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# Preparatory study of ecodesign and energy labelling measures for High Pressure Cleaners



*1st draft report*
*Tasks 5-7*

Rodríguez-Quintero, R. (JRC)

Paraskevas, D. (JRC)

Viegand, J. (VM)

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**Contact information** [optional element]
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# Table of Acronyms

| | |
|---|---|
| GHG | Greenhouse gas |
| MEErP | Methodology for Ecodesign of Energy-related Products |
| NACE | Nomenclature used in the European Union |
| HPC | High Pressure Cleaner |
| IECEE CB | International Electrotechnical Commission Electrical Engineering Certification Body |
| EN | European Norm |
| ISO | International Standardization for Organisation |
| IEC | International Electrotechnical Commission |
| EMC | Electromagnetic compatibility standards |
| ANSI | American National Standards Institute |
| CPC | Cleaning Performance Program |
| LCA | Life Cycle Assessment |
| LCC | Life Cycle Cost |

# 5 Environment and economics of base cases

## 5.1 Introduction

### 5.1.1 Aim of task 5

In accordance with the MEErP methodology, Task 5 quantifies and presents per base case the results of the environmental impact assessment and the Life Cycle Costs (LCC) for consumer per unit and at EU level; as well as the overall energy-water consumption during use phase and Greenhouse Gas (GHG) emission at EU level

The calculations are made with the European Commission's EcoModelling Framework Tool and the EcoReport Tool 2014 Version 3.0. All calculations are made for the defined 6 Base Cases (BC) as presented in Task 1. The EcoModelling tool is a calculation package used for the sales and stock estimations in Task 2, for the Business As Usual (BAU) scenario presented in this Task 5 and for the design option and policy measures scenarios presented in Task 6 and 7, respectively.

The EcoReport tool calculates the life cycle environmental impact for a reference year i.e. for the production, distribution, use and end-of-life treatment considering the bill of materials (BOM) assessed in Task 4 and the direct and indirect energy and resource consumption assessed in Task 3. The outputs from the EcoReport Tool are then imported to the EcoModelling Framework Tool and quantify the life cycle environmental impacts at EU level.

## 5.2 Product-specific inputs

### 5.2.1 Definition of Base Cases

The Base Cases have been defined by the overall scope and by the various product categories identified in Task 1 combined with the market analysis of Task 2.

The following base cases have been selected:

- BC1: Domestic HPC cold water electric motor
- BC2: Professional HPC cold water electric motor 1 phase
- BC3: Professional HPC cold water electric motor 3 phases
- BC4: Professional HPC cold water combustion motor
- BC5: Professional HPC hot water (fuel burner) electric motor 1 phase
- BC6: Professional HPC hot water (fuel burner) electric motor 3 phases

The selected base cases represents near 100% of the domestic and the professional HPC markets and allows a thorough analysis as professional HPC are split into 5 different BC. For each base case, data from average models within each base case already defined the previous tasks are used as input for the calculations as presented in Task 3. The average model data are based on collection of technical data from the manufacturers' specifications on their web sites and from the instruction manuals.

### 5.2.2 Market data

The market data that were used are presented in Task 2 and are based on the sales data and the calculated, from EcoModelling Tool stocks considering lifetime Weibull distribution for domestic and professional HPC.

Additional market data are defined and/or calculated in Task 5:

- Purchase prices are based on current purchase prices in Task 2 and graduated over the period by use of a learning curve in the model for the manufacturer production price.

- Energy prices (electricity, natural gas and gas oil) are from PRIMES 2016[1] from 2005-2050 in five-years intervals and interpolated in each interval to have annual prices. Before 2005, prices are de-escalated with approximately 2%/year.
- Water prices are extracted from the washing machines and dishwasher study (4.08 EUR/m3 incl. VAT for 2015).
- Average detergent price is set at 2.5 EUR/litre for the domestic base case and 0.4 EUR/litre for the professional base cases.
- Repair and maintenance cost over the lifetime for all professional products are assumed to sum up to approximately the same level as the purchase price in 2017 of one unit. This would include change of water pump, seals, minor component, and some maintenance. No repair and maintenance costs are assumed for the domestic types because as described in Task 2 domestic HPCs have very low reparability potentials.

### 5.2.3 Annual resources consumption and emissions

The annual resource consumption data come from Task 3 - mainly the Task 3 report Tables 21-25 - and based in the assumptions established in Task 3.

Emissions and environmental impact at EU level are calculated in the MEErP EcoReport 2014 tool and the EcoModelling Framework Tool, respectively.

### 5.2.4 Bill Of Material and end of life

The data for the production, distribution and end-of-life including the product weight and Bill of Material (BOM) come from Task 4 – Table 40, the underlying detailed data and data in the text - and the assumptions established in this task. The BOMS are based on total product weight and an assumed distribution on materials used in production of the HPCs.

Professional units are used in a high frequency and are designed to optimise durability and reparability. This results in a little contribution of the production phase (see section 5.3.2), and therefore, there is little room of improvement in that area and no design options are envisaged. For this reason and in order to simplify the modelling of the five professional bases cases, BOM for the professional BCs is based on the average of BC2 and BC3 (professional cold water units), i.e. not including BOM for heating unit, for combustion motor and for heavier HPCs. The environmental impact for each professional base case is therefore based on the production material content for BC2/BC3 and on the consumption of energy, water and detergent for the specific base case.

## 5.3 Base Case Environmental Impact Assessment

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for

- Raw materials use and manufacturing,
- Distribution,
- Use phase
- End-of-life phase.

### 5.3.1 Domestic high pressure cleaner (BC 1)

Table 1 shows the material consumption of a domestic high pressure cleaner over the whole life cycle of 9.5 years. The material consumption during the production is

[1] These are based on the PRIMES model and delivered by DG Energy.

equivalent to the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for spare parts replacement, and the sum of detergents (= auxiliaries) used over the life cycle. The material consumption during the End-of-Life phase is split in disposal, recycling and the stock. Stock is meant to keep the mass balance, since the mass discarded seldom equals the mass of new products sold.

Table 1. Life cycle material consumption of a domestic high pressure cleaner

| **Life Cycle phases** | | **Production** | **Use** | **End-of-Life** | | |
|---|---|---|---|---|---|---|
| **Materials** | unit | Total | | Disposal | Recycl. | Stock |
| Bulk Plastics | g | 5 257 | 53 | 2 382 | 1 949 | 978 |
| TecPlastics | g | 0 | 0 | 0 | 0 | 0 |
| Ferro | g | 3 880 | 39 | 160 | 3 037 | 722 |
| Non-ferro | g | 4 012 | 40 | 165 | 3 141 | 747 |
| Coating | g | 0 | 0 | 0 | 0 | 0 |
| Electronics | g | 30 | 0 | 12 | 13 | 6 |
| Misc. | g | 1 500 | 15 | 420 | 816 | 279 |
| Extra | g | 0 | 0 | 0 | 0 | 0 |
| Auxiliaries | g | 0 | 199 887 | 199 887 | 0 | 0 |
| Refrigerant | g | 0 | 0 | 0 | 0 | 0 |
| **Total weight** | g | 14 680 | 200 034 | 203 027 | 8 955 | 2 731 |

Table 2 shows the environmental impacts of a domestic high pressure cleaner over the whole life cycle of 9.5 years, and according to the assumptions made on user behaviour described in Task 3.

The results are also shown in

, Figure 2 and Figure 3 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 2. Life cycle environmental impacts of a domestic high pressure cleaner

| Life Cycle phases | Unit | PRODUCTION | | | DISTRIBUTION | USE | END-OF-LIFE | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| Resources Use and Emissions | | Material | Manuf. | **Total** | | | Disposal | Recycl. | |
| **Other Resources & Waste** | | | | | | | debet | credit | |
| Total Energy (GER) | MJ | 1 486 | 295 | 1 782 | 230 | 7 619 | 469 | -310 | **9 790** |
| of which, electricity (in primary MJ) | MJ | 285 | 176 | 461 | 0 | 1 065 | 0 | -45 | **1 481** |
| Water (process) | ltr | 41 | 3 | 44 | 0 | 26 574 | 0 | -3 | **26 615** |
| Water (cooling) | ltr | 736 | 84 | 819 | 0 | 55 | 0 | -48 | **826** |
| Waste, non-haz./ landfill | g | 6 578 | 917 | 7 495 | 166 | 8 029 | 1 779 | -1 924 | **15 545** |
| Waste, hazardous/ incinerated | g | 45 | 0 | 45 | 3 | 165 | 0 | -4 | **209** |
| **Emissions (Air)** | | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 74 | 16 | 91 | 16 | 333 | 2 | -17 | **424** |
| Acidification, emissions | g SO2 eq. | 854 | 71 | 925 | 48 | 1 859 | 17 | -235 | **2 615** |
| Volatile Organic Compounds (VOC) | g | 3 | 0 | 3 | 2 | 26 | 0 | -1 | **31** |
| Persistent Organic Pollutants (POP) | ng i-Teq | 99 | 0 | 99 | 1 | 45 | 0 | -31 | **115** |
| Heavy Metals | mg Ni eq. | 136 | 0 | 136 | 8 | 12 | 0 | -40 | **116** |
| PAHs | mg Ni eq. | 286 | 0 | 286 | 7 | 18 | 0 | -73 | **238** |
| Particulate Matter (PM, dust) | g | 79 | 11 | 91 | 342 | 40 | 4 | -22 | **456** |
| **Emissions (Water)** | | | | | | | | | |
| Heavy Metals | mg Hg/20 | 344 | 0 | 344 | 0 | 49 | 1 | -90 | **304** |
| Eutrophication | g PO4 | 3 | 0 | 4 | 0 | 10 714 | 3 478 | 0 | **14 196** |

Figure 1. Contribution of different life cycle phases to other resources and waste of a domestic high pressure cleaner

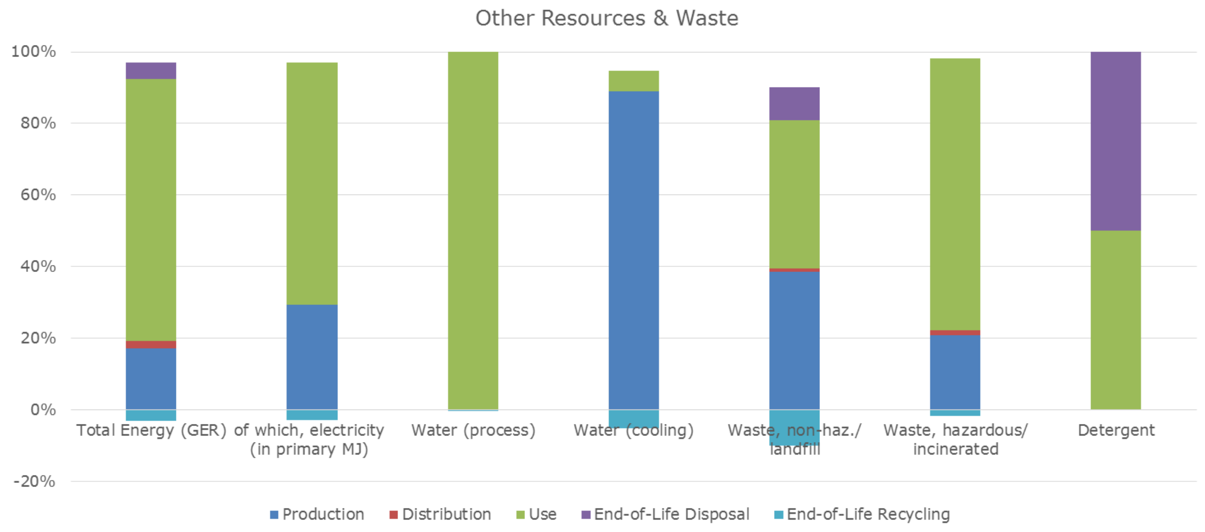



Figure 2. Contribution of different life cycle phases to emissions to air of a domestic high pressure cleaner

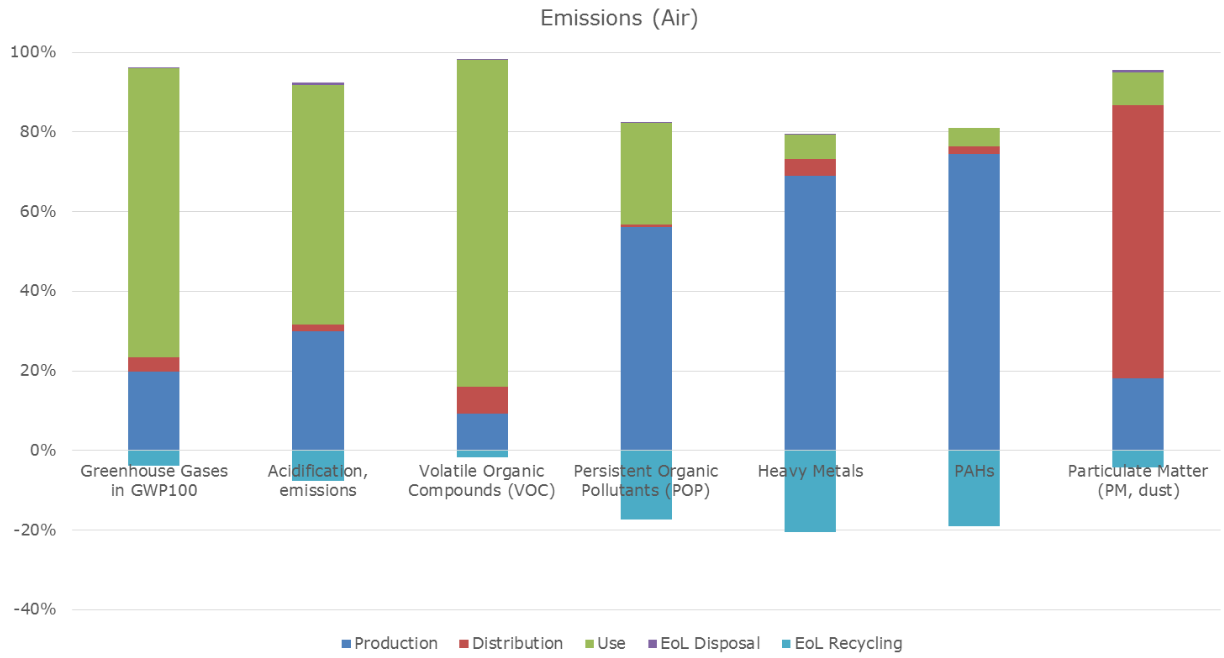
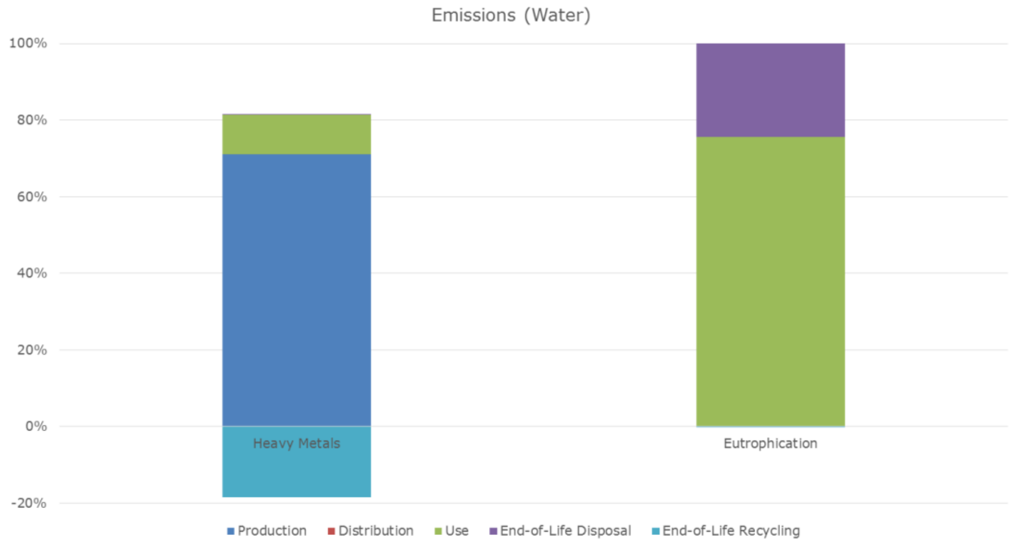


Figure 3. Contribution of different life cycle phases to emissions to water of a domestic high pressure cleaner




shows that the use phase clearly dominates the consumption of energy (>70%) and water (>95% of water process) and the generation of waste (especially hazardous/incinerated waste) along the life cycle. Process water is due to the consumption of water by use of the machine for cleaning, and it is one of the main resources, together with the consumption of electricity.

As can be observed in Figure 2 and Figure 3, the use phase is also dominant for the four impacts categories: global warming potential (GWP100) (≈ 80%), acidification potential (AP) (≈ 70%), volatile organic compounds (VOC) (≈ 90%) and eutrophication potential (EP) (≈80%). For persistent organic pollutants (POP), heavy metals to air (HM air), polycyclic aromatic hydrocarbons (PAHs), particulate materials (PM, dust) and heavy metals to water (HM water) the use phase has a contribution ranging from 5% to close to over 30% from the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase scores significantly in the following impacts categories: water for cooling (≈ 90%), non-hazardous waste (≈ 40%), POP (≈ 60%), HM air (≈ 70%), PAHs (≈ 75%), and PM (≈ 20%). The extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics is the main contributor to these impact categories.

The distribution phase is relevant only for the generation of VOCs (≈10%) and PM (>60%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories, as a result of the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials.

### 5.3.2 Professional high pressure cleaners (BC2 to BC6)

Table 3 shows the material consumption of an average professional unit along the whole life cycle. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair, which is more relevant for professional products than for domestic ones.

Table 3. Life cycle material consumption of a professional high pressure cleaner

| **Life Cycle phases** | | **PRODUCTION** | **USE** | **END-OF-LIFE** | | |
|---|---|---|---|---|---|---|
| Resources Use | | **Total** | | Disposal | Recycl. | Stock |
| Materials | unit | | | | | |
| Bulk Plastics | g | 18 502 | 185 | 9 423 | 7 710 | 1 554 |
| TecPlastics | g | 0 | 0 | 0 | 0 | 0 |
| Ferro | g | 34 476 | 345 | 1 596 | 30 329 | 2 896 |
| Non-ferro | g | 18 764 | 188 | 869 | 16 506 | 1 576 |
| Coating | g | 0 | 0 | 0 | 0 | 0 |
| Electronics | g | 104 | 1 | 47 | 49 | 9 |
| Misc. | g | 5 191 | 52 | 1 634 | 3 172 | 436 |
| Extra | g | 0 | 0 | 0 | 0 | 0 |
| Auxiliaries | g | 0 | 4 595 900 | 4 595 900 | 0 | 0 |
| Refrigerant | g | 0 | 0 | 0 | 0 | 0 |
| **Total weight** | g | 77 037 | 4 596 671 | 4 609 470 | 57 766 | 6 471 |

***BC 2 and BC 5: professional high pressure cleaners single-phase***

Table 4 shows the environmental impacts of a professional cold water high pressure cleaner over the whole life cycle according to the assumptions made on user behaviour described in Task 3. The results clearly show the main difference between domestic and professional products in terms of frequency of use.

As for the domestic base case, the results are also shown Figure 4 and Figure 5 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. These relative contributions are very similar among the different professional base cases, and therefore, they will only be analysed in this section.

Table 4. Life cycle environmental impacts of a professional single phase cold water high pressure cleaner

| **Life Cycle phases -->** | **Unit** | **PRODUCTION** | | | **DISTRIBUTION** | **USE** | **END-OF-LIFE** | | **TOTAL** |
|---|---|---|---|---|---|---|---|---|---|
| Resources Use & Emissions | | Material | Manuf. | **Total** | | | Disposal | Recycl. | |
| **Other Resources & Waste** | | | | | | | debet | credit | |
| Total Energy (GER) | MJ | 6 713 | 1 358 | 8 071 | 710 | 208 875 | 10 505 | -1 750 | **226 412** |
| of which, electricity (in primary MJ) | MJ | 1 024 | 810 | 1 834 | 1 | 54 793 | 0 | -189 | **56 439** |
| Water (process) | ltr | 153 | 13 | 167 | 0 | 1 161 943 | 0 | -15 | **1 162 095** |
| Water (cooling) | ltr | 2 618 | 386 | 3 003 | 0 | 2 461 | 0 | -198 | **5 266** |
| Waste, non-haz./ landfill | g | 52 754 | 4 225 | 56 980 | 406 | 199 277 | 39 798 | -18 021 | **278 440** |
| Waste, hazardous/ incinerated | g | 159 | 0 | 159 | 8 | 4 255 | 0 | -15 | **4 407** |
| **Emissions (Air)** | | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 359 | 76 | 435 | 47 | 9 145 | 34 | -102 | **9 558** |
| Acidification, emissions | g SO2 eq. | 3 334 | 327 | 3 661 | 142 | 48 363 | 380 | -1 044 | **51 502** |
| Volatile Organic Compounds (VOC) | g | 13 | 0 | 13 | 10 | 1 284 | 0 | -3 | **1 305** |
| Persistent Organic Pollutants (POP) | ng i-Teq | 800 | 0 | 800 | 2 | 1 100 | 9 | -280 | **1 630** |
| Heavy Metals | mg Ni eq. | 532 | 0 | 532 | 21 | 559 | 2 | -180 | **935** |
| PAHs | mg Ni eq. | 1 498 | 1 | 1 499 | 25 | 433 | 0 | -462 | **1 495** |
| Particulate Matter (dust) | g | 486 | 51 | 537 | 1 710 | 1 035 | 78 | -158 | **3 202** |
| **Emissions (Water)** | | | | | | | | | |
| Heavy Metals | mg Hg/20 | 1 398 | 0 | 1 398 | 1 | 1 198 | 7 | -423 | **2 181** |
| Eutrophication | g PO4 | 13 | 1 | 14 | 0 | 246 355 | 79 961 | -2 | **326 327** |

Figure 4. Contribution of different life cycle phases to other resources and waste of a professional high pressure cleaner

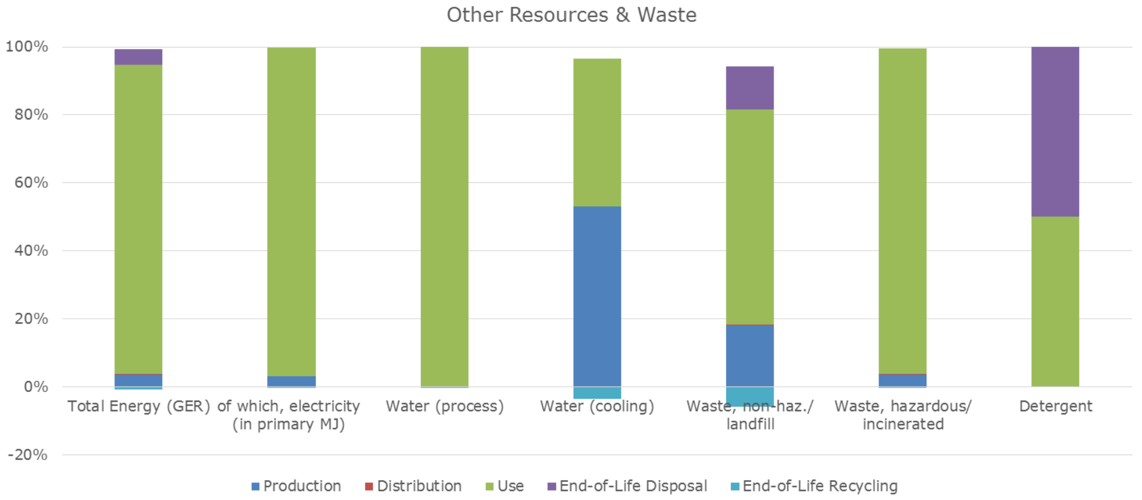



Figure 5. Contribution of different life cycle phases to emissions to air of a professional high pressure cleaner

