7	2	**5**	**3332**
18	Persistent Organic Pollutants (POP)	ng i-Teq	22514	1318	**23832**	**39**	**1784**	164	0	**164**	**25819**
19	Heavy Metals	mg Ni eq.	60775	3087	**63862**	**345**	**5985**	612	0	**612**	**70805**
	PAHs	mg Ni eq.	153	1	**154**	**658**	**1865**	0	0	**0**	**2677**
20	Particulate Matter (PM, dust)	g	11538	448	**11986**	**50930**	**24455**	2797	3	**2794**	**90165**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	35907	2	**35909**	**11**	**1880**	181	0	**181**	**37980**
22	Eutrophication	g PO4	998	4	**1002**	**0**	**17**	10	0	**10**	**1030**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-8 exposes the contribution of each life cycle phase to each environmental impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for the following categories :
  - Waste, non-hazardous /landfill: 82.3%
  - Persistent Organic Pollutants (POP): 87.2% (mainly due to steel)
  - Heavy metals emissions to the air: 85.8% (mainly due to stainless steel)
  - Heavy metals emissions to water: 94.5% (mainly due to stainless steel)
  - Eutrophication: 96.9% (mainly due to stainless steel)

  and contributes for the categories:
  - Acidification (emissions to air): 19.5%
- **Manufacturing** is not impacting any of the categories (less than 5.1%)

- **Distribution** is dominant for Particulate matter (PM, dust) emissions to the air, with 56.5%, and contributes to PAHs emissions to air, with 24.6%.
- **The use phase** impacts are dominating the total environmental impacts in the case of :
    - Total Energy (GER): 97.9%
    - Electricity: 93.7%
    - Water (process): 86.0%
    - Greenhouse gases: 96.9%
    - Acidification (emissions to air): 76.5%
    - Volatile Organic Compounds (VOC): 82.8%
    - PAHs (emissions to the air): 69.7%

  and contributes in the case of:
    - Waste, hazardous / incinerated: 30.0%
    - Particulate matter (PM, dust) emissions to the air: 27.1%
- **End-of-life** is predominant for the indicator Waste, hazardous / incinerated, with 68.1%, due to the 12.35 kg of plastics which are incinerated.

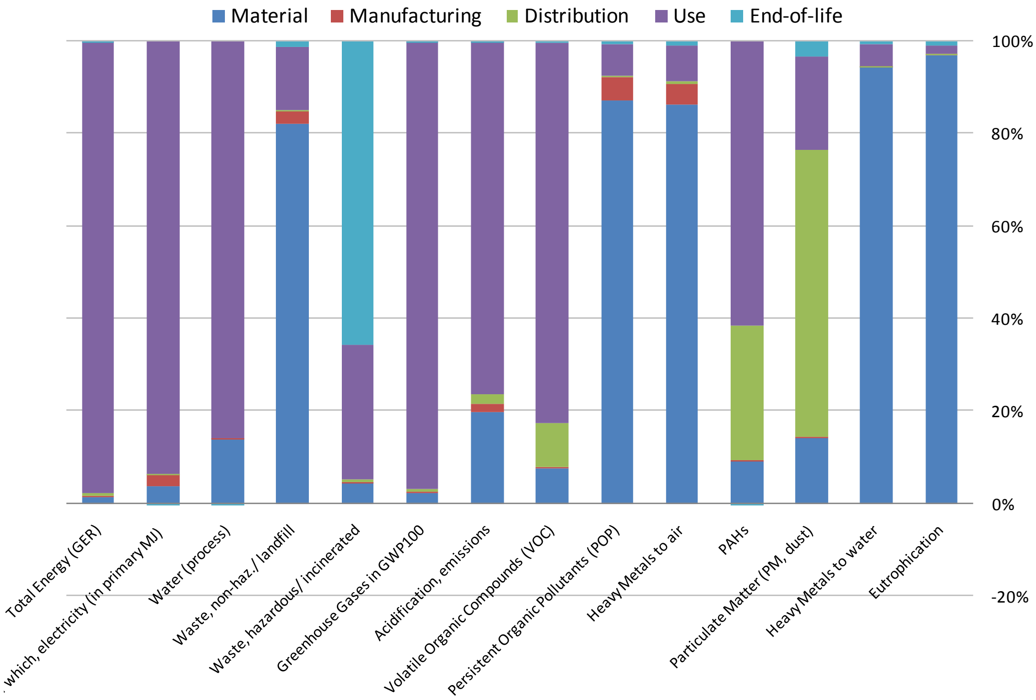

Figure 5-8: Distribution of environmental impacts of BC 8 per life cycle phase

5.2.3.4. BASE-CASE 9: ELECTRIC RACK OVEN

Table 5-32 shows the environmental impacts of an electric rack oven over its whole life cycle. The total primary energy consumption for the whole life cycle of Base-case 9 is 7.54 TJ, of which 7.47 TJ comes from the electricity consumption (equivalent to 718 MWh).

Table 5-32: Life cycle impact (per unit) of Base-case 9

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	37473	7772	**45245**	**7826**	**7471971**	1010	1803	**-793**	**7524249**
9	of which, electricity (in primary MJ)	MJ	7560	4518	**12079**	**20**	**7465621**	0	1	**-1**	**7477718**
10	Water (process)	ltr	33976	63	**34039**	**0**	**633040**	0	1	**-1**	**667079**
11	Water (cooling)	ltr	5298	1970	7268	0	19908073	0	8	-8	19915333
12	Waste, non-haz./ landfill	g	942126	34299	**976425**	**3227**	**8665589**	8754	6	**8748**	**9653990**
13	Waste, hazardous/ incinerated	g	1395	4	**1399**	**64**	**172041**	7724	1	**7723**	**181227**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	3460	441	**3900**	**461**	**326294**	75	133	**-58**	**330598**
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	28735	1910	**30645**	**1412**	**1923138**	149	168	**-18**	**1955177**
17	Volatile Organic Compounds (VOC)	g	122	7	**129**	**145**	**2910**	3	2	**1**	**3185**
18	Persistent Organic Pollutants (POP)	ng i-Teq	8830	751	**9581**	**18**	**49029**	60	0	**60**	**58689**
19	Heavy Metals	mg Ni eq.	65061	1759	**66820**	**164**	**130048**	282	0	**282**	**197314**
	PAHs	mg Ni eq.	222	1	**223**	**311**	**16009**	0	0	**0**	**16542**
20	Particulate Matter (PM, dust)	g	3955	292	**4247**	**23927**	**63153**	1302	3	**1299**	**92626**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	38883	1	**38884**	**5**	**48524**	84	0	**84**	**87498**
22	Eutrophication	g PO4	1041	3	**1043**	**0**	**240**	5	0	**5**	**1288**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Figure 5-9 exposes the contribution of each life cycle phase to each environmental impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for Eutrophication, with 80.8% of the total impact (mainly due to the stainless steel), and contributes to:
  - Waste, non-hazardous /landfill: 9.8%
  - Persistent Organic Pollutants (POP): 15.0% (mainly due to galvanised steel)
  - Heavy metals emissions to the air: 33.0% (mainly due to the stainless steel)
  - Heavy metals emissions to water: 44.4% (mainly due to the stainless steel)
- **Manufacturing** is not impacting any of the categories (less than 1.3%)
- **Distribution** contributes to Particulate matter (PM, dust) emissions to the air, with 25.8%.
- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 99.3%

- Electricity: 99.8%
- Water (process): 94.9%
- Waste, non-hazardous /landfill: 89.8%
- Waste, hazardous / incinerated: 94.9%
- Greenhouse gases: 98.7%
- Acidification (emissions to air): 98.4%
- Volatile Organic Compounds (VOC): 91.4%
- Persistent Organic Pollutants (POP): 83.5%
- Heavy metals emissions to the air: 65.9%
- PAHs (emissions to the air): 96.8%
- Particulate matter (PM, dust) emissions to the air: 68.2%
- Heavy metals emissions to water: 55.5%

and contributes in the case of:

- Eutrophication: 18.6%

- **End-of-life**: 4.3% of hazardous or incinerated wastes are produced during the end-of-life, the other impacts of this phase are even lower.

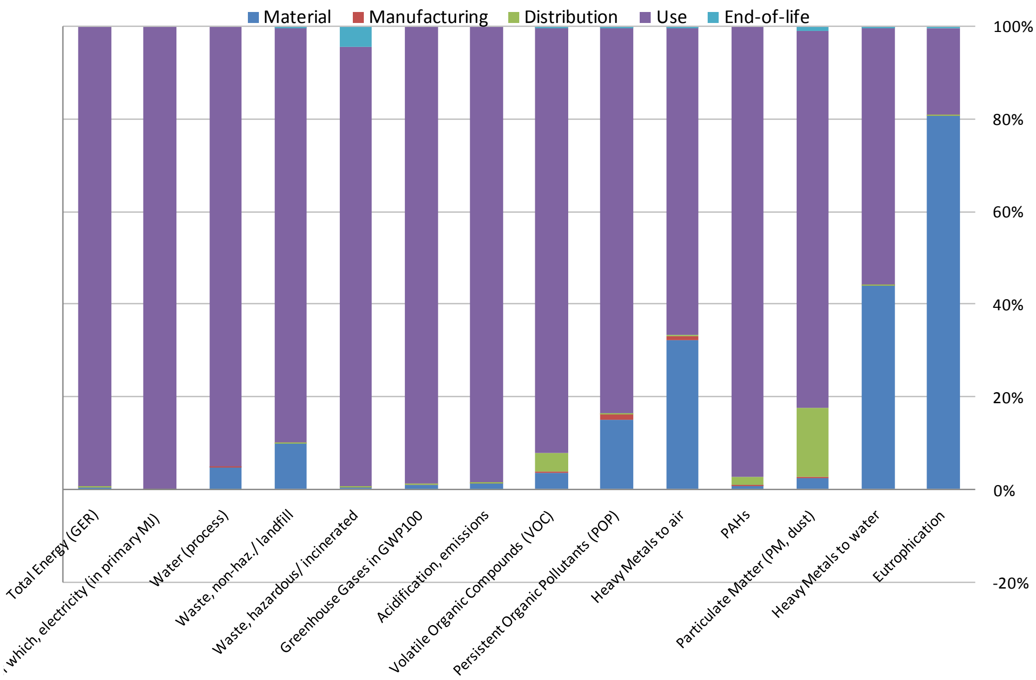

Figure 5-9: Distribution of environmental impacts of BC 9 per life cycle phase

5.2.3.5. Base-case 10: Gas rack oven

Table 5-31 shows the environmental impacts of a gas deck oven over its whole life cycle. The total primary energy consumption for the whole life cycle of Base-case 10 is 3,701 GJ, of which 633 GJ comes from the electricity consumption (equivalent to 60 MWh of final energy).

Table 5-33: Life cycle impact (per unit) of Base-case 10

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	37957	7797	**45754**	**7826**	**3631817**	1022	1805	**-783**	**3684614**
9	of which, electricity (in primary MJ)	MJ	7680	4533	**12213**	**20**	**620672**	0	1	**-1**	**632904**
10	Water (process)	ltr	34090	63	**34153**	**0**	**176712**	0	1	**-1**	**210864**
11	Water (cooling)	ltr	5311	1976	**7287**	**0**	**1654873**	0	8	**-8**	**1662152**
12	Waste, non-haz./ landfill	g	962042	34413	**996455**	**3227**	**729458**	8964	6	**8958**	**1738099**
13	Waste, hazardous/ incinerated	g	1395	4	**1399**	**64**	**14313**	7724	1	**7723**	**23500**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	3501	442	**3943**	**461**	**193739**	76	134	**-57**	**198086**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	28902	1916	**30818**	**1412**	**209020**	151	168	**-17**	**241233**
17	Volatile Organic Compounds (VOC)	g	125	7	**132**	**145**	**2539**	3	2	**1**	**2816**
18	Persistent Organic Pollutants (POP)	ng i-Teq	9118	753	**9871**	**18**	**4166**	62	0	**62**	**14118**
19	Heavy Metals	mg Ni eq.	65343	1765	**67108**	**164**	**12877**	286	0	**286**	**80435**
	PAHs	mg Ni eq.	223	1	**223**	**311**	**2869**	0	0	**0**	**3403**
20	Particulate Matter (PM, dust)	g	3990	293	**4283**	**23927**	**30757**	1317	3	**1314**	**60281**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	39049	1	**39050**	**5**	**4392**	85	0	**85**	**43532**
22	Eutrophication	g PO4	1045	3	**1048**	**0**	**30**	5	0	**5**	**1082**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Figure 5-10 exposes the contribution of each life cycle phase to each environmental impact. Several observations can be made from this analysis:

- **Material acquisition** is predominant in the total environmental impact for the following categories :
  - Waste, non-hazardous /landfill: 55.4%
  - Persistent Organic Pollutants (POP): 64.6% (mainly due to steel)
  - Heavy metals emissions to the air: 81.2% (mainly due to stainless steel)
  - Heavy metals emissions to water: 89.7% (mainly due to stainless steel)
  - Eutrophication: 96.6% (mainly due to stainless steel)

  and contributes for the categories:
  - Water (process): 16.2% (mainly due to stainless steel)
- **Manufacturing** is not impacting any of the categories (less than 5.3%)
- **Distribution** is contributes to Particulate matter (PM, dust) emissions to the air, with 39.7%
- **The use phase** impacts are dominating the total environmental impacts in the case of :
  - Total Energy (GER): 98.6%
  - Electricity: 98.1%
  - Water (process): 83.8%

- Waste, hazardous / incinerated: 60.9%
- Greenhouse gases: 97.8%
- Acidification (emissions to air): 86.6%
- Volatile Organic Compounds (VOC): 90.2%
- PAHs (emissions to the air): 84.3%
- Particulate matter (PM, dust) emissions to the air: 51.0%

and contributes in the case of:

- Waste, non-hazardous /landfill: 42.0%
- Persistent Organic Pollutants (POP): 29.5%
- Heavy metals emissions to the air: 16.0%

- **End-of-life** contributes to 32.9% of the impact for the indicator Waste, hazardous / incinerated, due to the 7 kg of plastics which are incinerated.

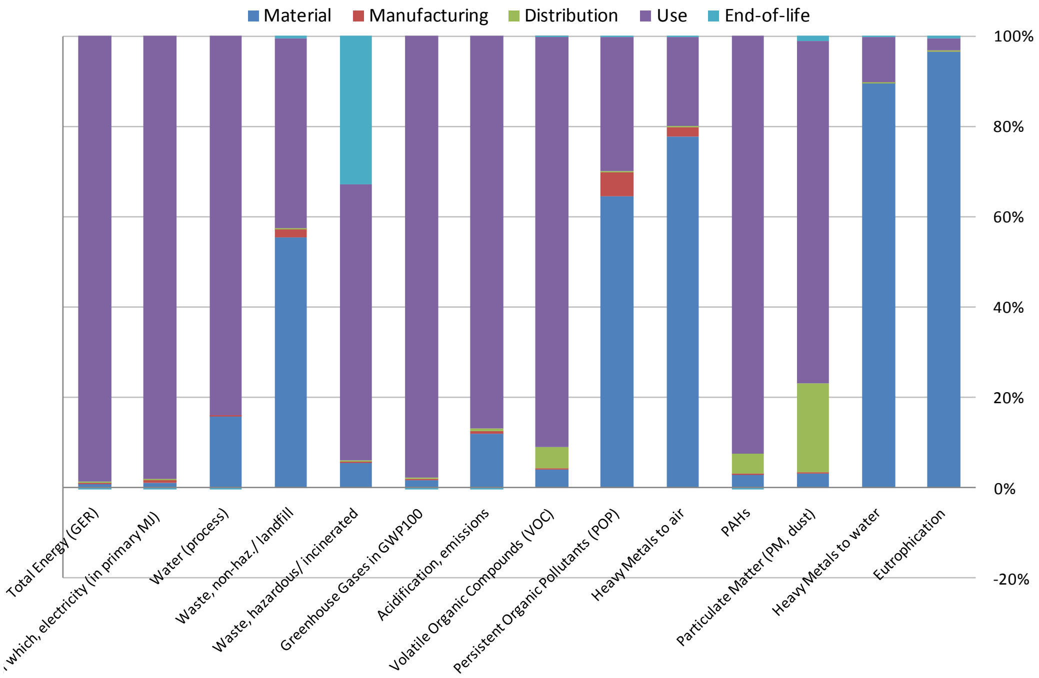

Figure 5-10: Distribution of environmental impacts of BC 10 per life cycle phase

5.2.3.6. CONCLUSIONS

The environmental impacts of bakery ovens are different depending on their type. For in-store convection ovens, the use phase is predominant for every impact. They are indeed consuming a significant amount of electricity, which makes the impacts of all other phases almost negligible. While electric and gas versions of deck and rack ovens are used for the same purpose, their impacts differs in many ways. This is also due to the fact that most impacts occur during the use phase: gas and electricity consumption bring about different impacts. Nevertheless, gas ovens consume almost half of the energy consumed by the electric version.

5.3. BASE-CASE LIFE CYCLE COSTS

The result of the procurement process should be the cheapest ovens, having the lowest total cost of ownership, i.e. taking into account the whole life cycle of the product.

5.3.1. DOMESTIC APPLIANCES

The Life Cycle Cost (LCC) of the three domestic Base-cases is presented in Table 5-34. This was automatically calculated by EcoReport using the product price, the energy consumption and the price of energy, and the discount rate.

Table 5-34: EcoReport outcomes of the LCC calculations for the three domestic Base-cases

	Base-case 1: Domestic electric oven		Base-case 2: Domestic gas oven		Base-case 3: Domestic microwave oven	
Product price	500 €	*58%*	335 €	*70%*	117 €	*55%*
Gas	0 €	*0%*	142 €	*30%*	0 €	*0%*
Electricity	358 €	*42%*	0 €	*0%*	96 €	*45%*
Total	**858 €**		**477 €**		**213 €**	

There are similarities between BC1 and BC3 concerning the life cycle cost. The product price represents indeed around 55% of the LCC for these two Base-cases. This is not the case for BC2, where the product price is 70% of the life cycle cost. From a consumer point of view, an increase in energy efficiency will be less visible for BC2, as the LCC will be reduced in a smaller proportion.