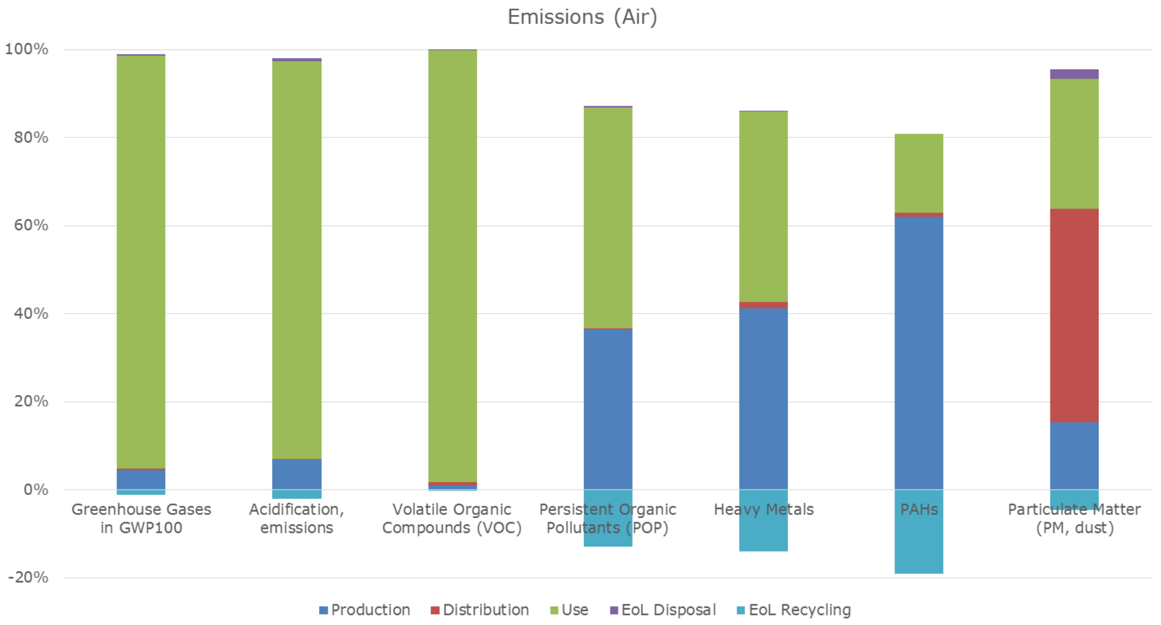


Figure 4 shows that the use phase is the main contributor to the consumption of energy (>85%) and water (>95% of water process and 40% water cooling) and the generation of waste (especially hazardous/incinerated waste) along the life cycle. Regarding the emissions to air and water (Figure 5), the use phase is also dominant for the four impacts categories: global warming potential (GWP100) and acidification potential (AP) (≈ 95%). For the rest of impact categories the use phase also contributes from 20 to 50%. The percentages are higher than domestic units, due to the larger lifetime and more intensive use which reduce the impact of production.

The contribution of the production phase scores significantly in the following impacts categories: water for cooling (≈ 50%), non-hazardous waste (≈ 20%), POP (< 40%), HM air (≈ 40%), PAHs (≈ 60%), and PM (< 20%). The variation on the contribution of production is also due to the different pattern of use and larger lifetime.

Table 5 shows the environmental impacts of a professional hot water high pressure cleaner over the whole life cycle of 10 years, and according to the assumptions made on user behaviour described in Task 3. The main difference is due to the heating oil consumed by the boiler, which increases the total energy consumption at the use phase and reduces the share of electricity compared to the cold water unit (from 26% to 14%).

Table 5. Life cycle environmental impacts of a professional single phase hot water high pressure cleaner

| **Life Cycle phases** | | **PRODUCTION** | | | **DISTRBUTION** | **USE** | **END-OF-LIFE** | | **TOTAL** |
|---|---|---|---|---|---|---|---|---|---|
| Resources Use & Emissions | | Material | Manuf. | **Total** | | | Disposal | Recycl. | |
| **Other Resources & Waste** | | | | | | | debet | credit | |
| Total Energy (GER) | MJ | 6 713 | 1 358 | 8 071 | 710 | 282 989 | 9 010 | -1 750 | **299 030** |
| of which, electricity (in primary MJ) | MJ | 1 024 | 810 | 1 834 | 1 | 39 732 | 0 | -189 | **41 378** |
| Water (process) | ltr | 153 | 13 | 167 | 0 | 988 344 | 0 | -15 | **988 496** |
| Water (cooling) | ltr | 2 618 | 386 | 3 003 | 0 | 1 792 | 0 | -198 | **4 597** |
| Waste, non-haz./ landfill | g | 52 754 | 4 225 | 56 980 | 406 | 167 046 | 34 179 | -18 021 | **240 590** |
| Waste, hazardous/ incinerated | g | 159 | 0 | 159 | 8 | 3 531 | 0 | -15 | **3 683** |
| **Emissions (Air)** | | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 359 | 76 | 435 | 47 | 15 942 | 29 | -102 | **16 350** |
| Acidification, emissions | g SO2 eq. | 3 334 | 327 | 3 661 | 142 | 50 927 | 326 | -1 044 | **54 012** |
| Volatile Organic Compounds (VOC) | g | 13 | 0 | 13 | 10 | 1 086 | 0 | -3 | **1 107** |
| Persistent Organic Pollutants (POP) | ng i-Teq | 800 | 0 | 800 | 2 | 926 | 7 | -280 | **1 456** |
| Heavy Metals | mg Ni eq. | 532 | 0 | 532 | 21 | 407 | 2 | -180 | **782** |
| PAHs | mg Ni eq. | 1 498 | 1 | 1 499 | 25 | 362 | 0 | -462 | **1 424** |
| Particulate Matter (dust) | g | 486 | 51 | 537 | 1 710 | 1 042 | 67 | -158 | **3 198** |
| **Emissions (Water)** | | | | | | | | | |
| Heavy Metals | mg Hg/20 | 1 398 | 0 | 1 398 | 1 | 997 | 6 | -423 | **1 979** |
| Eutrophication | g PO4 | 13 | 1 | 14 | 0 | 211 002 | 68 487 | -2 | **279 501** |

***BC 3 and BC 6: professional high pressure cleaners three-phase***

Table 6 shows the environmental impacts of a professional cold water high pressure cleaner three-phase over the whole life cycle according to the assumptions made on user behaviour described in Task 3. The main difference is due to the higher power and flow, which results in an increase of energy and water consumption at the use phase.

Table 6: Life cycle environmental impacts of a professional three phase cold water high pressure cleaner

| **Life Cycle phases -->** | | **PRODUCTION** | | | **DISTRIBUTION** | **USE** | **END-OF-LIFE** | | **TOTAL** |
|---|---|---|---|---|---|---|---|---|---|
| Resources Use and Emissions | | Material | Manuf. | **Total** | | | Disposal | Recycl. | |
| **Other Resources & Waste** | | | | | | | debet | credit | |
| Total Energy (GER) | MJ | 6 713 | 1 358 | 8 071 | 710 | 208 875 | 10 505 | -1 750 | **226 412** |
| of which, electricity (in primary MJ) | MJ | 1 024 | 810 | 1 834 | 1 | 54 793 | 0 | -189 | **56 439** |
| Water (process) | ltr | 153 | 13 | 167 | 0 | 1 161 943 | 0 | -15 | **1 162 095** |
| Water (cooling) | ltr | 2 618 | 386 | 3 003 | 0 | 2 461 | 0 | -198 | **5 266** |
| Waste, non-haz./ landfill | g | 52 754 | 4 225 | 56 980 | 406 | 199 277 | 39 798 | -18 021 | **278 440** |
| Waste, hazardous/ incinerated | g | 159 | 0 | 159 | 8 | 4 255 | 0 | -15 | **4 407** |
| | | | | | | | | | |
| **Emissions (Air)** | | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 359 | 76 | 435 | 47 | 9 145 | 34 | -102 | **9 558** |
| Acidification, emissions | g SO2 eq. | 3 334 | 327 | 3 661 | 142 | 48 363 | 380 | -1 044 | **51 502** |
| Volatile Organic Compounds (VOC) | g | 13 | 0 | 13 | 10 | 1 284 | 0 | -3 | **1 305** |
| Persistent Organic Pollutants (POP) | ng i-Teq | 800 | 0 | 800 | 2 | 1 100 | 9 | -280 | **1 630** |
| Heavy Metals | mg Ni eq. | 532 | 0 | 532 | 21 | 559 | 2 | -180 | **935** |
| PAHs | mg Ni eq. | 1 498 | 1 | 1 499 | 25 | 433 | 0 | -462 | **1 495** |
| Particulate Matter (PM, dust) | g | 486 | 51 | 537 | 1 710 | 1 035 | 78 | -158 | **3 202** |
| **Emissions (Water)** | | | | | | | | | |
| Heavy Metals | mg Hg/20 | 1 398 | 0 | 1 398 | 1 | 2 323 | 11 | -423 | **3 310** |
| Eutrophication | g PO4 | 13 | 1 | 14 | 0 | 451 841 | 146 653 | -2 | **598 506** |

Table 7 shows the environmental impacts of a professional three phase hot water high pressure cleaner over the whole life cycle according to the assumptions made on user behaviour described in Task 3. The main difference is due to the heating oil consumed by the boiler, which increases the total energy consumption at the use phase and reduces the share of electricity compared to the cold water unit (from 26% to 14%).

Table 7. Life cycle environmental impacts of a professional three phase hot water high pressure cleaner

| **Life Cycle phases** | | **PRODUCTION** | | | **DISTRIBUTION** | **USE** | **END-OF-LIFE** | | **TOTAL** |
|---|---|---|---|---|---|---|---|---|---|
| Resources Use & Emissions | | Material | Manuf. | **Total** | | | Disposal | Recycl. | |
| **Other Resources & Waste** | | | | | | | debet | credit | |
| Total Energy (GER) | MJ | 6 713 | 1 358 | 8 071 | 710 | 597 782 | 18 764 | -1 750 | **623 578** |
| of which, electricity (in primary MJ) | MJ | 1 024 | 810 | 1 834 | 1 | 103 186 | 0 | -189 | **104 832** |
| Water (process) | ltr | 153 | 13 | 167 | 0 | 2 077 140 | 0 | -15 | **2 077 292** |
| Water (cooling) | ltr | 2 618 | 386 | 3 003 | 0 | 4 612 | 0 | -198 | **7 417** |
| Waste, non-haz./ landfill | g | 52 754 | 4 225 | 56 980 | 406 | 359 559 | 70 862 | -18 021 | **469 785** |
| Waste, hazardous/ incinerated | g | 159 | 0 | 159 | 8 | 7 708 | 0 | -15 | **7 860** |
| **Emissions (Air)** | | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 359 | 76 | 435 | 47 | 33 132 | 61 | -102 | **33 572** |
| Acidification, emissions | g SO2 eq. | 3 334 | 327 | 3 661 | 142 | 109 012 | 679 | -1 044 | **112 449** |
| Volatile Organic Compounds (VOC) | g | 13 | 0 | 13 | 10 | 2 702 | 0 | -3 | **2 722** |
| Persistent Organic Pollutants (POP) | ng i-Teq | 800 | 0 | 800 | 2 | 1 978 | 15 | -280 | **2 515** |
| Heavy Metals | mg Ni eq. | 532 | 0 | 532 | 21 | 1 049 | 3 | -180 | **1 425** |
| PAHs | mg Ni eq. | 1 498 | 1 | 1 499 | 25 | 787 | 0 | -462 | **1 849** |
| Particulate Matter (dust) | g | 486 | 51 | 537 | 1 710 | 2 233 | 136 | -158 | **4 458** |
| **Emissions (Water)** | | | | | | | | | |
| Heavy Metals | mg Hg/20 | 1 398 | 0 | 1 398 | 1 | 2 159 | 11 | -423 | **3 146** |
| Eutrophication | g PO4 | 13 | 1 | 14 | 0 | 441 894 | 143 426 | -2 | **585 331** |

***Base Case 4: professional high pressure cleaners combustion engine driven***

Table 8 shows the environmental impacts of a professional high pressure cleaner combustion engine driven over the whole life cycle according to the assumptions made on user behaviour described in Task 3. The main difference is due to the fuel consumed by the combustion engine that substitute the power consumed by the electric-driven units. This reduces the share of electricity compared to the cold water unit (from 26% to 1.6%). The energy consumption at the use phase is larger than the three-phase cold water unit, although the electrical unit is more powerful. This means that the energy transformation (heat into mechanical energy) carried out by the internal combustion engine is less efficient than the electricity production together with the electric motor.

Table 8. Life cycle environmental impacts of a professional combustion engine driven cold water high pressure cleaner

| **Life Cycle phases -->** | | **PRODUCTION** | | | **DISTRIBUTION** | **USE** | **END-OF-LIFE** | | **TOTAL** |
|---|---|---|---|---|---|---|---|---|---|
| Resources Use and Emissions | | Material | Manuf. | **Total** | | | Disposal | Recycl. | |
| **Other Resources & Waste** | | | | | | | debet | credit | |
| Total Energy (GER) | MJ | 6 713 | 1 358 | 8 071 | 710 | 418 691 | 13 329 | -1 750 | **439 051** |
| of which, electricity (in primary MJ) | MJ | 1 024 | 810 | 1 834 | 1 | 6 697 | 0 | -189 | **8 343** |
| Water (process) | ltr | 153 | 13 | 167 | 0 | 1 474 664 | 0 | -15 | **1 474 816** |
| Water (cooling) | ltr | 2 618 | 386 | 3 003 | 0 | 323 | 0 | -198 | **3 128** |
| Waste, non-haz./ landfill | g | 52 754 | 4 225 | 56 980 | 406 | 220 753 | 50 417 | -18 021 | **310 534** |
| Waste, hazardous/ incinerated | g | 159 | 0 | 159 | 8 | 4 415 | 0 | -15 | **4 567** |
| **Emissions (Air)** | | | | | | | | | |
| Greenhouse Gases in GWP100 | kg CO2 eq. | 359 | 76 | 435 | 47 | 25 230 | 43 | -102 | **25 653** |
| Acidification, emissions | g SO2 eq. | 3 334 | 327 | 3 661 | 142 | 70 463 | 482 | -1 044 | **73 704** |
| Volatile Organic Compounds (VOC) | g | 13 | 0 | 13 | 10 | 511 | 0 | -3 | **531** |
| Persistent Organic Pollutants (POP) | ng i-Teq | 800 | 0 | 800 | 2 | 1 249 | 11 | -280 | **1 782** |
| Heavy Metals | mg Ni eq. | 532 | 0 | 532 | 21 | 73 | 2 | -180 | **449** |
| PAHs | mg Ni eq. | 1 498 | 1 | 1 499 | 25 | 411 | 0 | -462 | **1 473** |
| Particulate Matter (PM, dust) | g | 486 | 51 | 537 | 1 710 | 1 415 | 98 | -158 | **3 602** |
| **Emissions (Water)** | | | | | | | | | |
| Heavy Metals | mg Hg/20 | 1 398 | 0 | 1 398 | 1 | 1 248 | 8 | -423 | **2 233** |
| Eutrophication | g PO4 | 13 | 1 | 14 | 0 | 313 180 | 101 653 | -2 | **414 845** |

## 5.4 Base Case Life Cycle Costs for consumer per unit and at EU level

The base case life cycle costs (LCC) for consumer is the total price of ownership i.e. a sum of all costs for acquiring the HPC plus the annual costs over the lifetime. The annual cost includes energy (electricity for the direct consumption + electricity and natural gas for the small part of indirect consumption via the externally heated water + fuel for hot water machines), water and detergent. For the domestic HPCs the repair and maintenance costs are assumed null, while for the professional HPCs they are assumed to be at a total size over lifetime corresponding to the purchase price.

The annual energy, water and detergent consumption is constant over lifetime, however the utility prices vary from year to year. In the model, the energy prices are based on PRIMES 2016[2], and the water prices are extracted from the dishwasher and washing machines and the detergent price has been considered as constant, see previous description. Utility prices for all years are expressed in euros 2015 (as reference year).

For calculation of the LCC at EU level, the unit LCC is scaled up to EU-28 level based on the sales and stock model.

The following sections present two charts for each base cases: one showing the LCC for an HPC purchased in the particular year from 1987 to 2050 shown on the Y-axis and the other one showing the LCC scaled up to EU level. All prices are in 2015-constant prices.

### 5.4.1 BC1: Domestic HPC cold water

Figure 6 shows that the evolution of life cycle costs (at unit level) of a domestic high pressure cleaner for the examined period, 1987 till 2050. Water and detergent consumption are the main cost contributor areas. The overall LCC increases from nearly 470 EUR in 2017 to almost 570 EUR in 2050, mainly due to the increase over time of the water price. This means that any measure aiming at reducing the water consumption, would significantly positively impact the LCC and particularly the user expenditure. For example saving 20% water at unit level would mean for the consumer 17 EUR saving per year for 2019 and 37 EUR saving per year for 2050 (in 2015 EUR equivalent).

The cost of electricity also steadily grows, but remains stable within the range of 20-22 EUR/year for the period of 2019-2050. Considering a 20% energy savings would mean 4 EUR/year savings for the consumer only from electricity. Water and electricity are correlated in this product group, meaning that measures to save water will most probably lead to electricity savings. Detergent consumption is proportional to water use; therefore, water savings may also lead to a reduction on the detergent cost.

Regarding purchase price, domestic high pressure cleaners require a fine tuning between durability and purchase price, in order to achieve equilibrium between the additional costs of manufacturing and therefore increase of the price, and the turnover due to an extension of lifetime. This will be further investigated in Task 6.



[2] These are based on the PRIMES model and delivered by DG Energy.

Figure 6. Life cycle costs per unit for BC1 (in 2015 EUR equivalent).

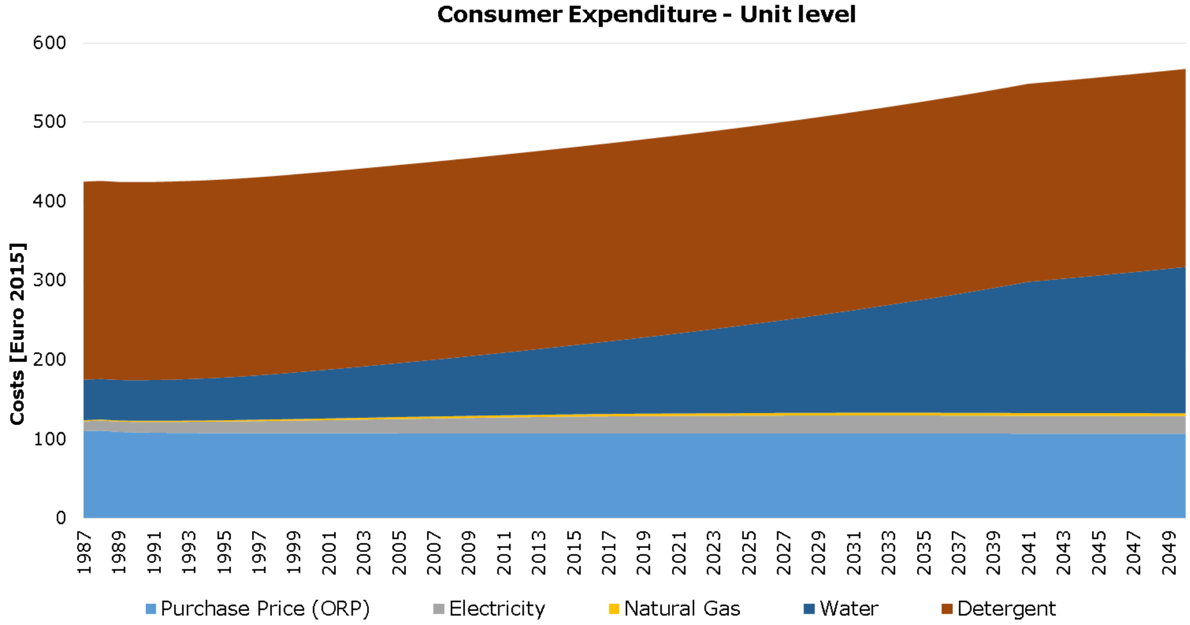
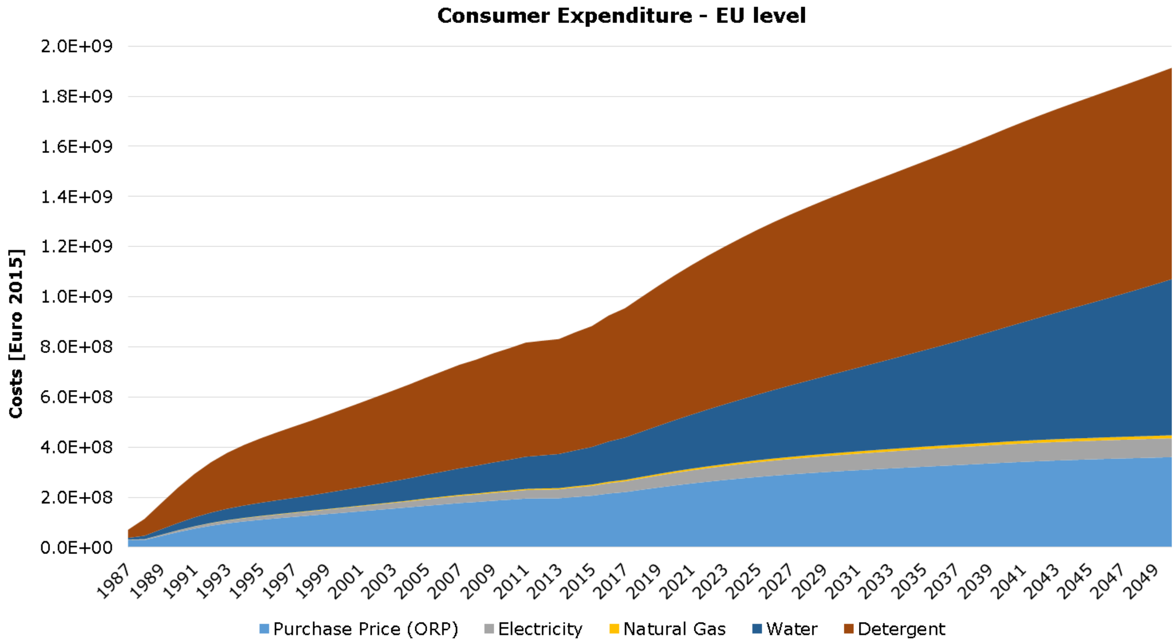



Figure 7 shows an increase in the overall consumer expenditure over the period due to the increased sales and increased LCC at unit level. In 2050, the total EU life cycle costs are about 1.9 billion EUR 2015, which means an increment of 75% referred to 2019 which is 1.09 billion EUR 2015. This means that this product group have large potential to become a significant share of consumer expenditure in the future.