5.3.2. COMMERCIAL APPLIANCES USED IN RESTAURANTS

The same indicators for the two combi-steamer Base-cases are presented in Table 5-32.

Table 5-35: EcoReport outcomes of the LCC calculations for the two commercial Base-cases

	Base-case 4: Commercial electric combi-steamer		Base-case 5: Commercial gas combi-steamer	
Product price	11,900 €	*48%*	13,200 €	*62%*
Installation/ acquisition costs	200 €	*1%*	300 €	*1%*
Gas	0 €	*0%*	5,130 €	*24%*
Electricity	11,680 €	*47%*	1,652 €	*8%*
Water	401 €	*2%*	401 €	*2%*
Repair & maintenance costs	568 €	*2%*	730 €	*3%*
Total	**24,748 €**		**21,412 €**	

The two biggest costs are purchase and energy. While gas combi-steamers are more expensive to buy, over their lifetime of 10 years, they appear to be cheaper than their electric equivalent.

5.3.1. Commercial appliances used in bakeries

Table 5-36 presents the life cycle costs of the three bakery Base-cases, detailing the different cost items.

Table 5-36: EcoReport outcomes of the LCC calculations for the bakery Base-cases

	Base-case 6: In-store convection oven		Base-case 7: Electric deck oven		Base-case 8: Gas deck oven	
Product price	10,000 €	*39%*	35,000 €	*29%*	35,000 €	*44%*
Installation/ acquisition costs	400 €	*2%*	0 €	*0%*	0 €	*0%*
Gas	0 €	*0%*	0 €	*0%*	36,327 €	*45%*
Electricity	13,078 €	*51%*	81,508 €	*67%*	2,588 €	*3%*
Water			329 €	*0%*	329 €	*0%*
Repair & maintenance costs	2,104 €	*8%*	4,447 €	*4%*	5,930 €	*7%*
Total	**25,582 €**		**121,284 €**		**80,173 €**	

	Base-case 9: Commercial electric rack oven		Base-case 10: Commercial gas rack oven	
Product price	15,000 €	*14%*	15,000 €	*24%*
Installation/ acquisition costs	1,800 €	*2%*	2,000 €	*3%*
Gas	0 €	*0%*	33,814 €	*54%*
Electricity	89,617 €	*82%*	7,449 €	*12%*
Water	289 €	*0%*	289 €	*0%*
Repair & maintenance costs	2,960 €	*3%*	4,441 €	*7%*
Total	**109,666 €**		**62,993 €**	

There are few similarities between the five Base-cases. The gas ovens are much cheaper to run that their electric equivalent. Energy represents about 50% of the cost of a gas oven, while it represents 67% of oven life cycle cost for the electric deck and 82% for the electric rack oven.

5.4. 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. As the Base-cases defined for the Lot 22 study were representative of average products in stock, the Overall Improvement ratio was defined to the value 1.

5.4.1. DOMESTIC APPLIANCES

5.4.1.1. LIFE CYCLE ENVIRONMENTAL IMPACTS

Table 5-37 shows the total environmental impacts of all domestic products in operation in EU-27 in 2008, based on the extrapolation of the Base-cases impacts (all ovens have the same impacts as the Base-case of their category). These figures come from the EcoReport tool by multiplying the individual environmental impacts of a Base-case with the stock of this Base-case in 2008.

Table 5-37: Environmental impacts of the EU-27 stock in 2008 for all Base-cases

Environmental Impact	Base-case 1	Base-case 2	Base-case 3	Total domestic
Total Energy (GER) (in PJ)	266	41	136	442
of which electricity (in PJ)	24.1	0.1	11.3	35.5
Water process (in million m^3)	18.9	0.5	12.0	31.4
Waste,non-hazardous/landfill (in kt)	638	133	923	1694
Waste, hazardous/ incinerated *(in kt)*	6.7	0.1	7.5	14.2
Emissions to air				
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	12	2	6	21
Acidification, emissions (in kt SO_2 eq.)	69	2	42	113
Volatile Organic Compounds (VOC) (in kt)	0.19	0.06	0.14	0.39
Persistent Organic Pollutants (POP) (in g i-Teq.)	6	2	4	12
Heavy Metals emissions to the air (in ton Ni eq.)	7	1	6	14
PAHs (in ton Ni eq.)	0.9	0.3	1.6	2.7

Environmental Impact	Base-case 1	Base-case 2	Base-case 3	Total domestic
Particulate Matter (PM, dust) (in kt)	13	4	9	26
Emissions to water				
Heavy Metals emissions to water (in ton Hg/20)	3.8	0.3	3.6	7.7
Eutrophication (in kt PO_4)	0.07	0.01	0.09	0.17

Summary of environmental impacts of Base-cases as a percentage of total impact are presented in Figure 5-11.

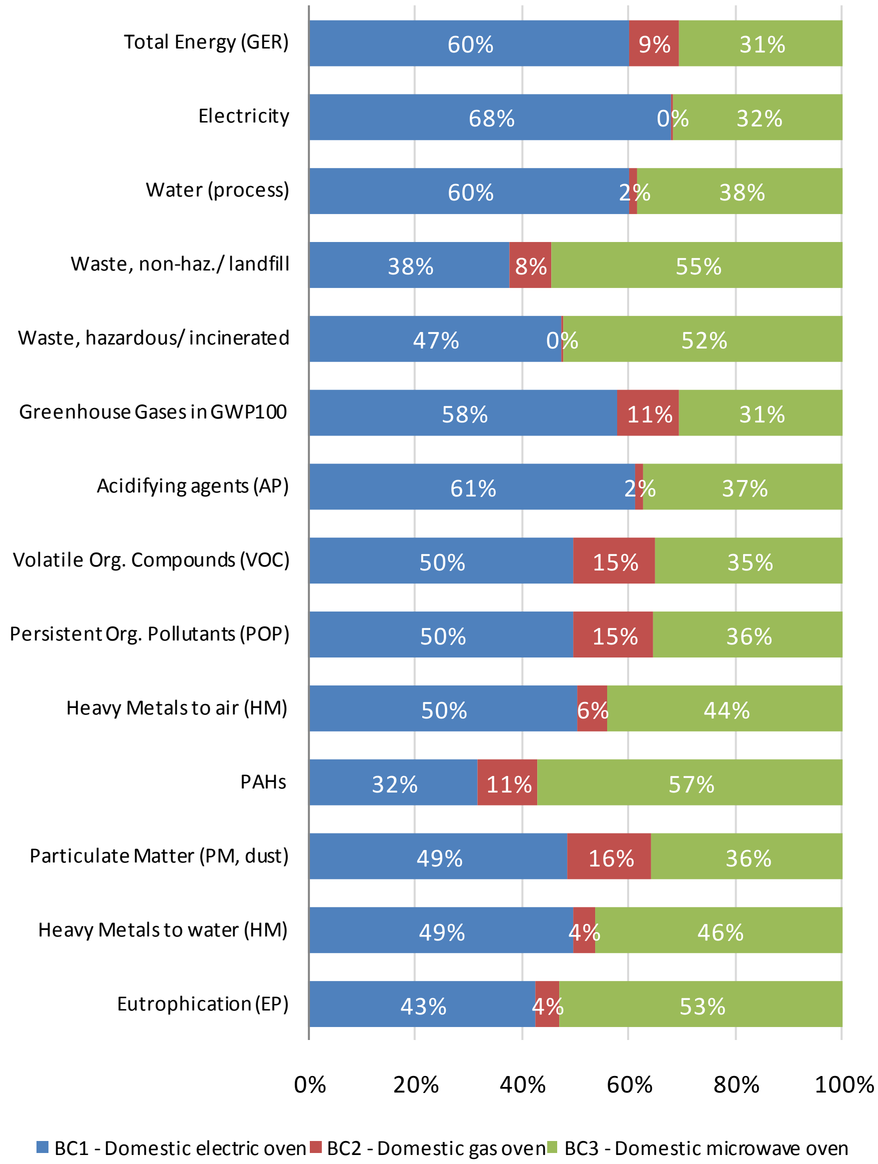

Figure 5-11: Base-cases' share of the environmental impacts of the 2008 domestic stock

Domestic electric ovens contribute to the biggest share in most of the indicators calculated by EcoReport. This is easily explained by the fact that this type of appliances has the biggest stock of products.

5.4.1.2. Life Cycle Costs

Regarding the total consumer expenditure in 2008 related to domestic electric and gas ovens, about 40% of the total costs are due to energy consumption. This percentage is higher for microwave ovens (68%). The distribution per Base-case is given in Figure 5-12 and details on consumer expenditure are presented in Table 5-38. Electricity and gas were grouped together under the category “energy”.

Table 5-38: Total Annual Consumer expenditure in EU-27 in 2007 for domestic Base-cases

	Base-case 1: Domestic electric oven	Base-case 2: Domestic gas oven	Base-case 3: Domestic microwave oven	Total domestic
EU-27 stocks (in mln units)	145	50	125	320
Share of the EU-27 sales	*45%*	*16%*	*39%*	
Product Price (in mln €)	4,495	730	1,623	6,848
Energy (in mln €)	3,950	541	1,790	6,281
Total (in mln €)	8,445	1,272	3,413	14,314
Share of the Total Annual Consumer Expenditure	*64%*	*10%*	*26%*	

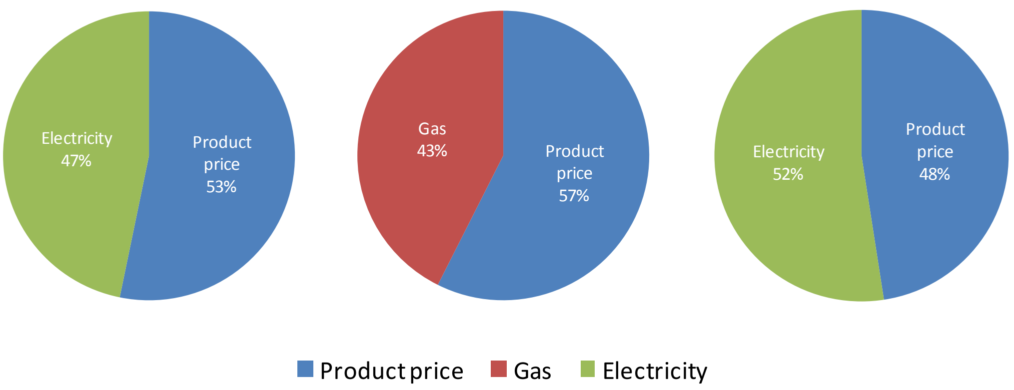

Figure 5-12: Base-cases’ share of the life cycle cost (BC1: left, BC2: middle, BC3: right)

5.4.2. COMMERCIAL APPLIANCES USED IN RESTAURANT

5.4.2.1. LIFE CYCLE ENVIRONMENTAL IMPACTS

Table 5-39 shows the total environmental impacts of all commercial ovens used in restaurants in operation in EU-27 in 2007, based on the extrapolation of the Base-cases impacts (all ovens have the same impacts as the Base-case of their category). These figures come from the EcoReport tool by multiplying the individual environmental impacts of a Base-case with the stock of this Base-case in 2007.

Table 5-39: Environmental impacts of the EU-27 stock in 2007 for restaurant Base-cases

Environmental Impact	Base-case 4	Base-case 5	Total Commercial
Total Energy (GER) (in PJ)	39.6	4.9	44.5
of which electricity (in TWh)	3.7	0.1	3.8
Water process (in million m^3)	10.5	1.7	12.1
Waste,non-hazardous/landfill (in kt)	52.4	3.1	55.5
Waste, hazardous/ incinerated (in kt)	1.3	0.1	1.4
Emissions to air			
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	1.8	0.3	2.0
Acidification, emissions (in kt SO_2 eq.)	10.4	0.4	10.8
Volatile Organic Compounds (VOC) (in kt)	0.019	0.004	0.023
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.30	0.02	0.32
Heavy Metals to air (in ton Ni eq.)	1.3	0.2	1.5
PAHs (in ton Ni eq.)	0.12	0.01	0.13
Particulate Matter (PM, dust) (in kt)	1.0	0.2	1.2
Emissions to water			
Heavy Metals to water (in ton Hg/20)	0.7	0.1	0.8
Eutrophication (in kt PO_4)	0.012	0.003	0.015

Summary of environmental impacts of Base-cases as a percentage of total impact are presented in Figure 5-13.