Figure 7. Life cycle costs at EU level for BC1 (in 2015 EUR equivalent).




### 5.4.2 BC2: Professional HPC cold water, electric motor 1 phase

Compared to BC1, Figure 8 shows the lower importance of the purchase price for professional cold water machines (it was considered 500 euros/unit based on stakeholders input). This is due to the resource consumption linked to a larger frequency and duration of use. The share of the purchase price is also reduced due to the longer lifetime and higher use frequency of professional products. Similar to BC1, the LCC increases from about 7 400 EUR in 2019 to 11 400 EUR in 2050, mainly due to the water price increase. Water consumption is the main part of the LCC during all the period, followed by far by electricity consumption. Compared to BC1, the costs are one order of magnitude higher, meaning that measures to reduce water and electricity would have a much larger impact.

This professional base case includes a cost on repair and maintenance, though is not significant compared to other costs. The total cost of repair and maintenance was assumed 70% of the purchase price for all professional HPC. However, the repair and maintenance of the unit have a positive impact on the lifetime of professional products.

Figure 8. Life cycle costs per unit for BC2 (in 2015 EUR equivalent).

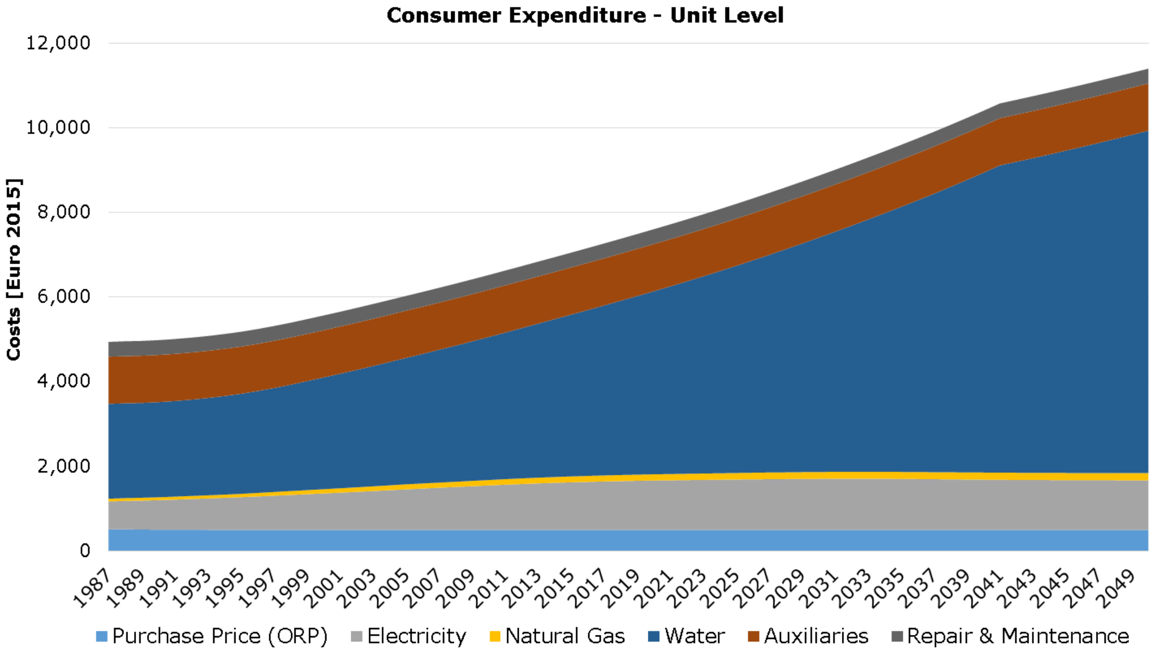
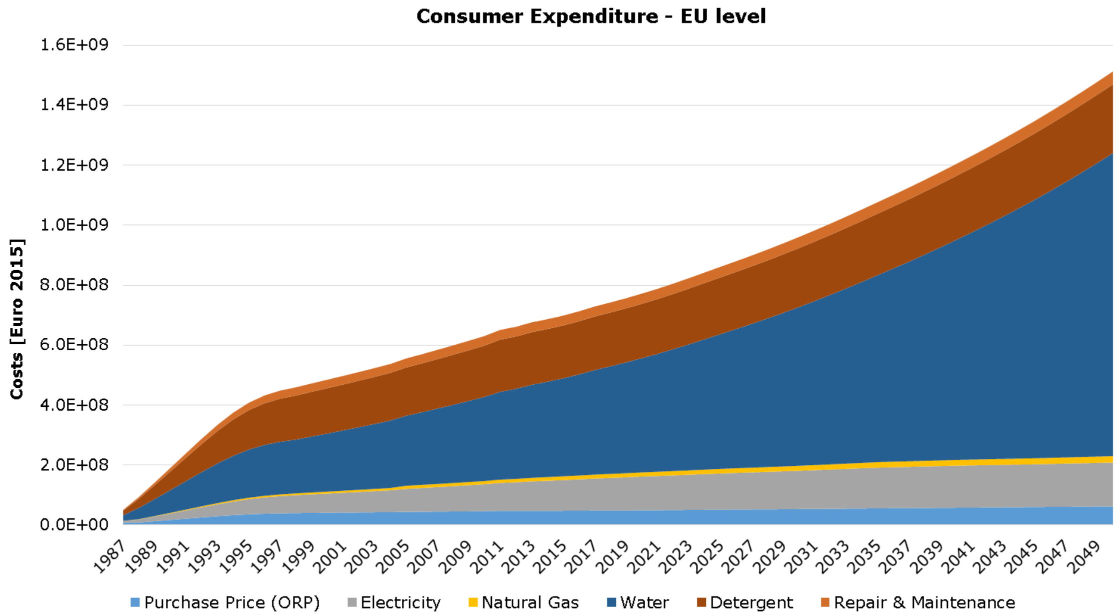



Figure 9 shows an increase in the overall consumer expenditure over the period due to the increased sales and increased LCC at unit level. In 2009 the total EU life cycle costs are about 0.75 billion EUR while in 2050 is estimated to double to 1.5 billion EUR, at the same levels with BC1. As can be observed the LCC at EU levels of BC1 and BC2 are similar, which means that the lower market volume of professional units is compensated by are more intensive use.

Figure 9. Life cycle costs at EU level for BC2 (in 2015 EUR equivalent).




### 5.4.3 BC3: Professional HPC cold water electric motor 3 phases

Figure 10 shows the LCC evolution for BC3 (professional – cold water -3 phase) at unit level for the period 1987-2050. Similarly for all professional HPC BCs, the importance of the purchase price for professional HPC is lower due to higher resource consumption. The average purchase price for BC3 was estimated 1 800 EUR/unit based on stakeholder's input. The LCC increases from about 14 400 EUR in 1987 to almost 22 400 EUR in 2050 which again is due to the water price increase. Water consumption is the main part of the LCC during all the period.

Figure 11 shows an increase in the overall consumer expenditure over the period due to the increased sales and increased LCC at unit level. In 2050, the total EU life cycle costs are estimated about 0.78 billion EUR.



Figure 10. Life cycle costs per unit for BC3 (in 2015 EUR equivalent).

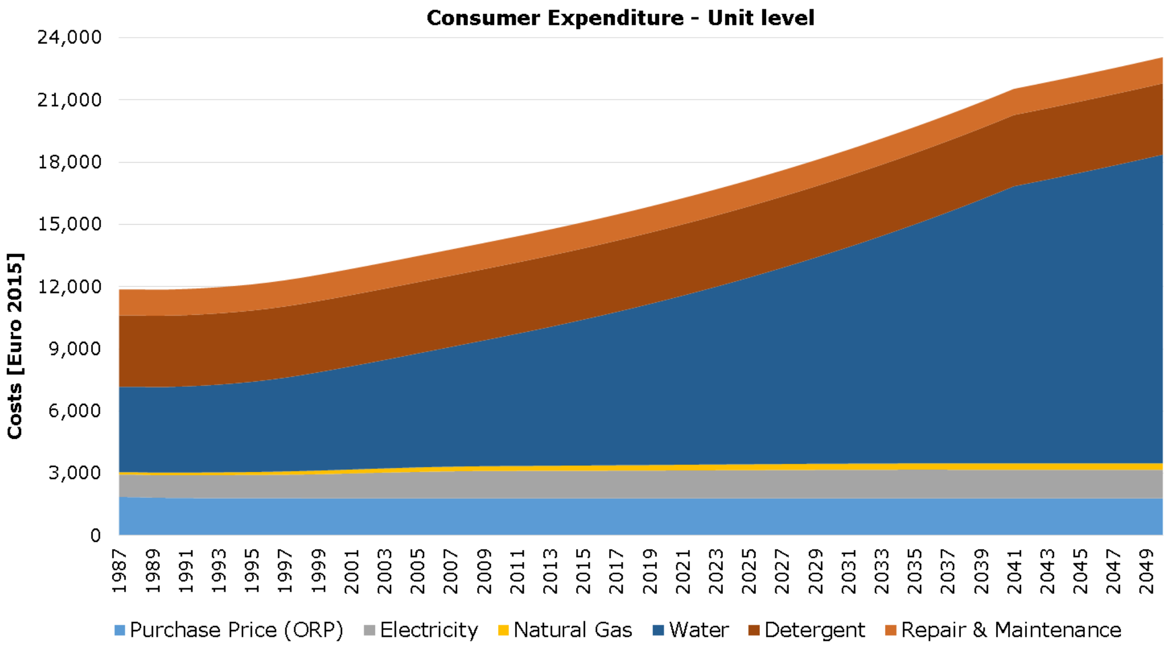
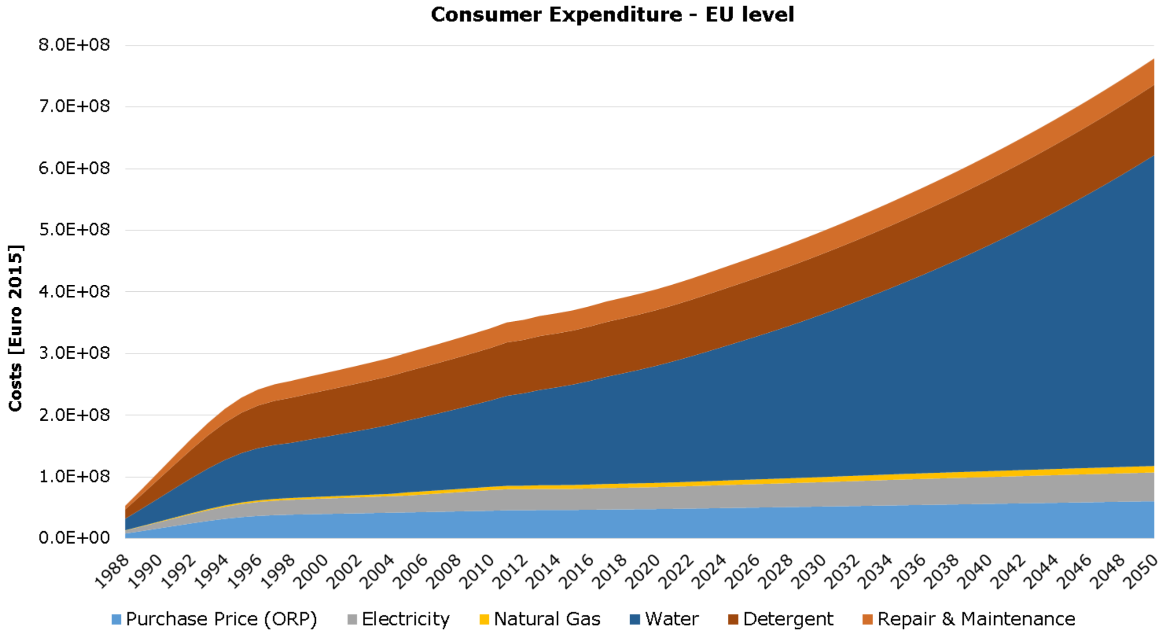


Figure 11. Life cycle costs at EU level for BC3 (in 2015 EUR equivalent).




### 5.4.4 BC4: Professional HPC cold water combustion motor

Figure 12 presents the LCC consumer expenditure at unit level for BC4. As in all professional HPC, it shows the lower importance of the purchase price for professional cold water combustion machines due to higher resource consumption. The LCC increases from about 12 100 EUR in 2019 to about 19 500 EUR in 2050 which is mainly due to the water and fuel (important cost contribution areas) price increase over the years. Water consumption is the main part of the LCC during all the period. Fuel consumption of the combustion engine has also a substantial cost and much higher than the electricity cost for the electric driven professional HPCs.

Figure 12. Life cycle costs per unit for BC4 (in 2015 EUR equivalent).

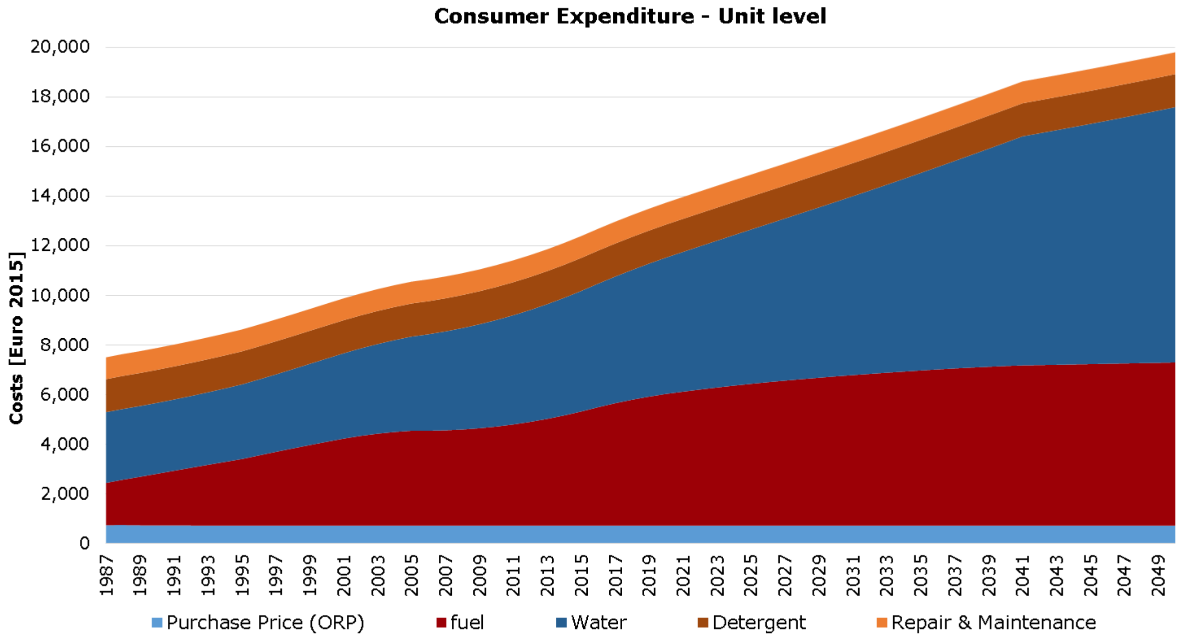
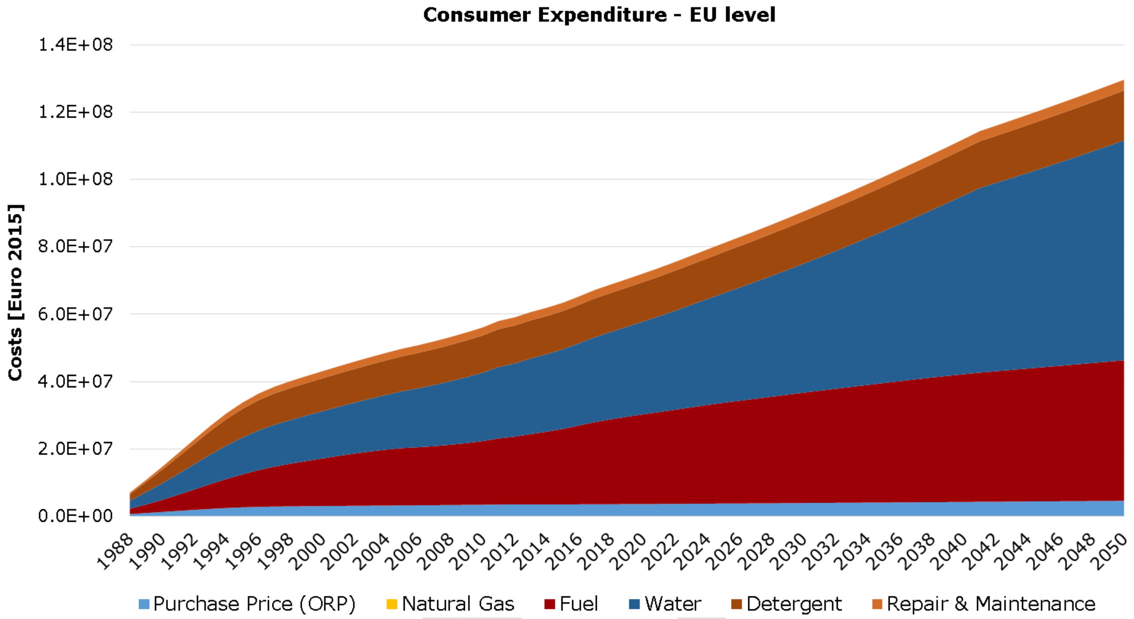


Figure 13 shows an increase in the overall consumer expenditure over the period due to the increased sales and increased LCC at unit level. In 2050, the total EU life cycle costs are about 0.13 billion EUR.

Figure 13. Life cycle costs at EU level for BC4 (in 2015 EUR equivalent).




### 5.4.5 BC5: Professional HPC hot water (fuel burner) electric motor 1 phase

Figure 14 presents the consumer expenditure for BC 5 at unit level. The LCC increases from almost 10 800 EUR in 2019 to about 15 500 EUR in 2050 which is mainly due to the water and fuel price increase. Water consumption is the main part of the LCC during all the period. However, energy consumption (both fuel for the water heater and electricity for driving the HPC motor) is equally important from cost perspective. The average purchase price for BC5 was estimated 2 500 EUR/unit based on stakeholder's input.

Figure 15 shows an increase in the overall consumer expenditure at EU level over the period due to the increased sales and increased LCC at unit level. In 2050, the total EU consumer expenditure will be at the level of 0.36 billion EUR.

Figure 14. Life cycle costs per unit for BC5 (in 2015 EUR equivalent).

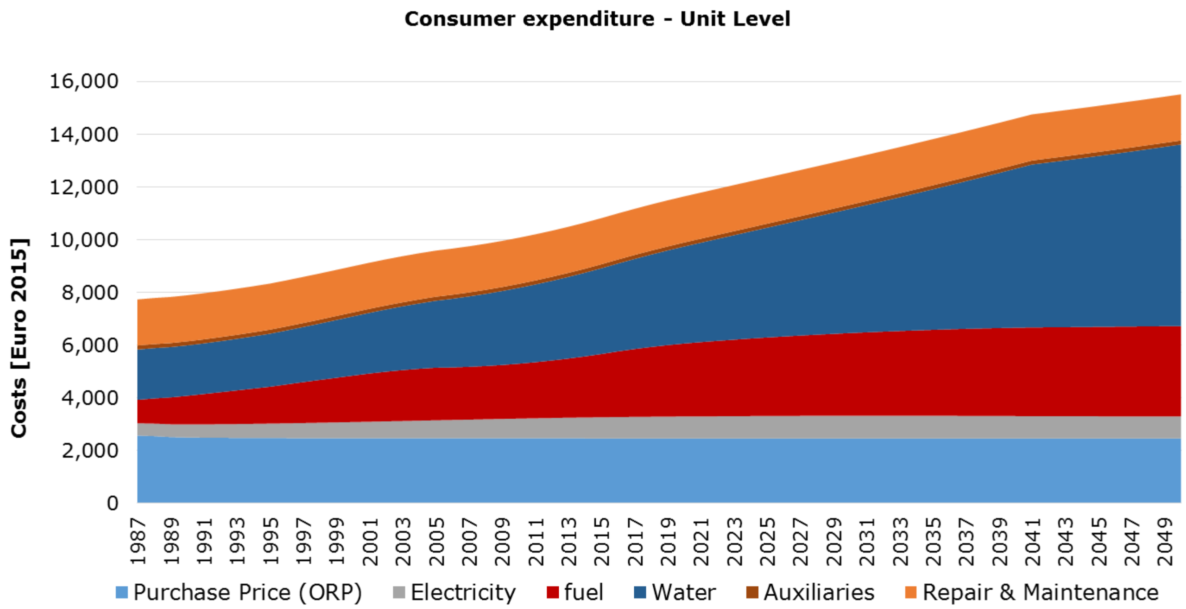
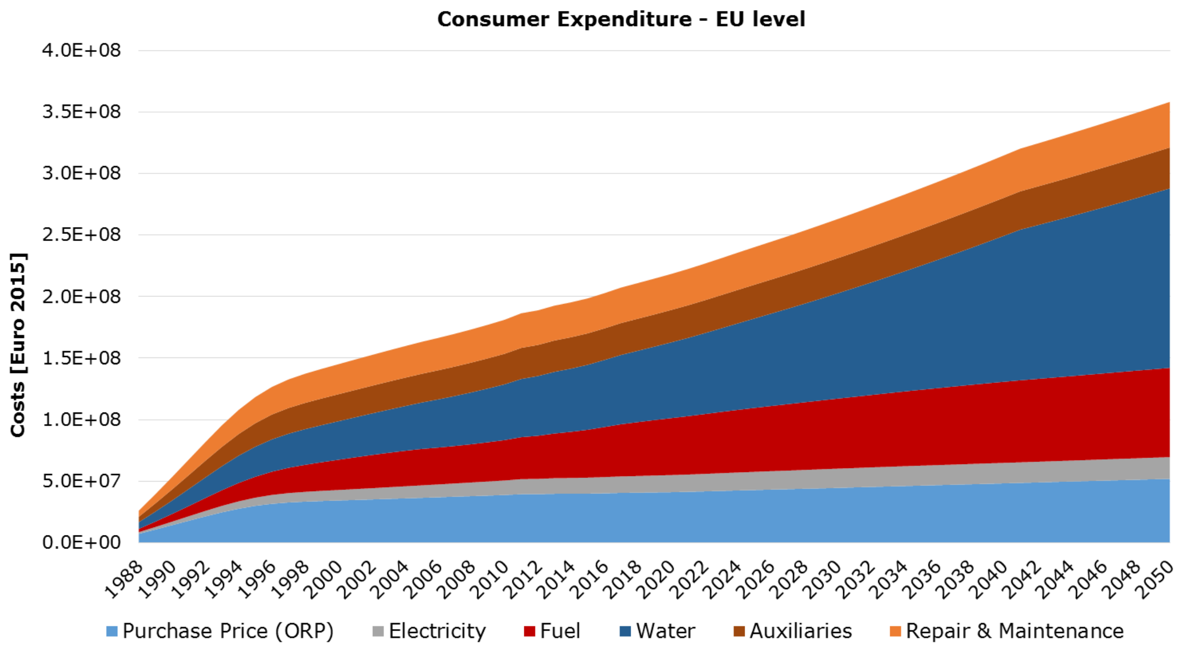



Figure 15. Life cycle costs at EU level for BC5 (in 2015 EUR equivalent).