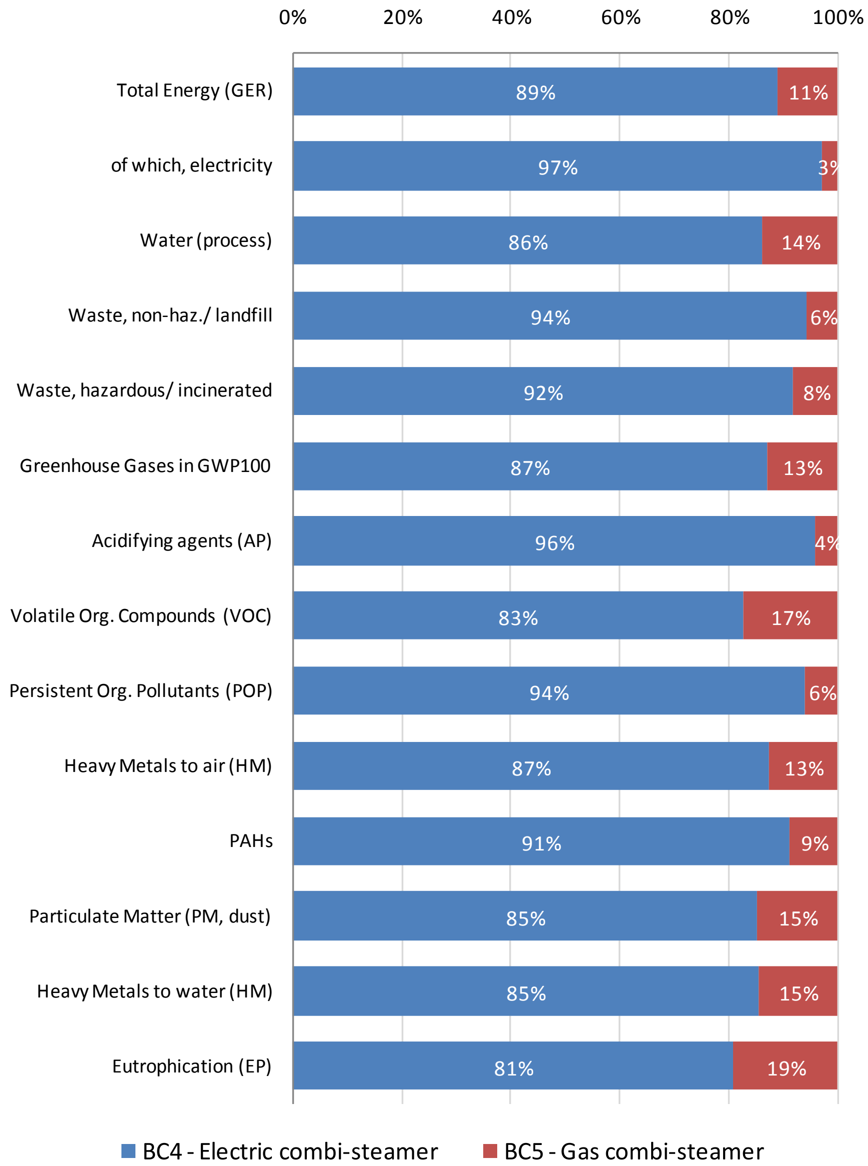

Figure 5-13: Base-cases' share of the environmental impacts of the 2007 stock of combi-steamers

5.4.2.2. Life Cycle Costs

Regarding the total consumer expenditure in 2007, the distribution per Base-case is given in Figure 5-12 and details are presented in Table 5-40.

Table 5-40: Total Annual Consumer expenditure in EU-27 in 2007 for combi-steamers

	Base-case 4 Commercial electric combi-steamer	Base-case 5 Commercial gas combi-steamer	Total Restaurant
EU-27 stock (2007) (in units)	400,000	80,000	480,000
Share of the EU-27 stock	*83.3%*	*16.7%*	
Product Price (in mln €)	488	121	609
Installation (in mln €)	8	3	11
Gas (in mln €)	0	51	51
Electricity (in mln €)	576	16	592
Water (in mln €)	20	4	24
Maintenance (in mln €)	28	7	35
Total (in mln €)	1,120	202	1,322
Share of the Total Annual Consumer Expenditure	*84.7%*	*15.3%*	

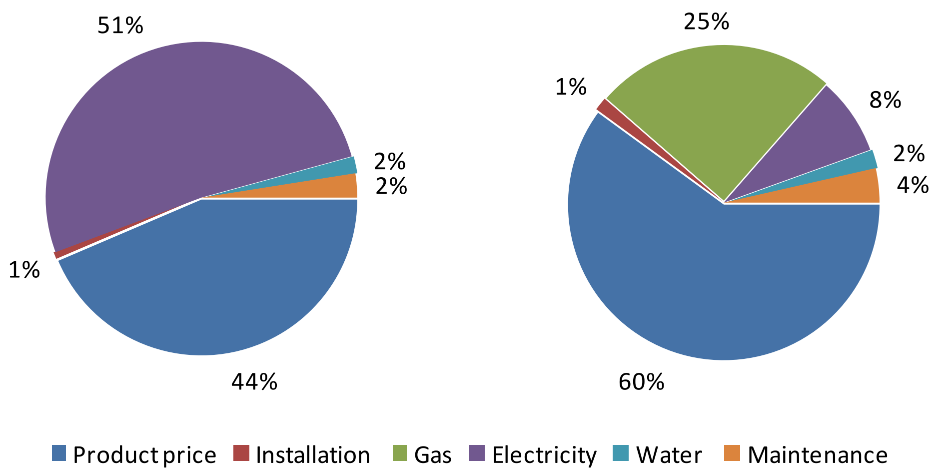

Figure 5-14: Share of the total annual consumer expenditure in EU-27 for Base-case 4 (left) and Base-case 5 (right)

5.4.3. Commercial appliances used in bakeries

This section presents the impacts of bakery ovens at the EU level. The environmental impacts and the consumer expenditure are presented aggregated, taking into account the stock. The year of reference for bakery ovens is 2006, as the market figures were available only for this year.

5.4.3.1. Life Cycle Environmental Impacts

Table 5-41 presents the environmental impacts of bakery ovens at the EU level, for 2006.