### 5.4.6 BC6: Professional HPC hot water (fuel burner) electric motor 3 phases

Figure 16 presents the LCC results of BC6 at unit level. The consumer expenditure increases from about 18 000 EUR in 2019 to about 27 600 EUR in 2050 which mainly due to the price increase in water and fuel. As average purchase price for BC5 was estimated 3 000 EUR/unit based on stakeholder’s input.

Figure 16. Life cycle costs per unit for BC6 (in 2015 EUR equivalent).

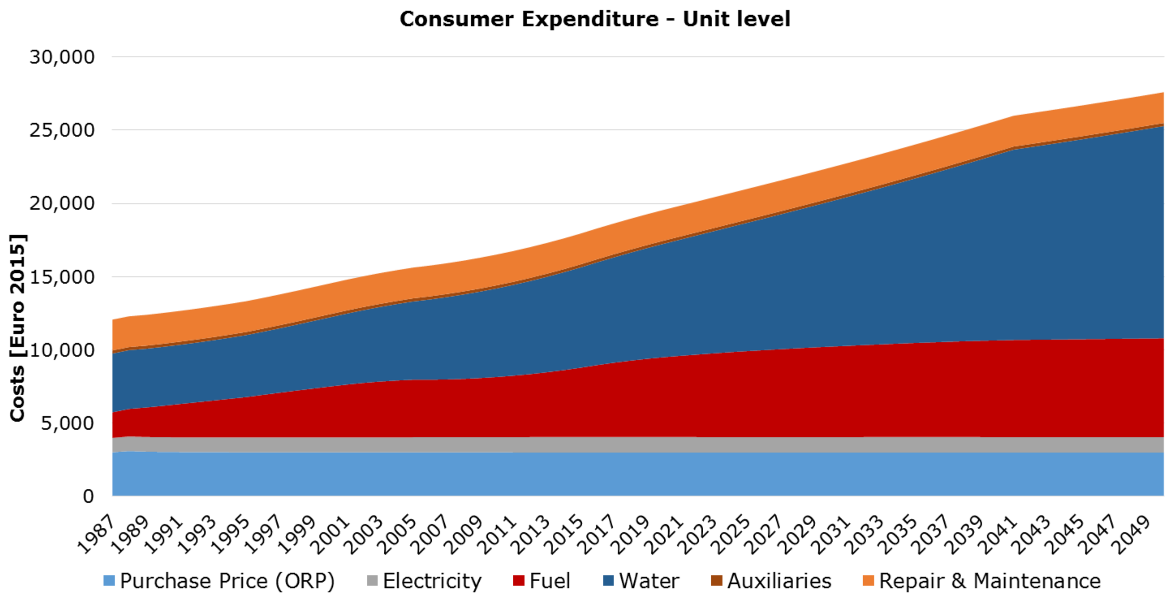
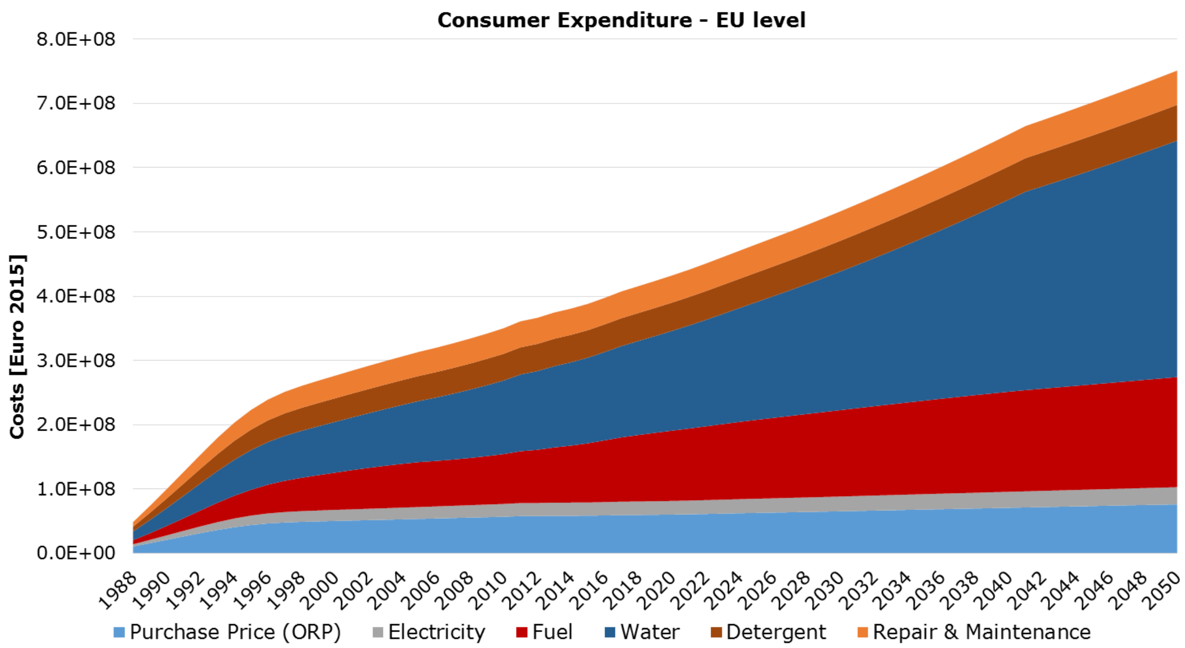



Figure 17 shows an increase in the consumer expenditure at EU level over the period due to the increased sales and increased LCC at unit level. In 2050, the total EU life cycle costs are estimated at the level of 0.75 billion EUR.

Figure 17. Life cycle costs at EU level for BC6 (in 2015 EUR equivalent).




## 5.5 EU Totals

### 5.5.1 Total direct energy consumption at EU level (Low usage scenario)

The direct energy consumption includes the energy consumption during the use phase of the HPC for EU-28 and excludes the indirect heat consumption, where the HPC is connected to a hot water tap having the water heated externally by the buildings sanitary hot water systems. This is further described in Task 3. Figure 18 presents the results of

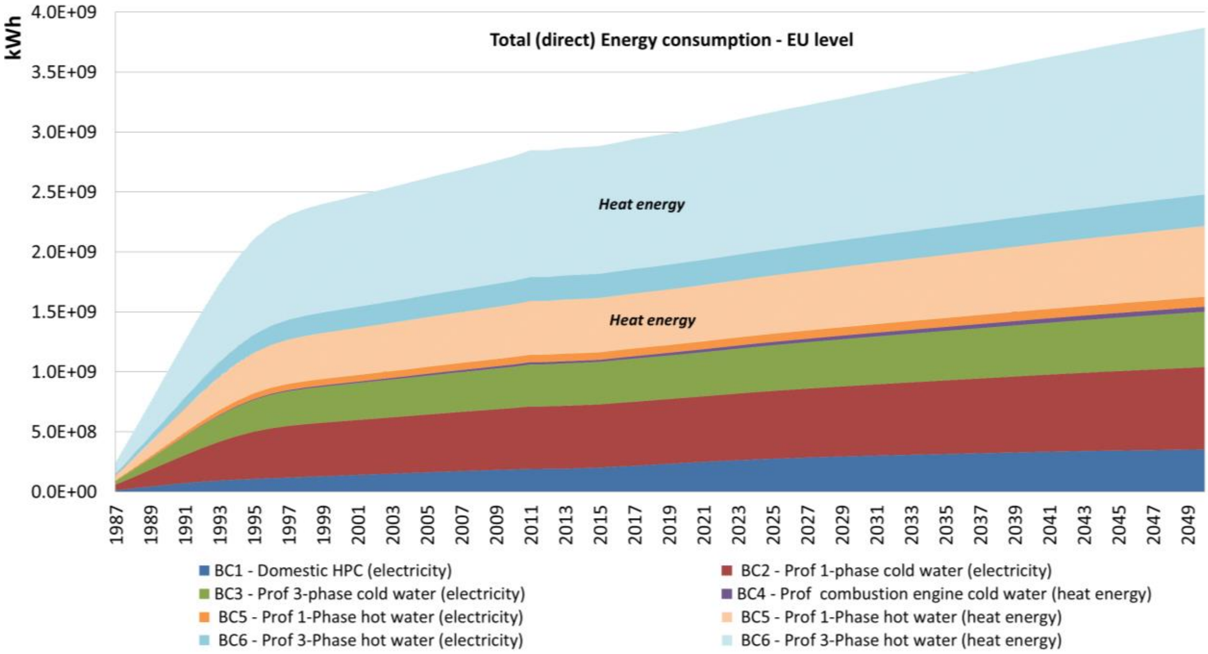
HPC energy (electricity as well as heat energy from liquid fuels) consumption during use for all BCs.

BC1 to BC3 are cold water electric BC, so are consuming only electric energy, while BC5 and BC6 are hot water machines consuming both electric energy for the electric motors as well as liquid fuels consumed in the build in water heater of the hot water HPC, thus heat energy is presented separately in the chart. BC4 represents a combustion engine driven HPC that consumes only gasoline.

Main conclusions from the energy chart of Figure 16 are:

- Total energy consumption of all HPCs in 2050 is estimated at the level of **3.9 TWh** (final energy at use phase), which is about one third of the estimated value in the working plan study (11.2 TWh in 2030 for EU-27)[3]. The overall HPC direct energy consumption is estimated 3.0 TWh and 3.3 TWh for the years of 2019 and 2030, respectively.
- The heat energy from liquid fuel used for hot water HPC (BC5-6) and combustion engine HPC (BC4) represents nearly half (52%) of the total energy consumption.
- For the hot water HPC, the energy for heating the water is more important than the electricity consumption even when taking the primary energy factor into account.
- The base case with highest electricity consumption is BC2 (professional cold water single phase), which represents nearly 38.3% of the overall electricity consumption; followed by BC3 with 25.7% share, BC1 with 16.6% share, BC6 with 14.7% share and BC5 with 4.6% share.
- Professional combustion engine HPC (BC4), does not have significant energy consumption at EU level, it represents nearly 0.8% of the overall energy consumption as its market share is very low (see Task 2).

Figure 18. Total direct energy consumption for each base case for EU-28. Energy consumption for hot water HPCs is presented separately for electric and heat energy.



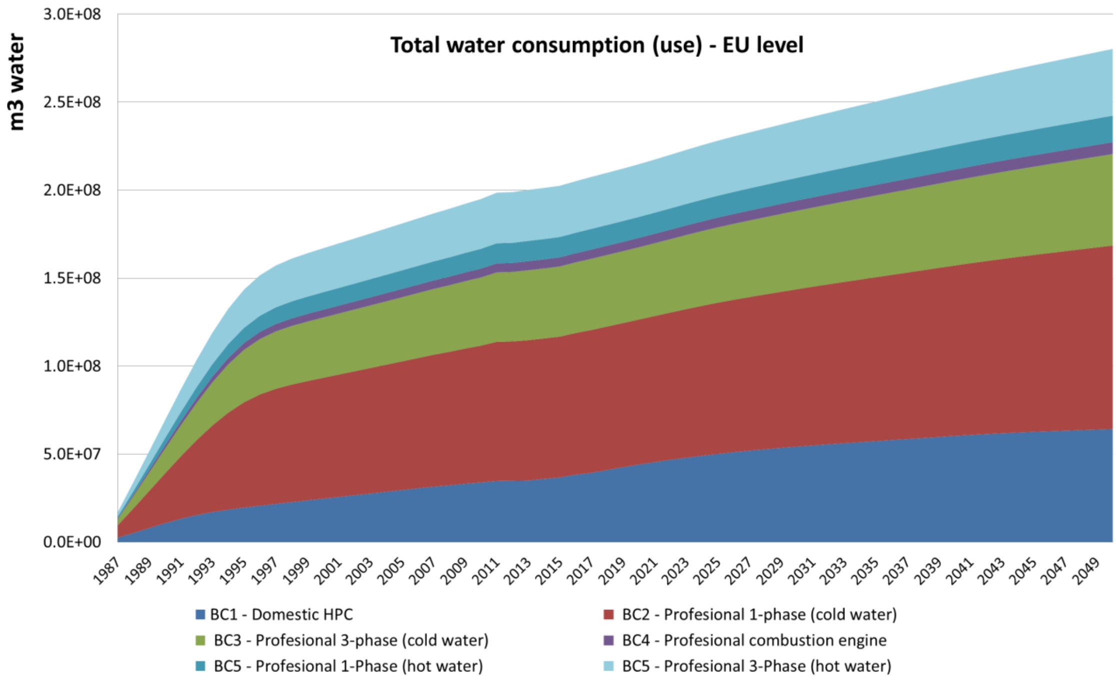

[3] Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC. Task 3 Final Report.

### 5.5.2 Total water consumption during use at EU level (Low usage scenario)

Figure 19 presents the water consumption during the use phase for all base cases for EU-28. Below are summarised the main conclusions:

- Total water consumption of all HPCs for 2019 is estimated 212 million $m^3$, for 2030 239 million $m^3$, and for 2050 is estimated 280 million $m^3$ which is less than half of the estimated figure in the working plan study (about 634 million m3 in 2012 for EU-27)[4].
- Each base case's share of the total water consumption correlates with the energy consumption presented in previous section.
- The base case with highest water consumption is BC2 (professional HPC with 1-phase connection and use of cold water) with 38.4% share. BC1 has a 20.5% share of the aggregated HPC water consumption, followed by BC3 with 19.1%, BC6 with 14% and BC5 with 5.5% share.
- Professional combustion engine (BC4) does not have significant water consumption at EU level compared to the other HCP types, it has only 2.5% share.

Figure 19. Total water consumption for each base case for EU-28.




### 5.5.3 GHG Emissions at EU level

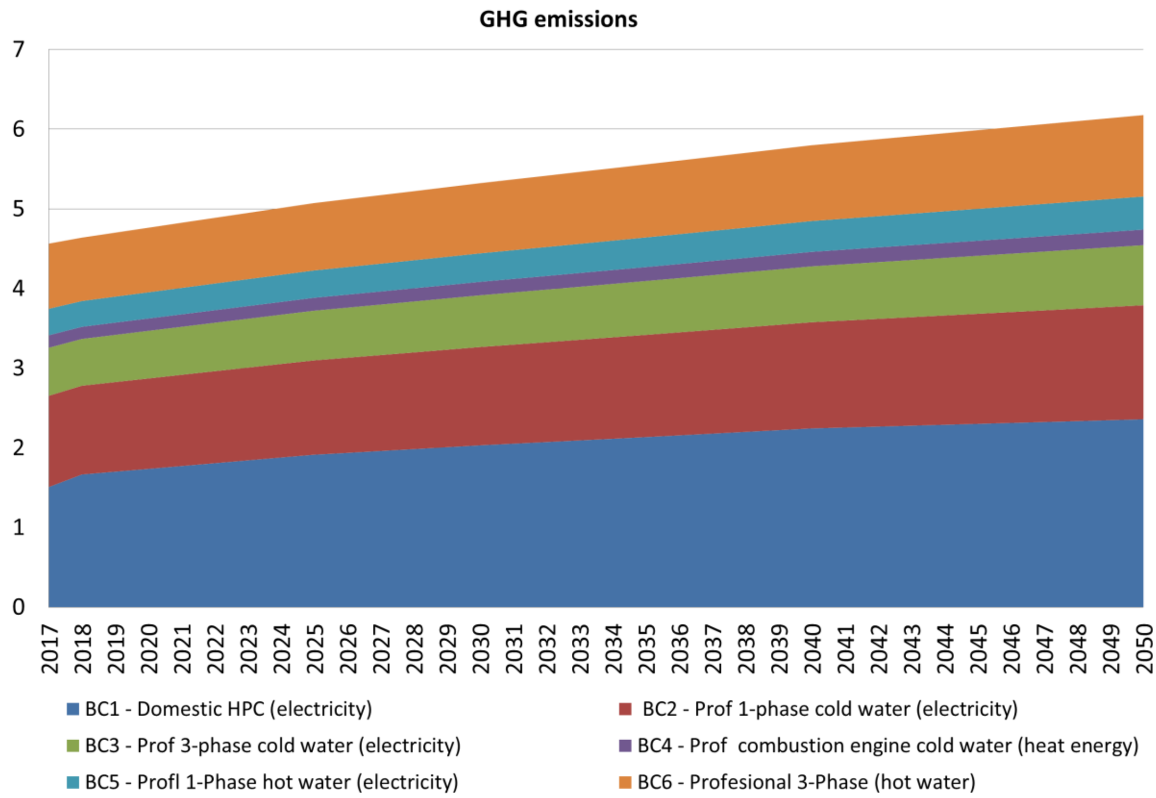
The Greenhouse Gas (GHG) emissions, expressed in million tons of $CO_2$eq., are estimated for the period 2017-2050 for all life cycle stages and for each BC. Figure 20 presents the overall GHG emissions generated during HPC life cycle stages (production, use, End-of-Life treatment) aggregated per Base Case. The main cconclusions are:

- Total GHG emissions of all HPCs are estimated to be currently at 2019 at the level of **4.7 million tons of $CO_2$ eq.**, increasing to 5.3, 5.8 and 6.2 million tons of $CO_2$ eq. in 2030, 2040 and 2050, respectively.

[4] Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC.

- The base case with largest share of GHG emissions is BC1 (domestic HPC), which represent nearly **36.2% of the total GHG emissions**. The main reason is the large volumes of domestic HPC produced and sold per year (see Task 2), thus, this BC has higher production impact at EU level (sales multiplied with the production phase impact) compared with the rest of the BCs. From the other hand, professional HPC have much lower sales/year compared to BC1 but much higher impact at the use phase as are more frequently used (150 hours instead of 5 hours of average use per year).
- Professional combustion engine (BC4) has the smallest GHG emissions at EU level compared to the other HPC types. BC2 has 23.9% share of the total GHG emissions, while BC6 has 17.1%, BC3 12.6%, BC 5 6.9% and BC4 with the lowest share of 3.2%.

Figure 20. Total GHG emissions for each base case for EU-28.




## 5.6 Conclusions

The use phase clearly dominates the consumption of energy and water, and GHG emissions. The use phase has a larger share in professional HPCs due to higher frequency of use. This suggests that measures aimed at reducing the energy and water consumption in the use phase will have a bigger impact in the professional units than in domestic units.

In terms of LCC, water represents the largest share in all base cases, and it is more dominant in the professional base cases. For domestic units, detergents share an important part of LCC, though the figures heavily rely on assumptions that should be contrasted.

These results may suggest that water and energy saving measures may be cost-effective; however, it depends on the additional cost and improvement potential of those measures.

# 6 Environment and economics of design options

## 6.1 Introduction

In accordance with the MEErP methodology, Task 6 identifies and presents the analysis of the design options, which are the options for improvement of the environmental performance taking into account the Least Life Cycle Costs (LLCC). The design options are based on the description and analyses in the Task 4 report. The assessments of impacts are based on the base cases (BC) as described in Task 5 and presented below.

The impacts of the design options are assessed quantitatively using the EcoReport Tool (LCA) and the EcoModelling Framework Tool (LCC) for the identified base cases.

The base cases selected in Task 5 are:

- BC1: Domestic HPC cold water electric motor
- BC2: Professional HPC cold water electric motor 1 phase
- BC3: Professional HPC cold water electric motor 3 phases
- BC4: Professional HPC cold water combustion motor
- BC5: Professional HPC hot water (fuel burner) electric motor 1 phase
- BC6: Professional HPC hot water (fuel burner) electric motor 3 phases

The following section describes the identification and selection of design options followed by a brief description of each design option with the assumed direct impact and the costs associated; and afterwards assessment of the LCA and LCC impact.

## 6.2 Design options

### 6.2.1 Identification of options

The design options have been based on analyses of the previous tasks, mainly based on Task 4 where opportunities for saving energy and water during use phase through design improvements have been identified. Additionally, opportunities were identified for improving the durability of domestic HPCs and improvement of repairability and increase of recyclability for all HPCs. Totally, six design options are described and assessed in the following:

- D1: Improvement of nozzle design (BC1-BC6)
- D2: Increase of electric motor-pump efficiency (BC1-BC3, BC5-BC6)
- D3: Increase of hot water fuel burner efficiency (BC5-BC6)
- D4: Improvement of durability (BC1)

### 6.2.2 D1: Improvement of nozzle design (BC1-BC6)

The nozzle creates the water spray jet and the shape and strength of the jet is determined by the type of nozzle meaning that the nozzle design has high impact of the cleaning performance.

Entry level HPCs usually come with just one nozzle while higher performing and more expensive HPCs often come with more types for different types of cleaning work and surfaces. Some top brands design their own improved-design nozzles, while low and medium brands normally purchase generic types from suppliers. A conclusion from Task 4 report was that there is significant variation in both water and energy consumption for similar cleaning quality for different nozzles. This indicates that there are potentials for energy and water savings through improvement of nozzle design.

The nozzles can be divided into three main types:

- Fixed jet: The shape and pressure of this jet cannot be adjusted
- Variable fan-jet: The nozzle has different positions that allow the user to vary the spray angle and pressure of the spray
- Rotating jet: A powerful, focused jet spins as it leaves the nozzle providing very strong cleaning power

The nozzle is connected to the main body of the HPC through a high-pressure hose.

The rationale behind this option is therefore that an improved nozzle design can save water and energy without reducing cleaning performance. Only some specific cleaning tasks need high water flow to remove loosened dirt and low water flow attachments cannot be used for these tasks but also there the assumption is that improved nozzle design can reduce the water consumption.

A policy measure to implement this design option would require a cleaning performance measurement method that measures water and energy consumption during a cleaning cycle.

#### *6.2.2.1 Impact*

The assessment is based on the water and energy consumption of the quantitative impact of improving the nozzle design on stakeholder data from cleaning performance tests carried out by an independent test laboratory (see Task 3, Section 3.5) of 43 domestic HPCs. The test consisted of cleaning m² dirty pavement twice by two experts respectively. Cleaning time, cleaning quality (a point score), total water consumption and input power during the test were measured.

We have identified HPCs with same cleaning quality and approximately same efficiency level. The efficiency is calculated as a proxy for efficiency: Increase of pressure over the HPC multiplied with water flow divided with input power. The difference in water consumption between these HPCs is assumed to be due to the nozzle design. Table 9 below shows the series of HPCs with same cleaning quality and approximately same efficiency proxy indicating the water savings achieved by the best (BAT) in the series compared to the average water consumption for all HPCs in the series. The results of the two individual tests for each HPC were averaged.

Table 9. Assessment of water savings using BAT compared to average nozzle technology within a series of tested HPCs with same cleaning quality

| Water consumption, l | Cleaning quality | Efficiency proxy | Savings BAT to average, % |
|---|---|---|---|
| 6.5 | 3 | 0.46 | 57 |
| 20.8 | 3 | 0.48 | |
| 18.5 | 3 | 0.51 | |
| 9 | 3 | 0.54 | 6 |
| 8 | 3 | 0.58 | |
| 10.9 | 3 | 0.73 | 21 |
| 7.1 | 3 | 0.86 | |
| 11.7 | 3.5 | 0.5 | 16 |
| 13.2 | 3.5 | 0.51 | |
| 12.1 | 3.5 | 0.52 | |
| 9.8 | 3.5 | 0.54 | |
| 14 | 4 | 0.47 | 10 |
| 11.4 | 4 | 0.49 | |
| 12.1 | 4 | 0.6 | 22 |
| 13.3 | 4 | 0.63 | |
| 9 | 4 | 0.64 | |
| 11.1 | 4 | 0.67 | 22 |
| 11.5 | 4 | 0.7 | |
| 7.8 | 4 | 0.7 | |
| 9.6 | 4 | 0.74 | |
| 10 | 4 | 0.78 | 18 |
| 6.9 | 4 | 0.78 | |
| 8.6 | 4.5 | 0.67 | 21 |
| 5.6 | 4.5 | 0.74 | |
| 7.6 | 4.5 | 0.78 | 16 |
| 5.5 | 4.5 | 0.83 | |
| **Average saving BAT compared to average** | | | **21** |

*Note: Dotted lines in the table separate HPCs with approximately same efficiency proxy. Each row represents a tested HPC. Bottom line shows an average of all savings.*



The average saving in water consumption using a BAT nozzle compared to an average nozzle is thereby calculated to be 21% for this dataset, the total average saving is reduced by 20% to take into account the uncertainty of the assumptions. The result is rounded down to 15%. The savings in water consumption are assumed to correlate directly with the savings in electricity consumption.

This result can be compared to an impact analysis for an improved nozzle design carried out as part of an Environmental Design of Industrial Products project, which included a redesign of a high pressure cleaner by the company Alto Denmark (now part of Nilfisk)[5]. The achieved result was about 30% saving of water and energy without reduction in cleaning performance.

These figures are for domestic HPCs, but no information disconfirms that the same pattern can be seen for professional HPCs.

[5] http://orbit.dtu.dk/files/4646274/Wenzel.pdf

The assumption is that the improved nozzle design can reduce the energy, water and detergent consumptions with 15% with maintained cleaning quality for all the base cases.

#### *6.2.2.2 Costs*

Improvement of the nozzle design will typically require a one-time redesign including testing of them with the HPCs that they are designed for followed by needed changes in the production process. Type and amount of raw materials for the improved nozzles may be slightly different, but this is assumed to entail only marginal additional costs.

It has not been possible to get data or estimations from the stakeholders on the costs related to this design option. Instead, the study team based the cost estimates on other sources. In Task 4 report retail prices in Spain of domestic nozzles as spare parts were stated from 7 EUR/unit to 27 EUR/unit for normal nozzles (Task 4 report, Table 14). The interval is seen to evidence of price difference between entry level basic nozzles and more advanced and supposedly more efficient nozzles and part or all of the difference, 20 EUR, is assumed to be price premium for an efficient nozzle. However, spare parts are typically at higher costs than the part's share of a retail price of the complete product because there are additional costs of handling spare parts. This means that the price premium is lower than 20 EUR, such as 15-17 EUR.

Additionally, the study team has collected retail prices for the same HPC models in the tests reported in the previous section and subject for the saving assessment. Comparing the prices for the HPCs in each comparable series, the price difference between the ones with lowest water consumption and the ones with highest consumption was around 20-40 EUR. Some of the price difference is due to being premium product, brand name, better quality material etc. and some a better nozzle design.

Based on these two sources, the assumption is that an improved nozzle design has a retail cost impact of added 16 EUR.

A similar pattern for professional products is assumed though with higher price premium due to better quality materials, assumed to be 50% higher than for the domestic sector, i.e. totally 24 EUR.

### 6.2.3 D2: Improvement of electric motor-pump efficiency (BC1-BC3, BC5-BC6)

A large proportion of the electric motors in domestic HPCs use universal motors, which are cheap, and usually operate at low efficiencies (30%-50%) and low lifetime (500-600 hours) which however is not a limitation for domestic HPC as the hours of use during lifetime is less than 500. Professional HPCs use induction motors with higher efficiency levels (around 60%-75%) and longer lifetime. The most efficient type of motors is brushless DC motors (BLDC) having efficiencies around 85%-95%. Lifetimes for induction and BLDC motors are around 3000-4000 hours.

There are HPC models, both domestic and professional, where the electric motors are completely integrated with the high pressure pump, and in these cases the energy performance of the motor cannot be tested independently. Therefore, a potential eco-design requirement for HPC should aim on the energy performance of the motor-pump combination.

#### *6.2.3.1 Impact*

The study team has assessed possible impact of increasing the electric motor-pump efficiencies from average levels to a BAT level without changing motor technology using the dataset of collected data of HPCs on the market as described in the Task 4 report.

The motor efficiencies were not available and instead, we calculated the following index to use as a proxy for the efficiency: Maximum working pressure (MPa) multiplied with maximum flow rate (litres/second) and divided by connection load (kW) for all domestic and professional HPCs. The results are presented in Figure 21, Figure 30 and Figure 31.

Figure 21. Proxy efficiency levels for domestic HPCs

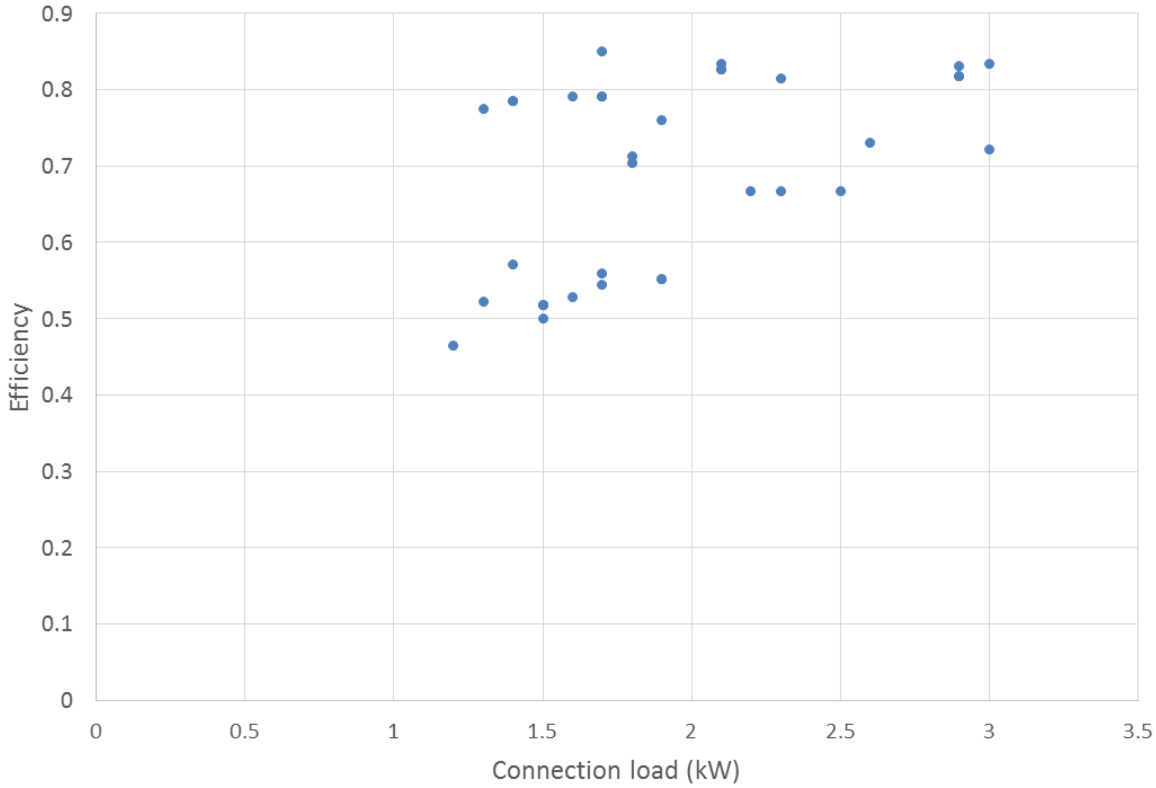



Figure 22. Proxy efficiency level for professional HPCs 1 phase.

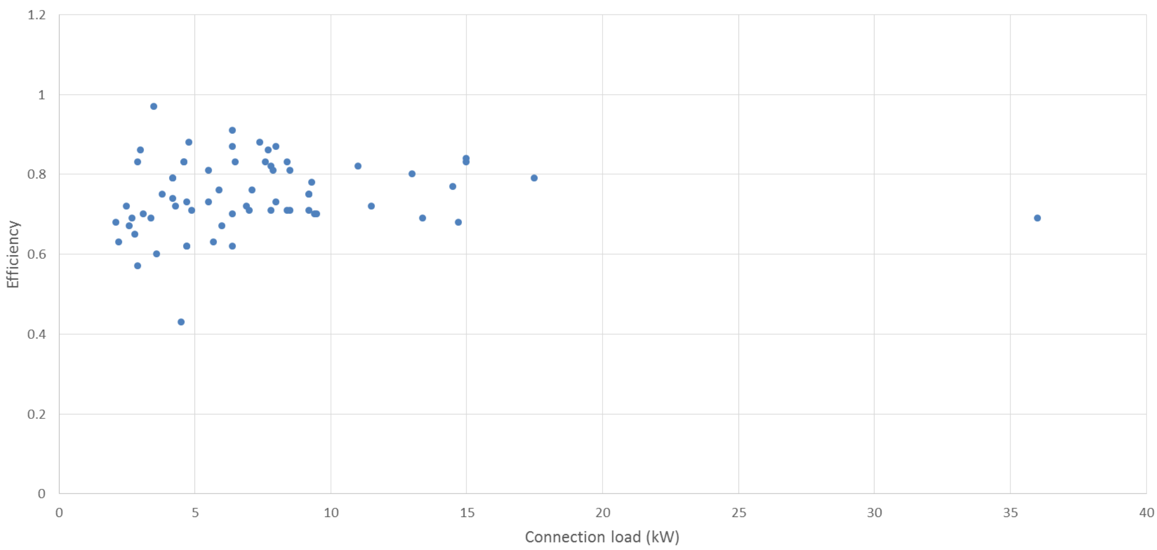
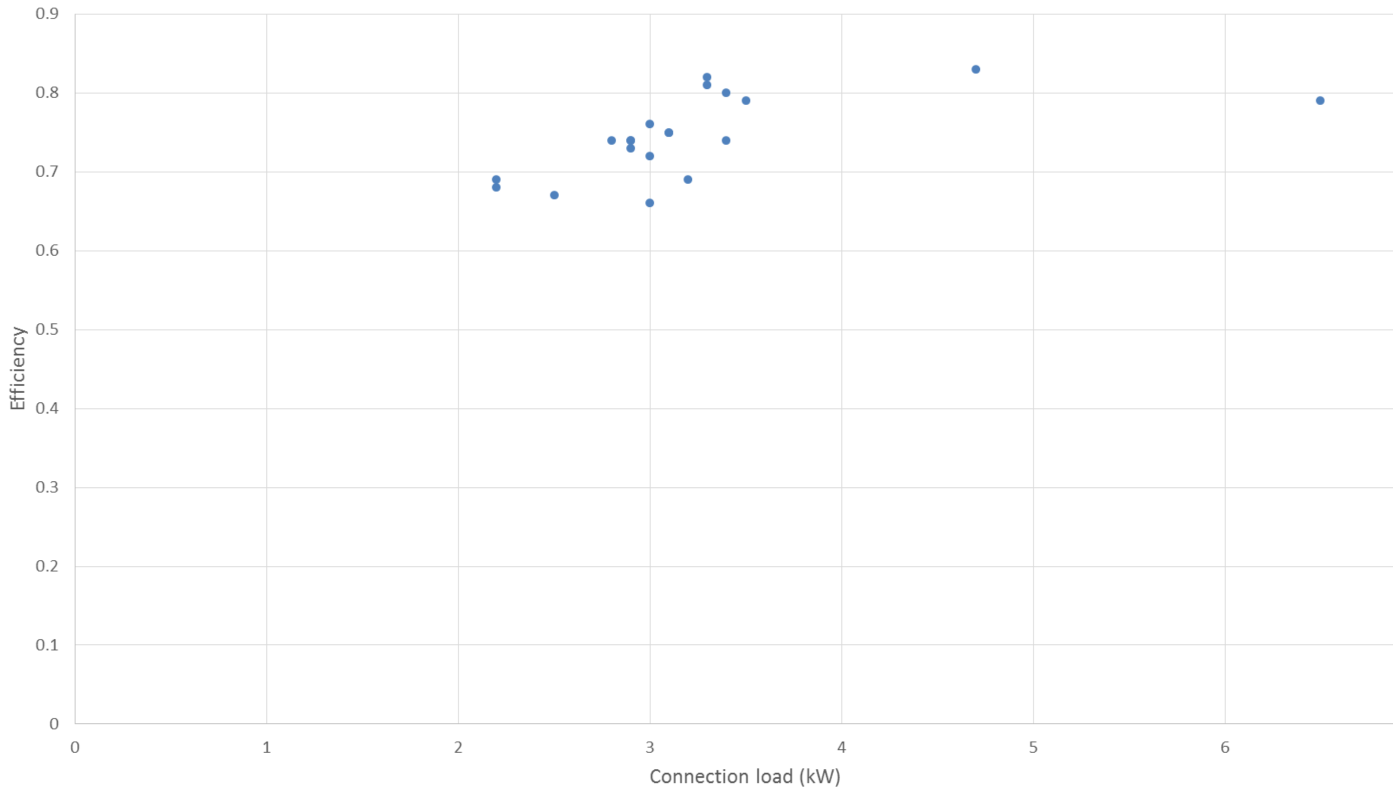


Figure 23. Proxy efficiency level for professional HPCs 3 phases




The efficiency of the design option for improving electric motor-pump, based on these datapoints, and the averaged associated savings are presented in Table 12.

Table 10. Proxy efficiency of electric motor-pump and the associated savings.

| **HPC type** | **Proxy efficiency of design option** | **Savings** |
|---|---|---|
| Domestic (BC1) | 0.75 | 16% |
| Professional 1 phase (BC2, BC5) | 0.75 | 6% |
| Professional 3 phases (BC3,, BC6) | 0.8 | 12% |



#### *6.2.3.2 Costs*

For domestic HPCs (BC1) the manufacturer price of universal motors is from around 4 EUR based on assessment of vacuum cleaner motors[6] verified through internet resources. With an assumed mark-up of 2.6, the retail price is around 10 EUR. Estimated additional cost for a more efficient universal motor (e.g. going from 35% to 44% electric efficiency to achieve 20% savings) is estimated at 25% i.e. 2.5 EUR.

For professional HPCs, the improvement of induction motors will lead to an increase of 25% of the manufacture cost of the unit, according to stakeholders input.

[6] "Review study on vacuum cleaners. Draft final report. Viegand Maagøe A/S, Van Holsteijn en Kemna B.V. November 2018.

### 6.2.4 D3: Improvement of hot water fuel burner efficiency (BC5-BC6)

Most of the professional hot water HPCs uses a fuel burner to heat the water. Electric heaters are only used for special HPCs used in areas, where fuel burners are not suitable. The pressurized water is pumped through a heating coil placed in the burner chamber where the water is heated. The efficiency depends on the burner efficiency, the length and form of the heating coil and how the hot air is circulated around the heating coil.

The option consists of setting requirements on maximum thermal losses for hot water fuel burner as defined by the EN IEC 62885-5:2018, and presented in Table 11.

Table 11. Thermal requirements for increasing fuel burner efficiency.

| Net power of heater P (kW) | Max. thermal loss *q*A (%) |
|---|---|
| 4 ≤ P ≤ 25 | 11 |
| 25 > P ≤ 50 | 10 |
| P > 50 | 9 |

Estimations from stakeholders are that about 75% of products in the market comply with these requirements. Most are just complying with the above thresholds and some are above these energy efficiency thresholds.

Most of the models in the dataset of professional heaters with fuel burner and with data on fuel consumption are above 50 kW and only few below 25 kW.

#### 6.2.4.1 Impact

It is assumed that an average non-complying model will have a net power of above 50 kW and with a thermal efficiency of 80%. The impact on the fuel consumption of this design option will be calculated as the increase in thermal efficiency from 80% to 91%. The fuel savings are thereby 12%.

#### 6.2.4.2 Costs

The professional hot water HPCs are expensive machines with prices around 2 000 EUR to 5000 EUR for common types. The HPCs with low thermal efficiency are assumed to be in the lower price end of the market. Comparing these with similar cold water machines, the price difference is about 1 000 EUR and above.

When a non-complying HPC should be brought to comply, the additional costs will consist of three cost elements:

- Redesign: It is needed to redesign the burner itself and accommodate a larger burner in the HPC. This is a one-time investment, which often is high. If a company is redesigning for other purpose in addition to redesigning for more efficient burner, the added cost related to the burner would naturally be smaller
- Machine tool sets: This is a one-time investment for the production of the HPCs in redesigned versions.
- Extra material: The coil needs to be longer and perhaps of better quality and the burner chamber may need double walls. This is an added cost for each product.

According to stakeholders input, the additional manufacture cost of this design option would be 190 EUR

## 6.2.5 D4: Improvement of durability (BC1)

This design option aims at improving the durability of the domestic HPCs where large variation on the technical lifetime has been observed (see section 3.5.2., Figure 21).

The aim of this design option is to set a minimum lifetime requirement should, where the lifetime is according to a defined test method based on a certain number and duration of usage cycles. An example of such test method has been provided by a stakeholder, who has tested a number of HPCs on the market (see section 3.5.2).

The minimum lifetime required in this design option has been assumed to be 6 years. The impact and costs have been assessed for domestic HPCs exclusively, but the policy measure should cover all HPCs, as all professional HPC units should already fulfil this minimum performance requirement.

### *6.2.5.1 Impact*

The JRC EcoModelling tool has been used to calculate an average lifetime using Weibull distribution based on the 6 years of minimum lifetime; this is 13.5 years.

### *6.2.5.2 Costs*

The study team estimated the cost by comparing retail prices of domestic 1 phase HPCs with prices of professional 1 phase cold water HPCs within the same range of rated flow and working pressure. These two types of HPCs mainly differ in component quality and durability and the price difference can be thereby estimated as the added cost for durability.

We used the data set of collected data of HPCs on the market as described in the Task 4 report and isolated data for HPCs with maximum flow rates 500-620 l/h and maximum working pressure 10-15 MPa. The average retail price in this range for domestic HPCs was 494 EUR and for professional HPCs 589 EUR resulting in a price difference of about 100 EUR. However, it is assumed that a main part of this price difference is other improvements for a professional product compared to a domestic product.

The assumption is an additional cost of 25 EUR per unit at the retail price level for increasing the minimum lifetime performance from 2 to 6 years.

## 6.2.6 Repairability and recyclability design options

### *6.2.6.1 Improvement of reparability (BC1-BC6)*

The option consists of increasing the lifetime of HPCs by improving the repairability potentials of the ones that are difficult to repair through:

i) Non-destructive access (disassembly) to critical components such as the motor-pump

ii) Assuring the availability of spare parts

iii) repair and maintenance information/manuals provided by the manufacturer for each model

Non-destructive access to main components means that main components of the HPC should be easily accessible; the HPC unit should be disassembled (non-destructive) with the use of common tools allowing professionals or end-users to replace the failed parts according to the list of spare parts that is presented in Task 7.

Availability of spare parts means that professional repairers and for some of the spare parts also end-users should be able to get spare parts to for a minimum period of 10 years after the last unit of the model is placed on the market.

Repair and maintenance information means that the manufacturer, importer or authorised representative should provide access and all repair and maintenance information to professional repairers and to end-users.

#### *6.2.6.2 Increase of recyclability (BC1-BC6)*

The design option consists of increasing the recyclability by setting requirements to dismantling (see above) for material recovery and recycling:

- Products shall be designed in such a way that materials/components in Annex VII to Directive 2012/19/EU can be removed with the use of commonly available tools (the WEEE directive).Manufacturers, importers or authorised representatives shall fulfill the obligations laid down in Article 15, Point 1 of Directive 2012/19/EU.

## 6.3 LCA and LCC impacts

The LCA impact is calculated using the EcoReport Tool for each base case and each design option like it was done for BAU in Task 5. The results are presented in the following subsections in form of total primary energy consumption and total water consumption over the full life cycle i.e. production, distribution, use and end-of-life (disposal and recycling) for all the relevant design options and for BAU for each base case.

No other impact parameters are presented, because GHG and other emission types correlate mostly with the energy consumption. Eutrophication ($PO_4$) correlate with the detergent consumption, but when there are no specific design options for detergent, meaning that the impact on eutrophication will be proportional to the detergent consumption which correlates to water consumption.

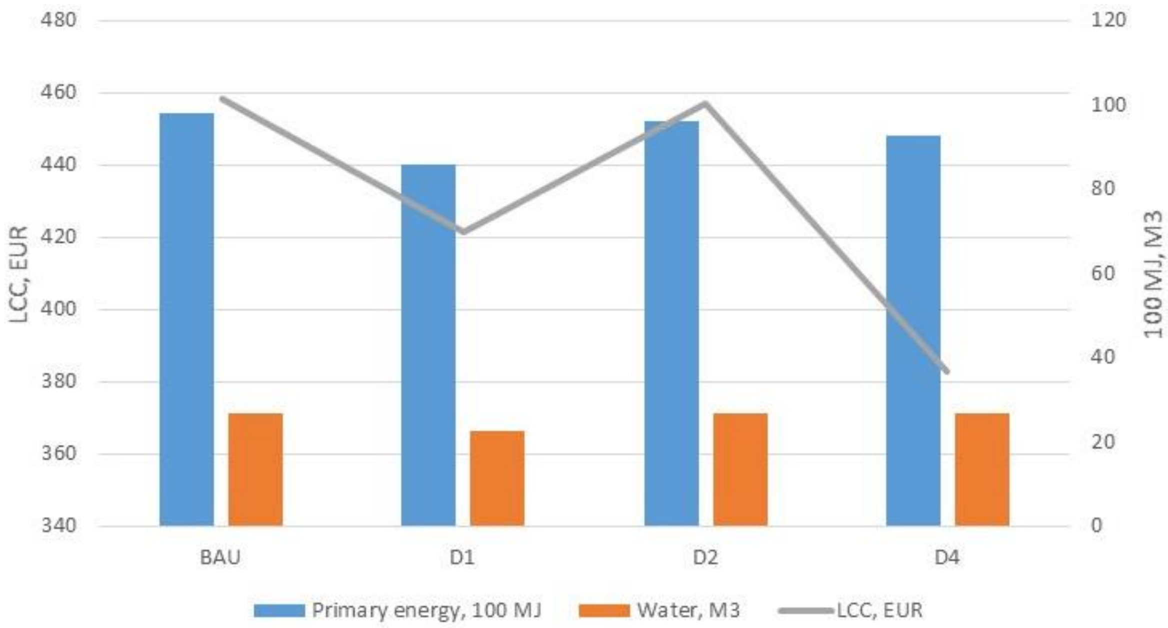
The LCC per unit is calculated using the EcoModelling Framework Tool, which sums the purchase cost, the annual repair and maintenance costs and the annual electricity, fuel and water costs (consumption multiplied with the unit price for electricity, fuel and water, respectively) over the full lifetime. The data presented are for products purchased in year 2018.