Table 5-41: Total Annual Consumer expenditure in EU-27 in 2006 for bakery ovens

Indicator	BC6	BC7	BC8	BC9	BC10	Total bakery
Total Energy (GER) (in PJ)	11.2	26.6	11.0	22.6	18.1	89.4
of which electricity (in TWh)	1.1	2.5	0.1	2.1	0.3	6.1
Water process (in million m^3)	1.0	2.5	0.6	2.0	1.0	7.0
Waste,non-hazardous/landfill (in kt)	13.7	37.9	4.3	29.0	8.1	92.9
Waste, hazardous/ incinerated (in kt)	0.26	0.67	0.04	0.54	0.11	1.63
Emissions (Air)						
Greenhouse Gases in GWP100 (in Mt CO_2 eq.)	0.5	1.2	0.6	1.0	1.0	4.2
Acidification, emissions (in kt SO_2 eq.)	2.9	6.9	0.4	5.9	1.2	17.2
Volatile Organic Compounds (VOC) (in kt)	0.005	0.012	0.009	0.010	0.014	0.050
Persistent Organic Pollutants (POP) (in g i-Teq.)	0.08	0.26	0.05	0.18	0.07	0.64
Heavy Metals to air (in ton Ni eq.)	0.21	0.71	0.14	0.59	0.37	2.02
PAHs (in ton Ni eq.)	0.03	0.06	0.01	0.05	0.02	0.16
Particulate Matter (PM, dust) (in kt)	0.2	0.5	0.2	0.3	0.3	1.5
Emissions (Water)						
Heavy Metals to water (in ton Hg/20)	0.1	0.3	0.1	0.3	0.2	0.9
Eutrophication (in kt PO_4)	0.000	0.005	0.002	0.004	0.005	0.016

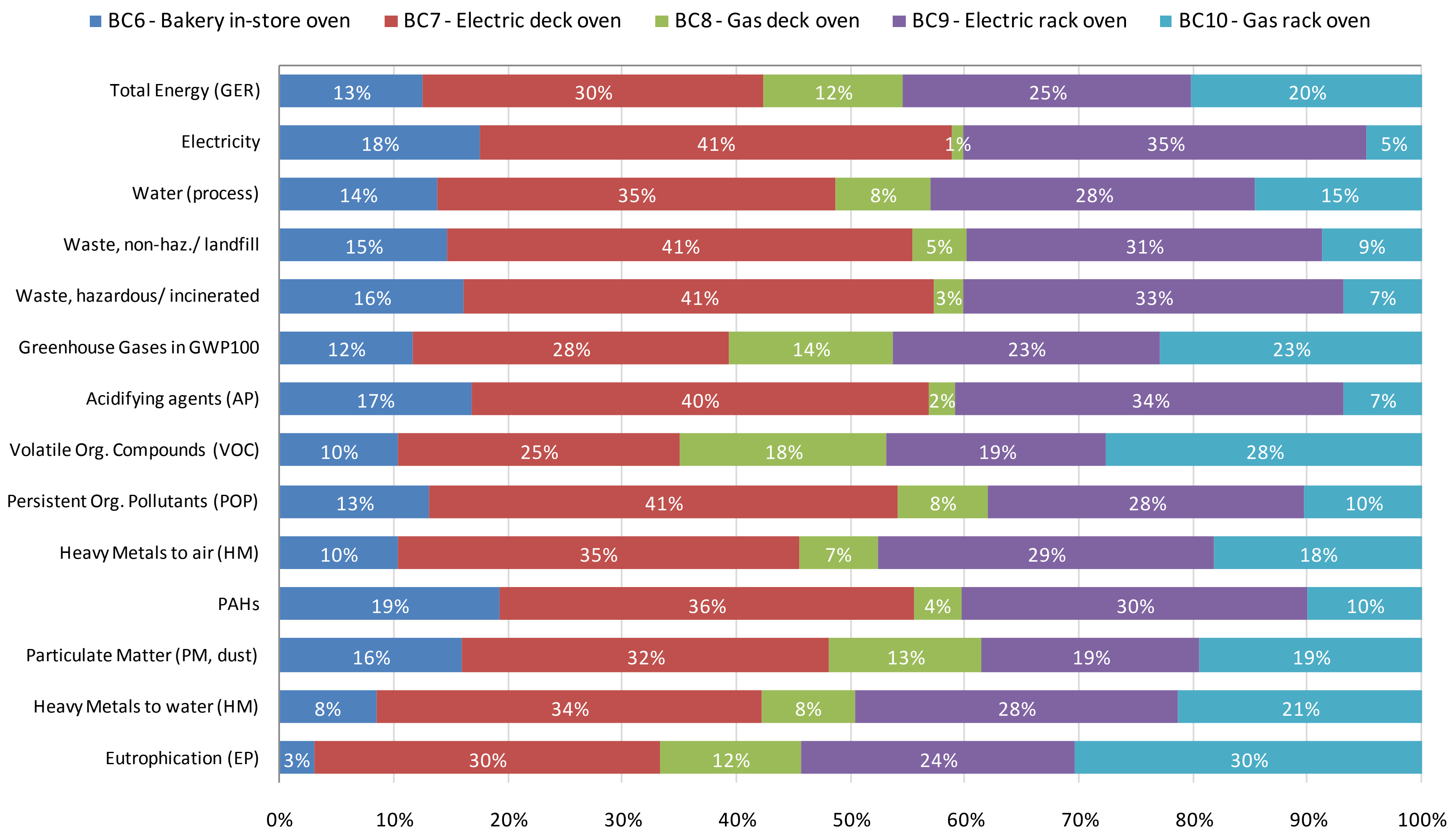

Figure 5-15: Base-cases' share of the environmental impacts of the 2006 stock of bakery ovens

Figure 5-15 presents the share of each Base-case for the 14 indicators measured by EcoReport. The electric deck oven is clearly the one with the biggest impact (from 21% of PM emissions to 41% of Eutrophication).