For D4, improvement of durability, the average lifetime is longer than for the other design options, 13.5 years compared to 9.5 years. In order to be able to compare with BAU and the other design options, energy and water consumption and LCC is converted to 9.5 years average lifetime using the proportion 9.5/13.5.

### 6.3.1 LCA and LCC for BC1: Domestic HPC cold water electric motor

In Figure 24 is shown the results of the calculations for BC1: Domestic HPC cold water electric motor.

Figure 24. BC1 in BAU and with design options 1, 2 and 4. Impact on primary energy and water consumption and LCC is shown. Constant 2015-EUR.




The figure shows that the LLCC is achieved for D4: Improvement of durability, resulting in 16.5% less LCC compared BAU. The main reason is that manufacture cost represents a high share of the life cycle cost of domestic HPCs, due to the low usage, so the margin of improvement is significant. Manufacture costs can be reduced by increasing the frequency of use, as can be seen for professional products, or extending the lifetime of the product.

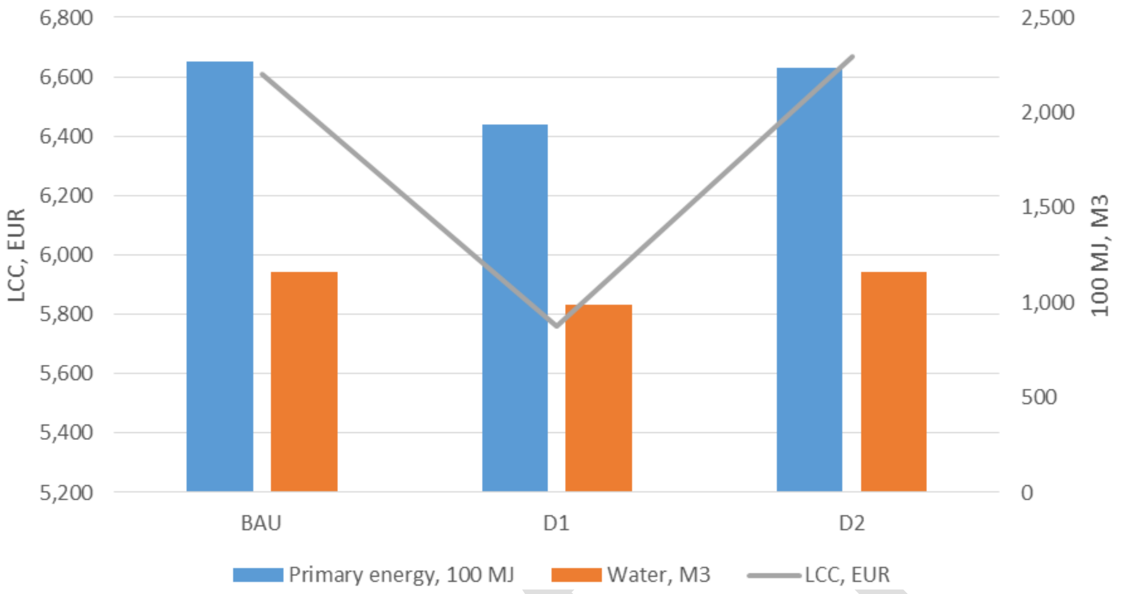
D1: Improvement of nozzle design results in lowest energy and water consumption. This design option entails savings on water, detergent and energy consumption per cleaning cycle. Therefore, it shows the most balanced results in terms of impacts (12% less energy and 15% less water consumption) and life cycle costs (8% less LCC). However, this design option would require a harmonised test method to measure the water and energy consumed per cleaning cycle that is not available. According to manufacturers, the development of a representative test method would be very complex due to the wide range of uses of HPCs.

D2: Increase of electric motor-pump efficiency does not result in significant improvements for domestic products. As mentioned before, this is due to the high share of the manufacture phase on the impacts for domestic HPCs. The life cycle cost is not much affected either since this option would only save electricity during the use phase but not water or detergent. The impact of this design option at EU level will be analysed in Task 7.

### 6.3.2 LCA and LCC for BC2 and BC3: Professional HPC cold water electric motor 1 phase and 3-phase

In Figure 25 is shown the results of the calculations for BC2: Professional HPC cold water electric motor 1 phase.

Figure 25. BC2 in BAU and with design options 1 and 2. Impact on primary energy and water consumption and LCC is shown. Constant 2015-EUR.

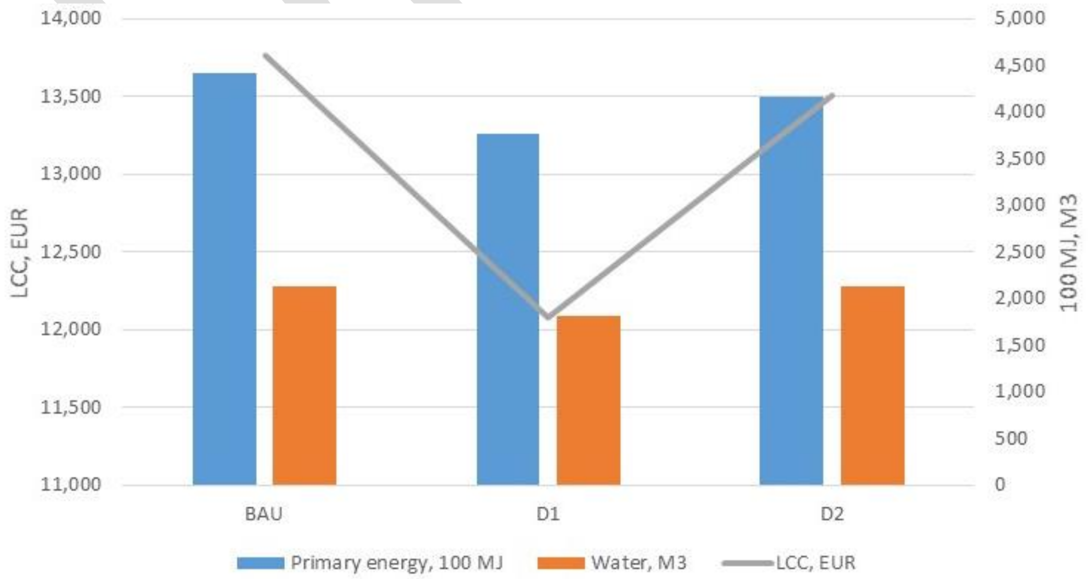



The figure shows that the LLCC is achieved for D1: Improvement of nozzle design, resulting in 13% less LCC compared BAU. It also has the lowest energy (15% reduction) and water consumption (13% reduction). The improvement is more significant due to the higher share of the use phase in life cycle of professional products. However, the lack of a harmonised test method is also an obstacle in this case.

D2: Increase of electric motor-pump efficiency would result in an increase of LCC (0.9%) and reduction of primary energy of (1.2%).

In Figure 26 is shown the results of the calculations for BC3: Professional HPC cold water electric motor 3 phases. The results show a similar pattern to BC2, though LCC and energy and water consumption are larger, since they are larger machines. D1 would result in a LCC saving of 12% and the energy and water consumption would be reduced by 15%. D2 would increase the LCC by 2% and decrease the energy 15%.

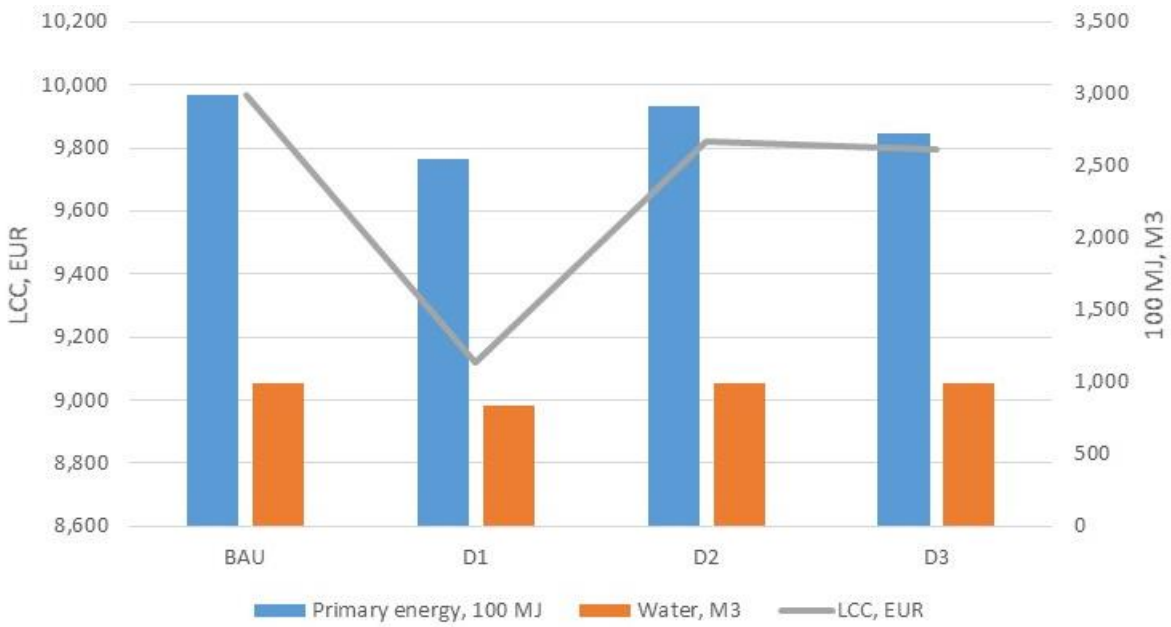
Figure 26. BC3 in BAU and with design options 1 and 2. Impact on primary energy and water consumption and LCC is shown. Constant 2015-EUR.



### 6.3.3 LCA and LCC for BC5 and BC6: Professional HPC hot water (fuel burner) electric motor 1 phase and 3-phase

In Figure 27 is shown the results of the calculations for BC5: Professional HPC hot water (fuel burner) electric motor 1 phase.

Figure 27. BC5 in BAU and with design options 1, 2 and 3. Impact on primary energy and water consumption and LCC is shown. Constant 2015-EUR.

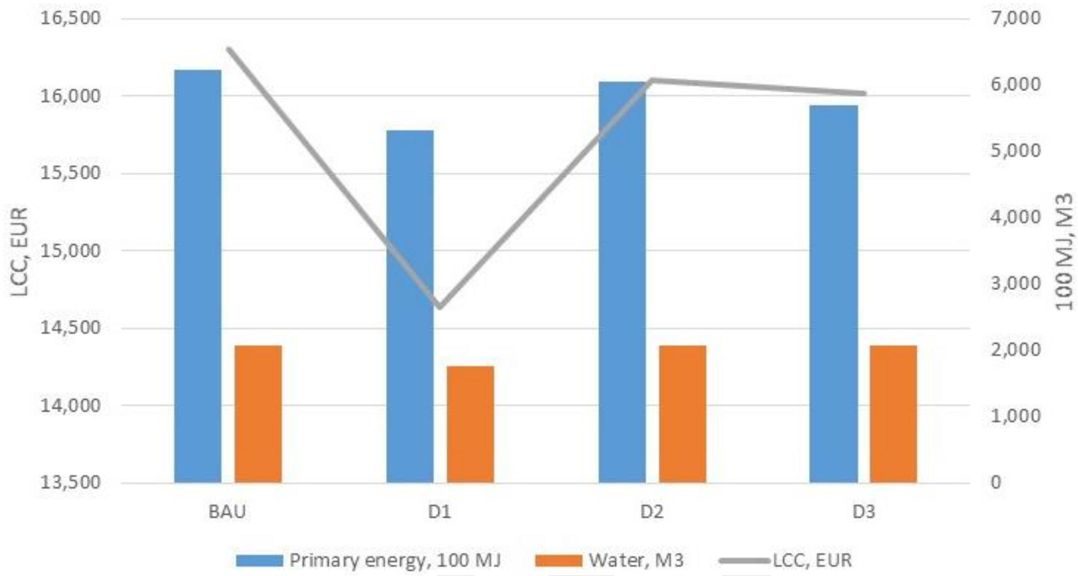



The figure shows that the LLCC is achieved for D1: Improvement of nozzle design, which also results in lowest energy and water consumption, showing similar results than the cold water machines.

D2: Increase of electric motor-pump efficiency results in a less significant reduction in the energy consumption, compared to cold water machines (0.7% reduction). This is due to the share of the fuel consumed by the burner in the energy consumed at the use phase. For this same reason, D3: Increase of hot water fuel burner efficiency results in larger energy savings (9% reduction) compared to D2. The LCC is increased by both design options: D2 results in 5% higher LCC, and D3 in 2%

In Figure 28 is shown the results of the calculations for BC6: Professional HPC hot water (fuel burner) electric motor 3 phases. The results show a similar pattern to BC5, though LCC and energy and water consumption are larger, since they are bigger machines. D1 would result in a LCC saving of 10% and the energy and water consumption would be reduced by 15%. D2 would increase the LCC by 4% and decrease the energy 8%. D3 would result in LCC 0.3% less than BAU, and 9% less energy.

Figure 28. BC6 in BAU and with design options 1, 2 and 3. Impact on primary energy and water consumption and LCC is shown. Constant 2015-EUR.




## 6.4 Conclusions

### Domestic HPCs

The design option D1: Improvement of nozzle design has a significant potential to reduce energy and water consumption, and also LCC. D3: Improvement of the motor-pump efficiency would result in modest energy and LCC savings. D4: Improvement of durability is the design option with the largest energy and water savings potential. LCC would be also reduced. These three design options will be considered to propose policy options in Task 7, and their impact at EU level will be modelled and analysed.

### Professional HPCs

The design option D1: Improvement of nozzle design has a significant potential to reduce energy and water consumption, and also LCC. D3: Improvement of the motor-pump efficiency would result also result in energy savings, and would increase the LCC due to the additional cost of manufacture. This increase is larger in 3-phase units. D3: Improvement of the burner efficiency has the potential to reduce 9% energy. This saving would slightly increase the LCC for single-phase units and decrease it for three-phase units. These three design options will be considered to propose policy options in Task 7, and their impact at EU level will be modelled and analysed.

# 7 Policy analysis and scenarios

## 7.1 Introduction

In accordance with the MEErP methodology, this Task 7 report collects the information of all previous tasks and looks at suitable policy instruments and measures to achieve the potential e.g. implementing LLCC as a minimum and BAT as a promotional target, using legislation or voluntary agreements, labelling, benchmarks and possible incentives. It draws up scenarios until 2050 quantifying the improvements that can be achieved versus a Business-as-Usual scenario.

It makes an estimate of the impact on the industry and the consumers. Finally, in a sensitivity analysis of the main parameters it studies the robustness of the outcome.

## 7.2 Policy analysis

### 7.2.1 Stakeholder consultation

Stakeholder consultation and stakeholder input is necessary for the technical study and the following policy process. JRC has established a dedicated web site[7] as a communication hub (information, registration, documents, etc.) combined with e-mail submissions to the registered persons and organisations.

Stakeholders include the industry (OEMs and component manufacturers), industry associations, Member States, consumer and environmental organisations.

Formal stakeholder consultations carried out were a 1st Technical Working Group (TWG) held on 3 May 2018 in Brussels and a 2nd stakeholder meeting held as a webinar over two days (23 and 24 January 2019). A 3rd stakeholder meeting is to be held on 17 June 2019.

Additionally, separate meetings and telephone conferences were held with industry associations and manufacturers throughout the study.

### 7.2.2 Barriers and opportunities for improvements

The basis for identifying the policy measures is the assessment of barriers and opportunities for improvements identified in the previous Tasks 4, 5 and 6. Data from all the previous tasks have been used for the analyses in this report.

Based on the above assessments, five design options were selected for analyses in Task 6:

- D1: Improvement of nozzle design (BC1-BC6)
- D2: Increase of electric motor-pump efficiency (BC1-BC3, BC5-BC6)
- D3: Increase of hot water fuel burner efficiency (BC5-BC6)
- D4: Improvement of durability (BC1)
- D5: Improvement of reparability (BC1)

D1 was deselected, see further in a following section.

The base cases defined in Task 5 and used in Task 6 are:

- BC1: Domestic HPC cold water electric motor
- BC2: Professional HPC cold water electric motor 1 phase

7 http://susproc.jrc.ec.europa.eu/HighPressureCleaners

- BC3: Professional HPC cold water electric motor 3 phases
- BC4: Professional HPC cold water combustion motor
- BC5: Professional HPC hot water (fuel burner) electric motor 1 phase
- BC6: Professional HPC hot water (fuel burner) electric motor 3 phases

### 7.2.3 Policy instruments

There are several policy instruments available, which could be used to regulate high pressure cleaners (HPCs) aiming at a better environmental performance. The main types of policy instruments are presented in the following.

#### *7.2.3.1 Ecodesign requirements*

Ecodesign requirements (under the Ecodesign Directive (2009/125/EC)[8]) means that mandatory minimum requirements would be introduced for a set of parameters; the manufacturers would bear the responsibility for their products to be compliant when placed on the market and the Member States would verify compliance via market surveillance activities. This acts as a "push" instrument for products to achieve better performance because all appliances will have a minimum level of energy efficiency performance regulated by the implementing measure.

#### *7.2.3.2 Energy labelling*

Energy labelling (under the Energy Labelling Regulation (2017/1369/EU)[9]) implies mandatory labelling of the product for a set of parameters and with an A to G scale (A indicates best level). Manufacturers are responsible for labelling their products and the labelling is enforced by Member State market surveillance regarding both the actual labelling and the correct energy class. This acts as a "pull" instrument because the consumers will choose the products they want to purchase, which can pull the market towards higher energy performance.

The energy label can contain further information than the energy class e.g. via icons and numbers content of specific substances, noise etc.

A combination of ecodesign requirements and energy labelling is possible, where ecodesign will remove the least environmentally performing products from the market and energy labelling will promote the better environmentally performing products.

#### *7.2.3.3 Self-regulation*

Self-regulation is as an alternative to Ecodesign requirements. The Ecodesign Directive (2009/125/EC) recognizes self-regulation by industry as an alternative to binding legislation. Self-regulation, which can be based on voluntary agreements, is a valid alternative as long as it delivers the policy objectives set out in the legislation faster and in a less costly manner than mandatory requirements. Self-regulation is not initiated by the Commission, but by the manufacturers proposing a self-regulative mechanism to the Commission. The directive gives specific requirements for self-regulative measures such as a sufficiently high market coverage.

#### *7.2.3.4 Voluntary labelling*

Voluntary labelling implies that manufacturers can choose whether to label their products. In the case of the EU Ecolabel[10], the specifications are established through

8 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0125

9 Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU

10 Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel

regulations, ensuring that the labelled product belongs to the upper segment of the market in terms of energy consumption and other environmental aspects. Member States are responsible for market surveillance.

#### *7.2.3.5 Recommended policy instruments*

Energy labelling is also seen as an effective policy instrument for promoting more efficient products. However, energy labelling or Ecodesign water and energy efficiency will require the development of a standard to measure the cleaning performance of HPC and to establish the label classes. In the case of high pressure cleaners, the absence of a harmonised standard leads to lack of comparable measurements of energy consumption needed to develop Energy labelling instruments. For this reason, it is recommended to include in the first revision of the Ecodesign regulation an assessment of possible energy labelling requirements.

Self-regulation in the form of a voluntary agreement has been not been considered as an option because this has not been proposed by the manufacturers.

A voluntary industry labelling scheme already exists, which the "EUnited Cleaning Burner Efficiency" is labelling scheme which is based on the EN IEC 62885-5:2018 standard that applies to burners of oil-heated HPCs, which have to meet requirements on thermal exhaust loss, CO emissions, and dust emissions. This is however not a label which fulfils the requirement for a self-regulative initiative or a voluntary labelling. Voluntary labelling has furthermore the disadvantage that the market coverage may not be high and thereby the impact low.

### 7.2.4 Policy measures

The design options presented in Task 6 have been selected for further assessment as specific requirements.

#### *7.2.4.1 No action - Business as Usual (BaU)*

The business as usual option is based on no further interventions than already taking place or agreed on and therefore is a no action scenario. The BaU option will be used as reference for comparison with other policy scenarios. The development in environmental impact over the scenario period is based on the development of the sales and stock of HPC products.

#### *7.2.4.2 D2: Increase of electric motor-pump efficiency (BC1-BC3, BC5-BC6)*

The policy measure sets a minimum efficiency requirement of the electric motor-pump assembly used for HPCs.

An ecodesign implementing measure is already in place for certain types of electric motors defined in an amended regulation[11,12]. Motors in scope include squirrel cage induction motor (i.e. not universal motors), which are rated on the basis of continuous duty operation. Motors that are completely integrated into a product (for example gear, pump, fan or compressor), of which the energy performance cannot be tested independently from the product, are not in the scope of the measure. A majority of the motors on the market fall outside of the scope of the regulation, and where they fall within the scope, the measure only addresses the motor, not the pump. This existing measure will therefore not sufficiently ensure high efficiency of the motor-pump.

[11] Commission Regulation (EC) No 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors OJ L 191, 23.07.2009

[12] Commission Regulation (EU) No 4/2014 of 6 January 2014 amending Regulation (EC) No 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors OJ L 2, 7.1.2014

The minimum efficiency requirement proposed in this measure will be based on a proxy for the efficiency calculated as maximum working pressure (MPa) multiplied with maximum flow rate (litres/second) and divided by connection load (kW) based on the technical specifications for the HPC. The first term in the equation (pressure multiplied with flow rate) is the output power from the motor-pump and the second term (connection load) is the input power.

The minimum efficiency requirement proposed in this measure will be based on a proxy for the efficiency calculated as maximum working pressure (MPa) multiplied with maximum flow rate (litres/second) and divided by connection load (kW) based on the technical specifications for the HPC. The first term in the equation (pressure multiplied with flow rate) is the output power from the motor-pump and the second term (connection load) is the input power.

Threshold levels have been set aiming at removing the least efficient products, see Figure 29, Figure 30 and Figure 31 for domestic, professional 1 phase and professional 3 phases.

Figure 29. Threshold proxy efficiency levels for domestic HPCs ≤ 2 kW and > 2 kW. Total number of datapoints is 35.

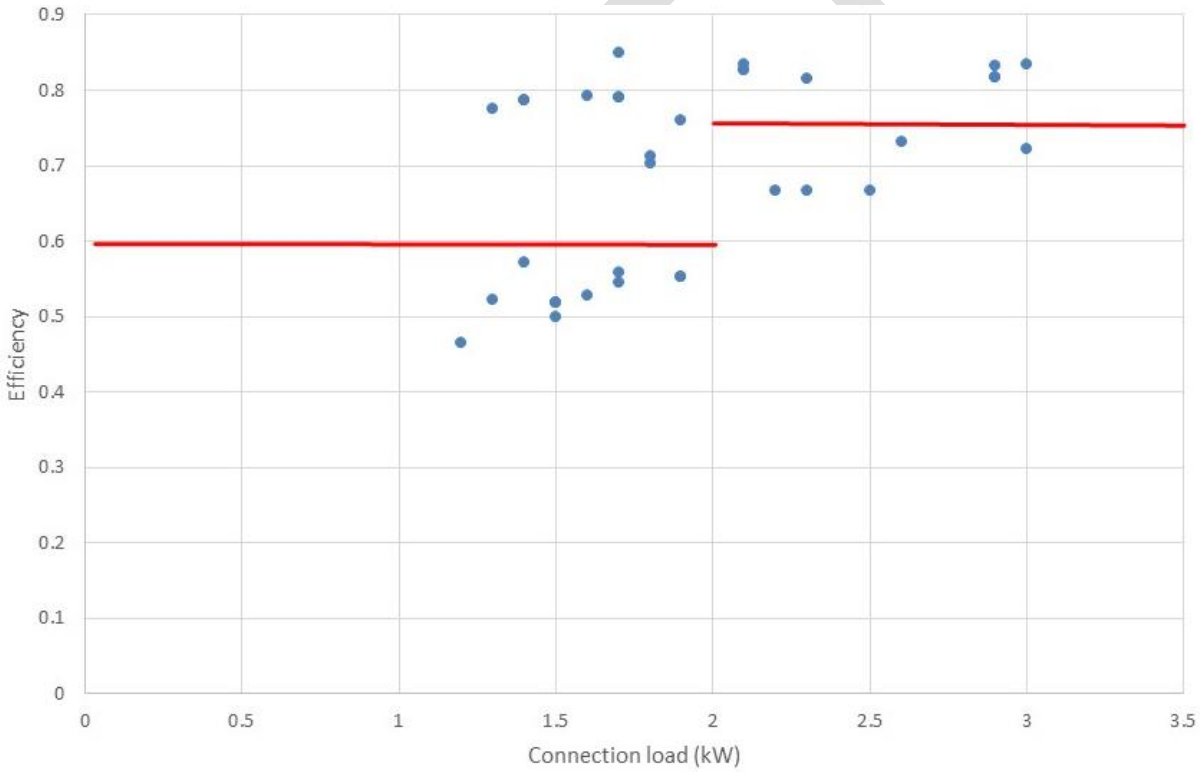


Figure 30. Threshold proxy efficiency level for professional HPCs 1 phase. Total number of datapoints is 20.

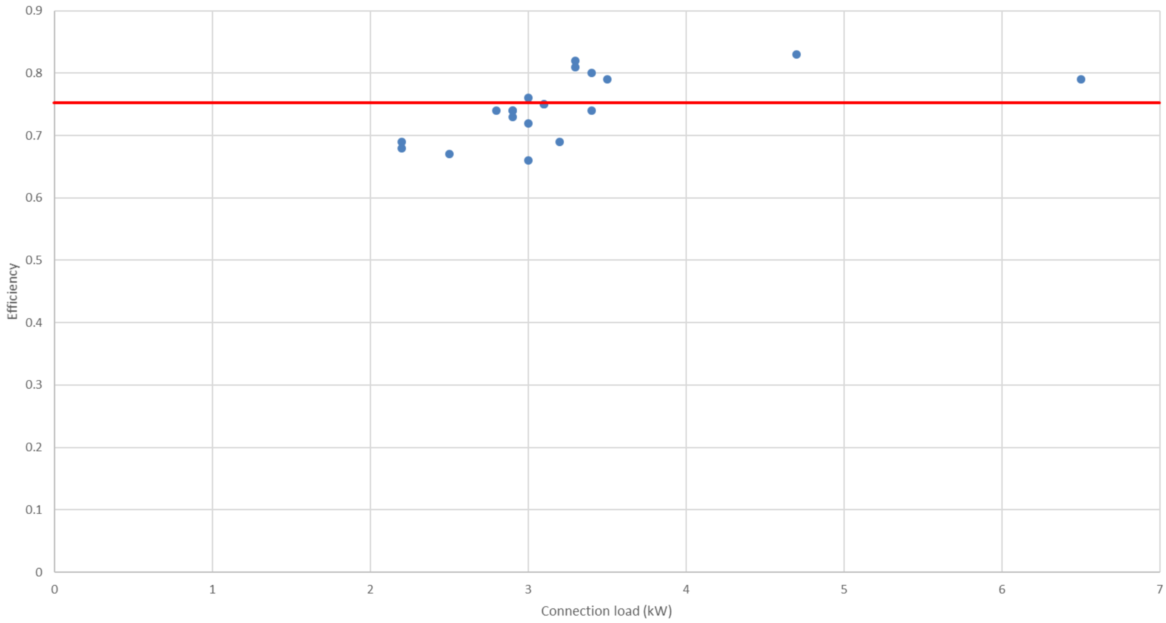
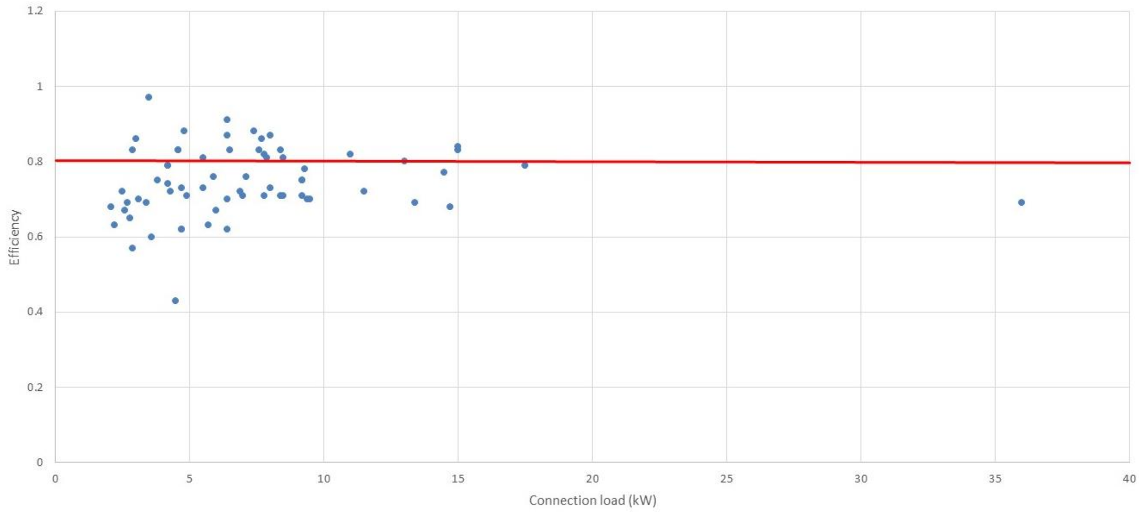



Figure 31. Threshold proxy efficiency level for professional HPCs 3 phases. Total number of datapoints is 67.




The proposed requirements for the proxy efficiency of electric motor-pump, based on the limited amount of datapoints and the associated savings are presented in Table 12.

Table 12. Proposed requirements for the proxy efficiency of electric motor-pump and the associated savings.

| HPC type | Threshold proxy efficiency | Savings |
|---|---|---|
| Domestic < 2 kW | 0.6 | 11% |
| Domestic > 2 kW | 0.75 | 16% |
| Professional 1 phase | 0.75 | 6% |
| Professional 3 phases | 0.8 | 12% |

The proposed date of effect is January 2025, assuming publication of the measure in beginning of 2022 and adding a transitional period for compliance.

A transitional test method needs to be developed and published around the same time as the publication date.

#### *7.2.4.3 D3: Increase of hot water fuel burner efficiency (BC5-BC6)*

The policy measure sets a minimum efficiency requirement of the hot water fuel burner efficiency used for HPCs. The requirement is proposed to be in line with the EN IEC 62885-5:2018[13], which is based on exhaust thermal losses. The threshold values for the fuel burner efficiency are presented in Table 11.

Table 13. Thermal requirements for increasing fuel burner efficiency.

| Net power of heater P (kW) | Max. thermal loss $q$A (%) |
|---|---|
| 4 ≤ P ≤ 25 | 11 |
| 25 > P ≤ 50 | 10 |
| P > 50 | 9 |

As presented in Task 6 report, about 75% of products on the market are assumed to comply with the requirements. An average non-complying model with a net power of above 50 kW (which most of the professional heaters with fuel burner are) is assumed to have a thermal efficiency of 80% based on stakeholder input. The fuel savings of increasing the thermal efficiency from 80% to 91% (equal to 9% thermal losses) are 12%. The proposed effective date is January 2025, assuming publication beginning of 2022 and a transition period for compliance. The test method is the one of the EN IEC 62885-5:2018[7].

#### *7.2.4.4 D4: Improvement of durability*

The policy measure sets a minimum lifetime performance requirement aiming at ensuring a minimum lifetime performance for the domestic HPCs. The threshold level is **90 hours** corresponding to 8 years of use assuming around 1 hour of use per month.

A test method should be developed, where the test is based on a certain number and duration of usage cycles. An example of such test method has been provided by a stakeholder, who has tested a number of HPCs on the market: The test consists running a number of cycles, with each cycle having 40 minutes duration as described below:

- 15 minutes with highest pressure and maximum water flow
- 3 minutes with closed nozzle jet and the machine on
- 12 minutes with highest pressure and maximum water flow
- 10 minutes with the machine switched off

Each cycle has thus 27 minutes of active use at maximum load and with a requirement of 90 hours. This would mean that the HPC should operate for at least 200 cycles with pressurized water flowing, without motor or pump or nozzle breakage and without water leakages. This will be further described as part of the test method that would be developed.

The proposed effective date is January 2025, assuming publication beginning of 2021 and a transition period for compliance.

[13] https://webstore.iec.ch/publication/27171

#### *7.2.4.5 D5: Improvement of reparability*

The measure sets requirements on easy access to main components, availability of spare parts, and mandatory repair and maintenance information resulting in improved repairability potential, affecting mainly for domestic HPC as explained above, and thereby increased lifetime of domestic HPCs. This measure can be either an alternative or a supplement to the previous policy measure D4: Improvement of durability (BC1). The impact is naturally different for these two cases. More specifically includes the following:

- *Disassembly requirements* which means that the main components of an HPC should be easily accessible in a non-destructive way, allowing professionals and/or end-users to replace them according to instruction described in the repair-maintenance manual provided by the manufacturer and the spare parts that would be available.
- *Availability of spare parts* means that professional repairers and for some of the spare parts also end-users should be able to get spare parts to for a minimum period of 10 years after the last unit of the model is placed on the market.
- *Repair and maintenance information* means that the HPC manufacturer or importer or authorised representative shall provide access and manuals for repair and maintenance to professionals' personnel; as well as all relevant information to end-users for repair and maintenance operations by themselves for the failures that do not entail potential health and safety issues.

The proposed effective date is January 2025, assuming publication in beginning of 2021. The specific requirements are included in Annex I, and cover:

- Non-destructive access (disassembly) to critical components
- Spare parts availability
- Repair and maintenance manuals

#### *7.2.4.6 Ecodesign or Energy labelling based on cleaning performance*

The Task 6 assessments showed that D1: Improvement of nozzle design (BC1-BC6), can reduce the energy, water and detergent consumptions with 15% with maintained cleaning quality for all the base cases with a limited retail price increase of 16 and 24 EUR/unit for domestic and professional HPCs, respectively.

However, its implementation would require a cleaning performance measurement method. Methods exist already; however, there are no harmonised methods available capturing main usage situations. The industry stakeholders have informed that such method would be difficult to develop, since there is a wide variety of surfaces and soils that the test should be able to represent. In order to achieve a robust and reliable test method, it should be developed by the European Committee for Standardization, possibly in response to a standardisation request that may encompass all the relevant test methods for this product group. This would deliver a dataset representative enough for the development of Ecodesign minimum requirements and/or Energy labelling.

### 7.2.5 Summary of policy scenarios

In Table 14 we present a summary of the policy scenarios.

Table 14. Summary of policy options*

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Domestic + Professional HPC | Energy Labelling and/or Ecodesign criteria based on cleaning performance (to be considered for the revision) [1, 2] | Energy Labelling and/or Ecodesign criteria based on cleaning performance , [2] (to be considered for the revision) [1, 2] | |
| | Motor-Pump efficiency Ecodesign criteria [3] | | |
| Hot water HPC | Fuel burner efficiency Ecodesign requirement [4] | Fuel burner efficiency Ecodesign requirement [4] | Fuel burner efficiency Ecodesign requirement [4] |
| Domestic & Professional HPC | Durability requirements ED<br>Threshold: 90hours as minimum lifetime performance<br>Method: 200 cycles[5] | Durability requirements ED<br>Threshold: 90hours as minimum lifetime performance<br>Method: 200 cycles[5] | Durability requirements ED<br>Threshold: 90hours as minimum lifetime performance<br>Method: 200 cycles[5] |
| Domestic & Professional HPC | Reparability requirements [6] | Reparability requirements [6] | Reparability requirements [6] |

* ***options indicated in green can be taken up in the regulation directly, those in orange can be considered in its revision.***

[1] Based on a cleaning performance efficiency standard, which will be developed possibly in response to a standardisation request covering all parameters relevant for this product group.

[2] Energy Labelling and/or Ecodesign requirements will be considered in the revision of the regulation

[3] As transitional method to measure maximum working flow and pressure and input power to be developed

[4] In line with EN IEC 62885-5

[5] Cycle: 15 minutes with highest pressure and maximum water flow - 3 minutes with closed nozzle jet and machine on – 12 with highest pressure and maximum water flow – 10 minutes with the machine switched off

[6] Repairability requirements (see Annex I for details): i) non-destructive access (disassembly) to critical components; ii) spare part availability; iii) repair manuals

## 7.3 Scenario analysis

### 7.3.1 Methodology for scenario modelling on environmental impacts

The Ecomodelling Framework Tool developed on behalf of Joint Research Centre, Seville, has been used for the scenario modelling. The policy areas of potential use of the model are ecodesign, energy label, ecolabel, green public procurement (GPP), extended product responsibility and product end-of-life policy. It is based on a bottom-up sales and stock model, an LCC (life cycle costs) and LCA (Life Cycle Assessment) model, importing data from Ecoreport tool based on BOM (Bill Of Material) and consumption of energy, water and detergent calculated in Task 3. The scenario modelling gives the impact on energy, environment, economy and employment.

#### *7.3.1.1 Policy options modelling*

Each policy option has been modeling as follows:

- Energy Labelling and/or Ecodesign criteria based on cleaning performance efficiency: the lack of harmonised test method to measure cleaning performance hinders the availability of data needed to model this policy option. The analysis carried out in Task 6 suggested that the variation in energy consumption in domestic units is allocated in similar shares among the effect of the motor-pump efficiency and the effect of the nozzle design. Therefore, it is assumed that this option would add the same the effect of Motor-pump efficiency criteria when they are combined in Scenario 1, and that would entail double savings of Motor-pump efficiency criteria in Scenario 2. However, it is important to highlight that this assumption is very uncertain and the results of the modelling must be taken into account with caution.
- Motor-pump efficiency Ecodesign criteria for domestic and professional HPCs: it is assumed that non-compliant units represent 50% of the market. The saving potential described in section 7.2.4.2 would affect to 50% of new sales.
- Fuel burner efficiency Ecodesign requirement: it is assumed that the average fuel burner efficiency of non-compliant burners is 80% and that non-compliant burners represent 30% of the market. The saving potential described in section 7.2.4.3 would affect to 30% of new sales.
- Durability requirements: see section 7.3.1.2
- Reparability requirements: see section 7.3.1.2

#### *7.3.1.2 Modelling the effect of durability and repairability requirements*

Both ‘durability’ and ‘repairability’ requirements that are proposed should be applied to all HPC categories as defined by the scope in Task 1, for domestic and professional HPC. However, professional HPC are more durable than domestic HPC as are manufactured with higher quality materials and components, and should already comply also with the repairability requirements. Therefore, both proposed Ecodesign requirements are expected to affect mainly the domestic HPC category, and thus, the modelling of durability-repairability requirements was performed only on BC1. Both durability and repairability requirements are proposed as horizontal Ecodesign requirements applied for all HPC.

As mentioned above the durability requirements will assure a minimum lifetime performance of 90 hours of use, which are defined by 200 prescribed cycles (see 7.2.4.4). To capture the effect of the extended durability, the so-called ‘delay’ factor in the Weibull lifetime distribution used in the Ecomodelling Framework Tool (see section

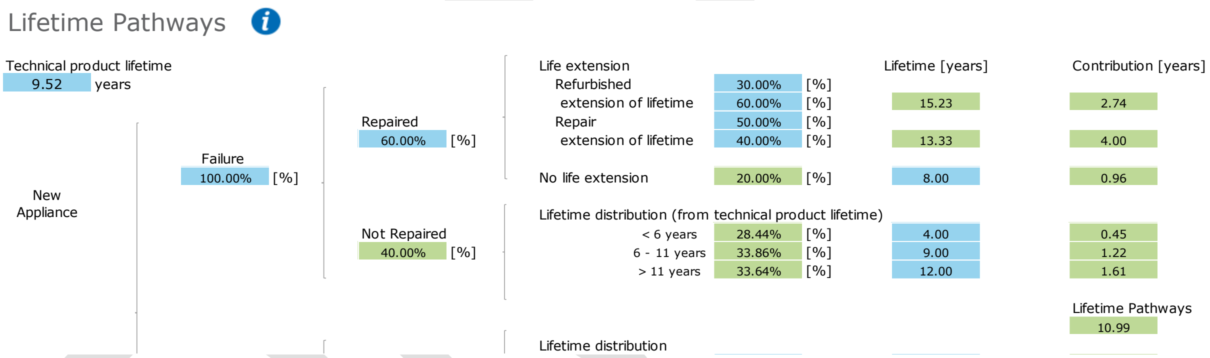
2.2.1.2 for the domestic HPC lifetime calculations) has been increased accordingly. In the BAU scenario the delay factor is 2 years representing the legal guarantee and for the extended durability, this value has been increased to 8 years. The reason for this is that a minimum 90 hours of lifetime performance for domestic HPC would assure the consumers at least of 8 years for normal use without any failure.

From the other hand, the repairability requirements will aid in the direction of extended the average lifetime extension of domestic HPC. To quantify this effect, a repairability scenario was constructed in the 'Lifetime Pathways' function of the Ecomodelling tool. This scenario, presented in Figure 32, assumes that from the failed HPC domestic units, 60% are going to be repaired. From these 60% fraction of the units that are going to be repaired:

- 30% regards major repair issues (mentioned as 'Refurbished') which could result in 60% lifetime extension.
- 50% regard minor repair issues which could results in 40% lifetime extension.
- 20% will not be repairable at all (assuming failing at their 8th year of use as average), thus will not have any lifetime extension.

Based on this lifetime pathway scenario the new average lifetime is calculated to be 11 years instead of 9.5 years of the BAU scenario.

Figure 32. The repairability lifetime pathway scenario and the incensement of the average lifetime for the domestic HPC (BC1).




The combination of the repairability and the durability requirements is then modelled by applying 8 years of 'delay' for the durability and 11 years of average lifetime in Ecomodelling tool. Figure 33 presents the new Weibull lifetime distribution for the repairability-durability combined scenario. Figure 34 presents the % percentage of retiring domestic HPCs for the BAU versus the combination of the repairability and durability requirements, divided into 5-years periods.

Figure 33. The new Weibull lifetime distribution for domestic HPC due to the repairability and durability requirements.

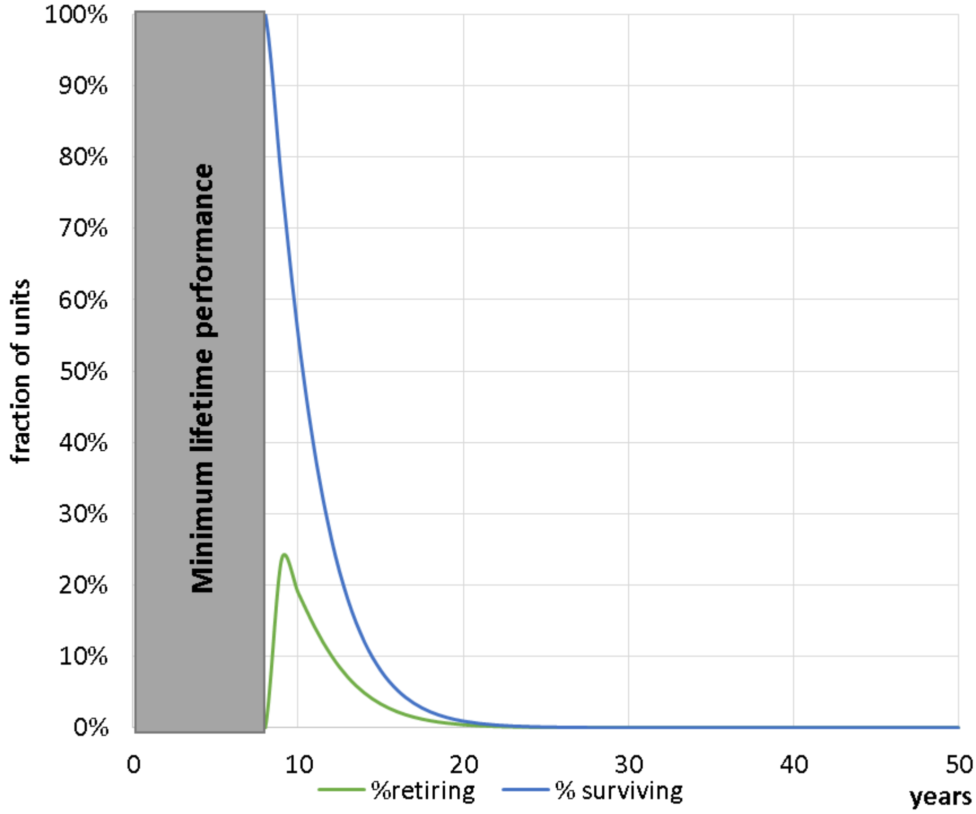
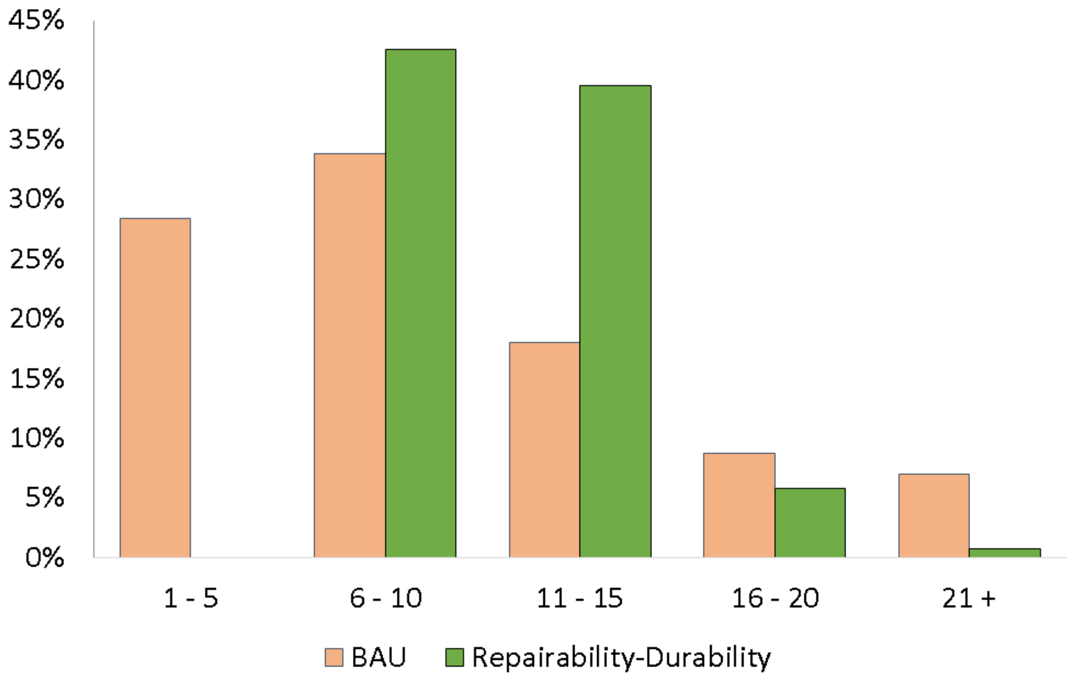



Figure 34. Percentage of retiring domestic HPCs divided into 5-years periods for BAU and for a combination of repairability and durability measures.