5.4.3.2. Life Cycle Costs

Table 5-42: Total Annual Consumer expenditure in EU-27 in 2006

	BC6	BC7	BC8	BC9	BC10	Total bakery
EU-27 stock (2007) (in units)	85,000	53,000	43,000	30,000	45,000	256,000
Share of the EU-27 stock	*33%*	*21%*	*17%*	*12%*	*18%*	
Product Price (in mln €)	106	158	67	45	68	443
Installation (in mln €)	4	0	0	5	9	19
Gas (in mln €)	0	0	140	0	204	345
Electricity (in mln €)	165	389	10	331	45	940
Water (in mln €)	0	2	1	1	2	6
Maintenance (in mln €)	27	21	23	11	25	106
Total (in mln €)	302	569	241	394	352	1,858
Share of the Total Annual Consumer Expenditure	16.3%	30.6%	13.0%	21.2%	19.0%	

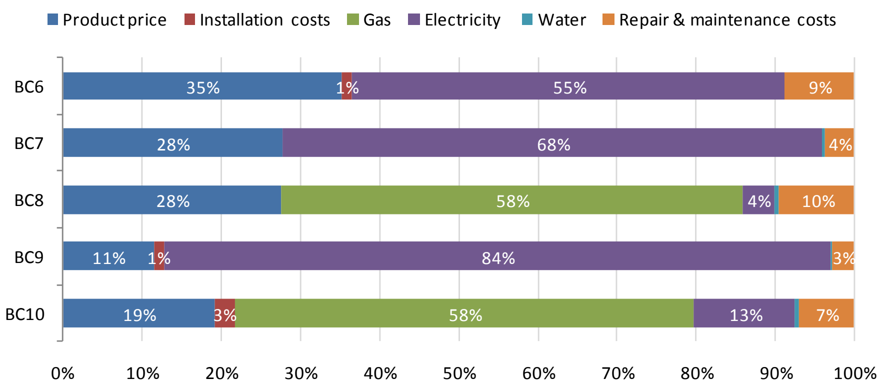

Figure 5-16: Share of the total annual consumer expenditure in EU-27 for bakery ovens

5.4.4. Impacts of domestic and commercial appliances at the EU level

As ovens used in households, in restaurants and in bakery are designed for different market, and do not compete with each other, they were assessed separately. However, it is interesting to compare the energy consumed at the EU level by all oven types.

Figure 5-17 presents the share of each Base-case in the total primary energy consumed. More than half of this consumption is due to the domestic electric oven. The commercial sector represents only 18% of the total consumption. Oven powered with gas (Base-cases 2, 5, 8 and 10) have a much smaller share in the energy

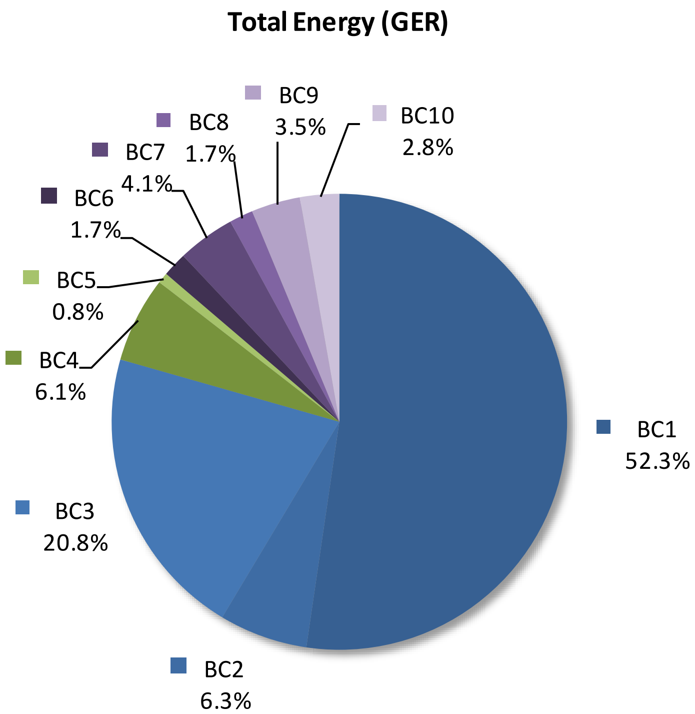

Figure 5-17: Share of the overall EU primary energy consumption for Lot 22 Base-cases

It can seem surprising that more energy is consumed by the bakery ovens than by restaurant ovens. However, this represents only the energy consumption of combi-steamers. Other types of cooking appliances are used in restaurants. Hobs, grills and fry-tops are covered by the ENER Lot 23 study. Other type of appliances such as boiling kettles and fryers are also used to cook a significant amount of food. Altogether, the energy consumed for cooking in restaurants should be higher than the energy used in bakeries.

5.5. EU-27 TOTAL SYSTEM IMPACT

When operating, ovens produce heat which is partially transferred to the room where it is located. 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 oven will complement the heating system. On the contrary, if the room needs to be cooled, operating an oven will require additional cooling.
- The energy source of the oven and of the heating system: electricity needs to be produced from a primary energy, generally with low efficiency. If both appliances are using the same energy source, there will be no noticeable difference in the energy efficiency. However, if they use different energy efficiency, the global efficiency of heating will be modified.

According to the MTP study[9] on the "heat replacement effect" (the contribution to heating made by lighting and appliances in heated living space), only 18% of the heat produced by an oven throughout a year is actually heating the building. Moreover, this figure is valid only for UK, where it is estimated that building heating is required during 41% of the year. In Member States where this percentage is lower, the heat replacement ratio is even lower.

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

5.6. CONCLUSIONS

The environmental impact assessments carried out with the EcoReport tool shows that there are some common observations to all domestic Base-cases: the use phase is by far the most impacting stage of the life cycle in terms of energy consumption and greenhouse gases emissions. The production phase has a significant contribution to the following impacts: generation of non-hazardous waste, heavy metals emissions to air and water and eutrophication. Finally, the end-of-life phase is not dominating any category. However, electricity generation is contributing to an important part of the global environmental impacts of the electric appliances, and so the impacts of the gas oven are different.

The analysis of the improvement potential in Task 7 will focus on technologies that reduce the energy consumption, and also on alternative material reducing environmental impacts. Task 6 will examine the improvement options of ovens considered as best available technologies, in an attempt to improve upon the Base-cases.

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[9] MTP report BNXS05 version 9.0 updated 15th March 2010.