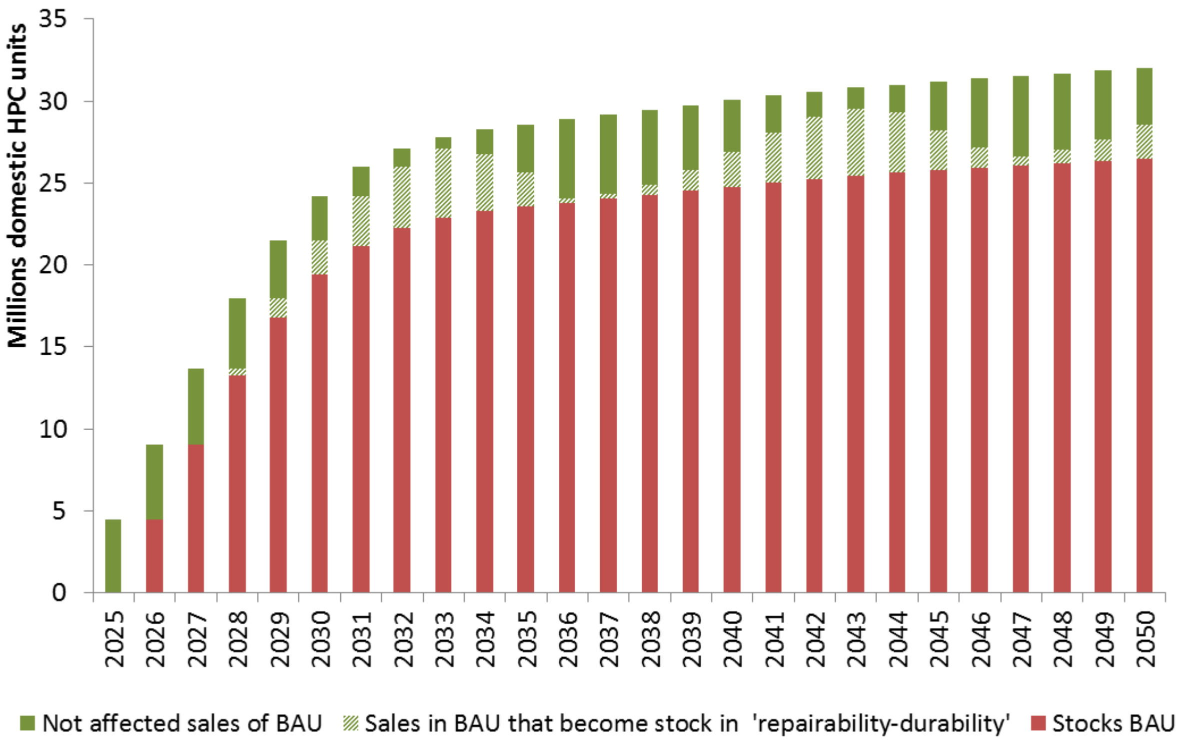



As can be seen from Figure 34, the 'Repairability-Durability' scenarios can swift the lifetime distribution of the domestic HPC to higher values. The first 8 years zero retiring units are expected due to the durability requirements, in contrast with the BAU scenario; however, for the following years a higher percentage of units are expected to fails in the 'repairability-durability' scenario compared with the BAU scenario. In total the average lifetime of the 'repairability-durability' scenario will be increased from 9.5 of the BAU to 11 years with a different distribution as presented in Figure 33.

Based on the above analysis of the new lifetime distribution, the new sales and stocks from 2025 to 2050 were calculated, assuming that the estimated overall units (sales and stocks) in the market will be the same as in the BAU scenario (see Task 2). This would mean that the share of new sales and stocks will change as result of the new lifetime distribution of the repairability-durability requirements without increasing the overall units, the summation of the new sales and stocks. As the average lifetime increases from 9.5 to 11 years in combination with the change of the lifetime distribution with the increased delay factor, the % of retiring units over time also change (see Figure 34), there will be a decrease in the new sales as the units will generally last longer as stock. A fraction of the new sales of the BAU scenario will be become stocks in the 'repairability-durability' scenario.

Figure 35 graphically presents this potential change in the share of new sales and stocks of the BAU versus the 'repairability-durability' scenario. The environmental impact savings were therefore calculated based on the avoided sales-produced domestic HPC units.

Figure 35. Stock and new sales of the BAU and of the repairability and durability measures.




The impact of the combination of durability and reparability requirements has been analysed for domestic HPCs only, because the main impact will be achieved for these. The requirements are however proposed to cover all HPCs in scope of the regulation to ensure that no HPCs will be a grey area and all comply with the minimum Ecodesign requirements.

## 7.3.2 Analysis and comparison of environmental impacts of scenarios

### *7.3.2.1 Scenario 1*

This scenario consists of:

- Domestic + Professional HPC: Energy Labelling and/or Ecodesign criteria based on cleaning performance efficiency - to be further analysed during revision.
- Domestic + Professional HPC: Motor-Pump efficiency Ecodesign criteria
- Hot water HPC: Fuel burner efficiency Ecodesign requirement
- Domestic & Professional HPC: Durability Ecodesign requirements
- Domestic & Professional HPC: Reparability Ecodesign requirements

The results of scenario 1 will be presented distinguishing between domestic and professional sectors, as follow:

- Scenario DOM 1: Energy Labelling and/or Ecodesign criteria based on cleaning performance efficiency + Motor-Pump efficiency Ecodesign criteria + Durability and reparability requirements
- Scenario PROF 1: Motor-Pump efficiency Ecodesign criteria + Fuel burner efficiency Ecodesign requirement + Durability and reparability requirements.

### *7.3.2.2 Scenario 2*

This scenario consists of:

- Domestic + Professional HPC: Energy Labelling and/or Ecodesign criteria based on cleaning performance efficiency - to be further analysed during revision
- Hot water HPC: Fuel burner efficiency Ecodesign requirement
- Domestic & Professional HPC: Durability Ecodesign requirements
- Domestic & Professional HPC: Reparability Ecodesign requirements

The results of scenario 2 will be presented distinguishing between domestic and professional sectors, as follow:

- Scenario DOM 2: Energy Labelling and/or Ecodesign criteria based on cleaning performance efficiency + Durability and reparability requirements
- Scenario PROF 2: Energy Labelling and/or Ecodesign criteria based on cleaning performance efficiency + Fuel burner efficiency Ecodesign requirement + Durability and reparability requirements.

### *7.3.2.3 Scenario 3*

This scenario consists of:

- Hot water HPC: Fuel burner efficiency Ecodesign requirement
- Domestic & Professional HPC: Durability requirements
- Domestic & Professional HPC: Reparability and fuel burner efficiency requirements

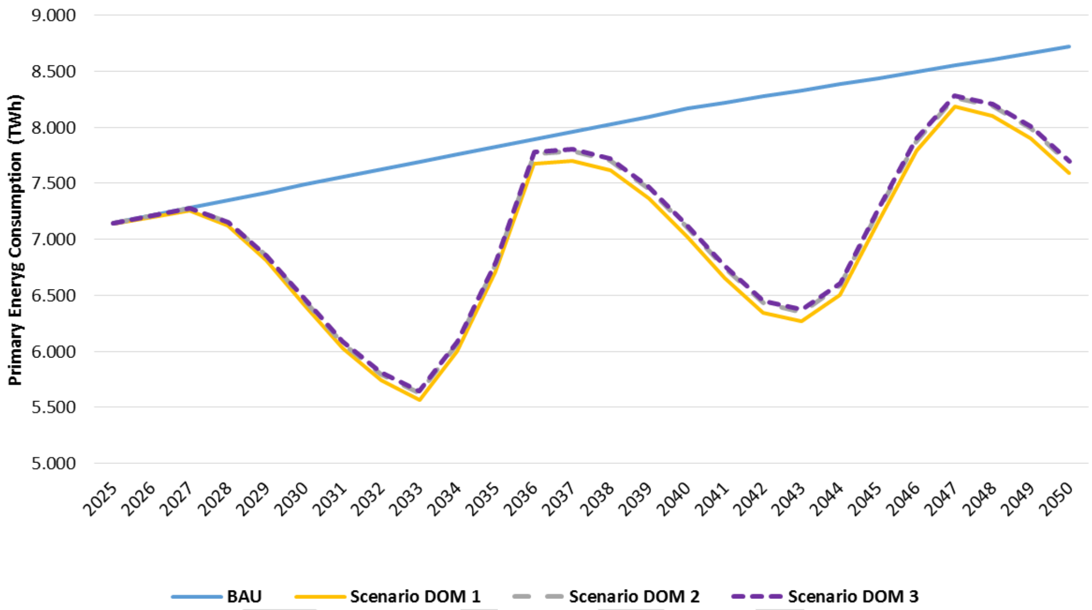
The results of scenario 3 will be presented distinguishing between domestic and professional sectors, as follow:

- Scenario DOM 3: Durability and reparability requirements
- Scenario PROF 3: Fuel burner efficiency Ecodesign requirement + Durability and reparability requirements.

#### *7.3.2.4 Domestic scenarios*

The total life cycle primary energy demand for the scenarios DOM 1, DOM 2 and DOM3 compared to BAU is shown in Figure 36.

Figure 36. Total primary energy demand for production, use and end-of-life of the domestic HPCs for BAU and the policy scenarios.




The primary energy savings are gathered in Table 15.

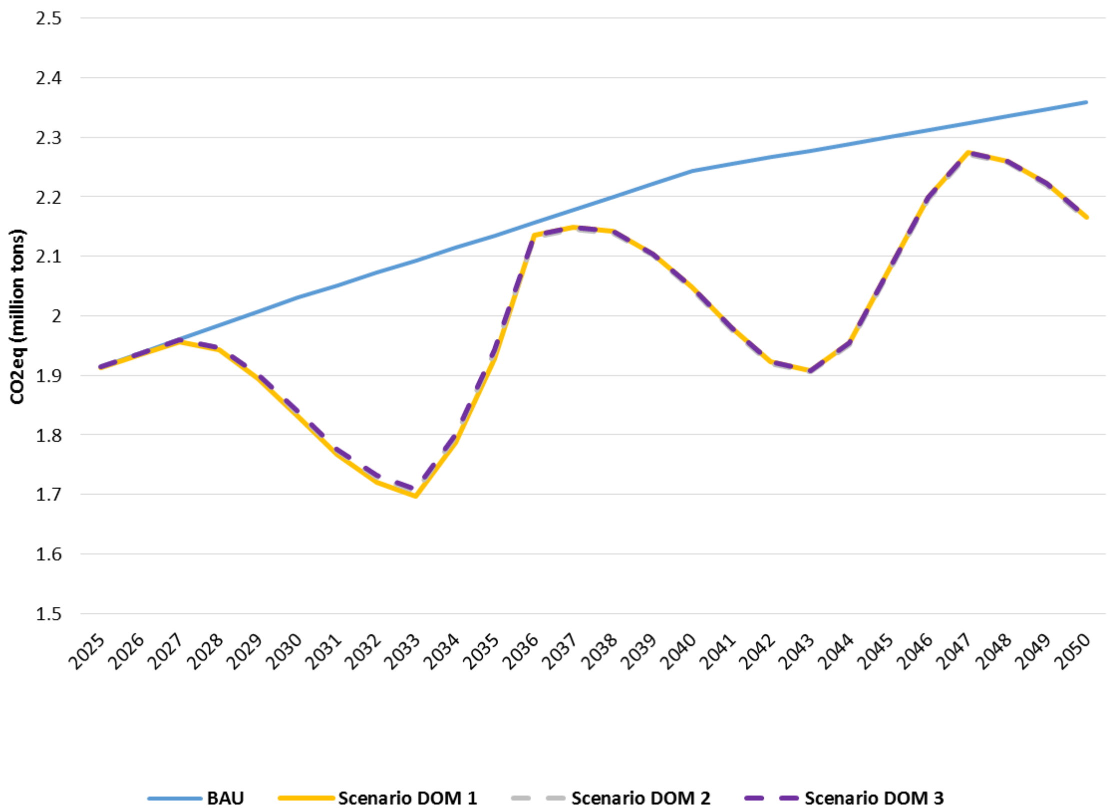
Table 15. Primary energy savings for scenarios DOM 1, DOM 2 and DOM 3 vs BAU scenario (TWh / as % of BAU)

| | 2030 | 2040 | 2050 | Cumulative (2025 - 2050) |
|---|---|---|---|---|
| Scenario DOM 1 | 1.08 / 14.4% | 1.14 / 14.0% | 1.13 / 13.0% | 25.30 |
| Scenario DOM 2 | 1.04 / 13.9% | 1.06 / 12.9% | 1.04 / 12.0% | 23.54 |
| Scenario DOM 3 | 1.02 / 13.7% | 1.04 / 12.7% | 1.03 / 11.8% | 23.18 |

Due to the fluctuation of the curve, the annual savings range from 12% to 14%, depending on which year is taken into account. The difference in cumulative primary energy savings between scenario DOM 3 and the other two scenarios is around 2 TWh, meaning that the Durability and reparability policy options would entail the largest shares of savings linked to the manufacture of HPCs. Scenario DOM 2 would add 0.4 TWh savings. Scenario DOM 1 would benefit of an earlier implementation that would increase the cumulative savings up to 25.3 TWh.

The total life cycle GHG emissions for the scenarios DOM 1, DOM 2 and DOM 3 compared to BAU are shown in Figure 37.

Figure 37 GHG emissions for production, use and end-of-life of the domestic HPCs for BAU and the policy scenarios




The GHG savings are gathered in Table 16. Similar to the primary energy savings, Durability and reparability policy options would entail the largest shares of savings linked to the manufacture of HPCs. Scenario DOM 2 would add 0.05 Mton CO2eq savings to Scenario 3. Scenario DOM 1 would benefit of an earlier implementation that would increase the cumulative savings up to 4.45 Mton CO2eq.

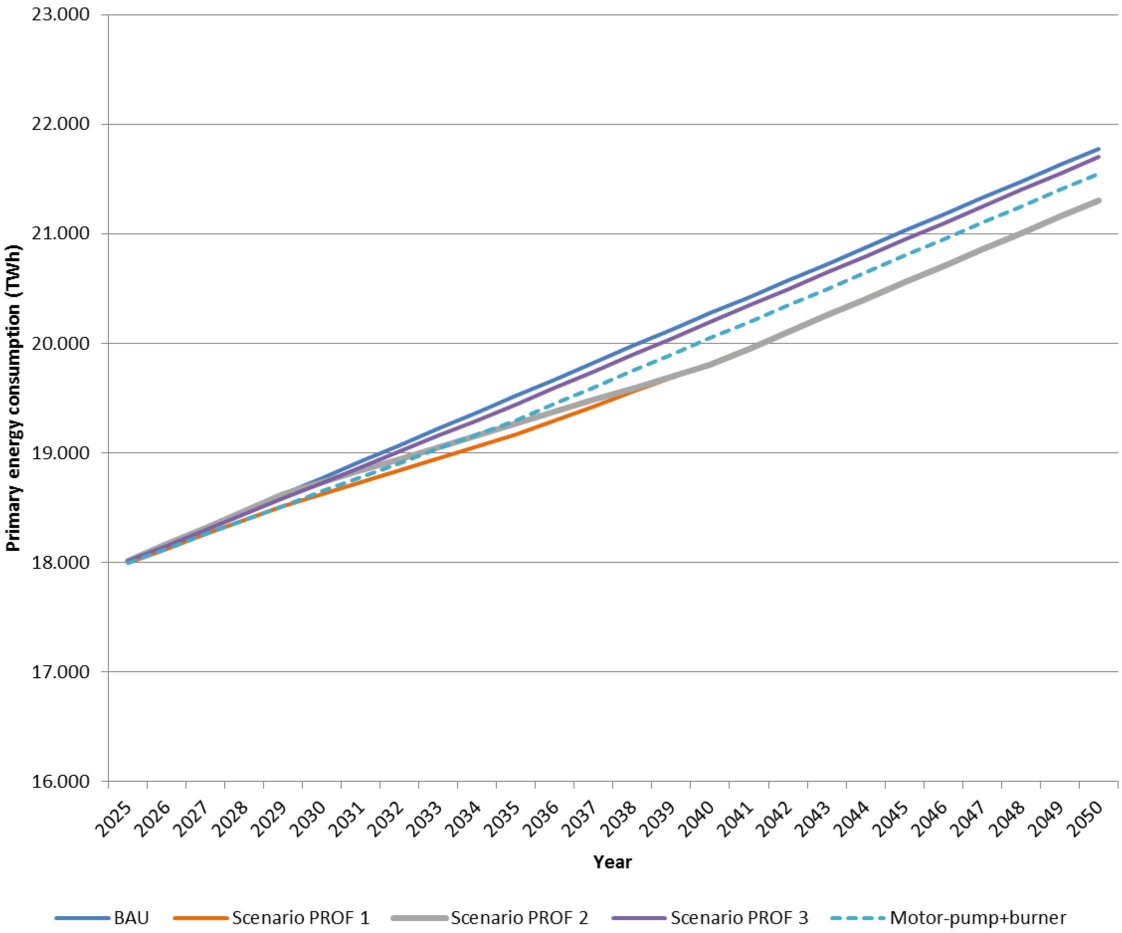
Table 16. COeq savings scenarios DOM 1, DOM 2 and DOM 3 vs BAU scenario (Mton / as % of BAU)

| | 2030 | 2040 | 2050 | Cumulative (2025 - 2050) |
|---|---|---|---|---|
| Scenario DOM 1 | 0.20 / 9.9% | 0.20 / 8.7% | 0.19 / 8.2% | 4.45 |
| Scenario DOM 2 | 0.20 / 9.6% | 0.20 / 8.8% | 0.20 / 8.3% | 4.42 |
| Scenario DOM 3 | 0.19 / 9.5% | 0.20 / 8.7% | 0.19 / 8.2% | 4.37 |

#### *7.3.2.5 Professional HPC scenarios*

The total life cycle primary energy demand for the scenarios PROF 1, PROF 2 and PROF 3 compared to BAU is shown in Figure 38. The effect of the motor-pump and burner efficiency is plotted in order to quantify its magnitude.

Figure 38. Total primary energy demand for production, use and end-of-life of the professional HPCs for BAU versus the different policy scenarios.




The primary energy savings are gathered in Table 17.

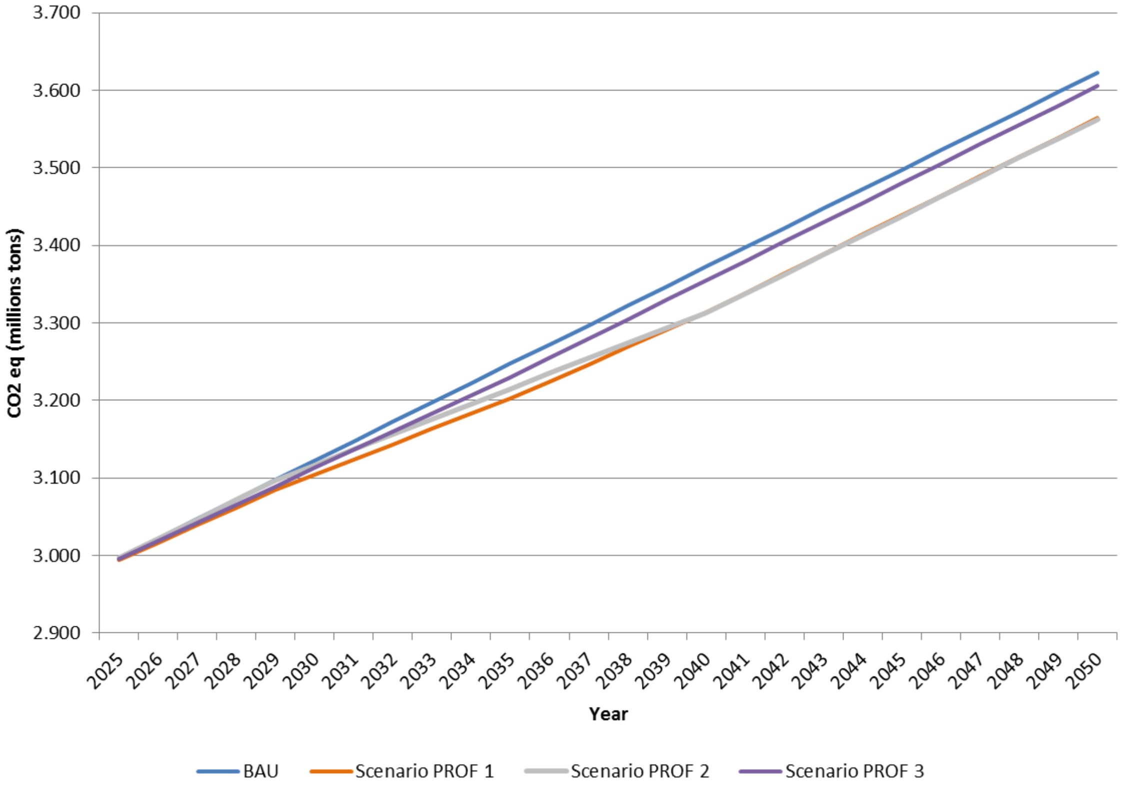
Table 17. Primary energy savings scenarios PROF 1 and PROF 2 vs BAU scenario (TWh / as % of BAU)

| | 2030 | 2040 | 2050 | Cumulative (2025 - 2050) |
|---|---|---|---|---|
| Scenario PROF 1 | 0.14 / 0.8% | 0.46 / 2.23% | 0.46 / 2.12% | 8.5 |
| Scenario PROF 2 | 0.04 / 0.22% | 0.47 / 2.32% | 0.47 / 2.17% | 7.5 |
| Scenario PROF 3 | 0.04 / 0.22% | 0.08 / 0.40% | 0.08 / 0.36% | 1.7 |

As can be observed, Scenario PROF 1 would entail the largest saving potentials, due to benefit of an earlier implementation that would increase the savings 1 TWh. compared to PROF 2. Scenario PROF 3 would result in the lowest saving potential, reaching cumulative savings of 1.7 TWh.

The total life cycle CO2eq for the scenarios PROF 1, PROF 2 and PROF 3 compared to BAU is shown in Figure 39.

Figure 39. Total GHG emissions expressed in CO2eq. for the production, use and end-of-life of the professional HPCs for BAU versus the different policy scenarios.




The CO2eq savings are gathered in Table 16.

Table 18. COeq savings scenarios PROF 1 and PROF 2 vs BAU scenario (Mton CO2eq / as % of BAU)

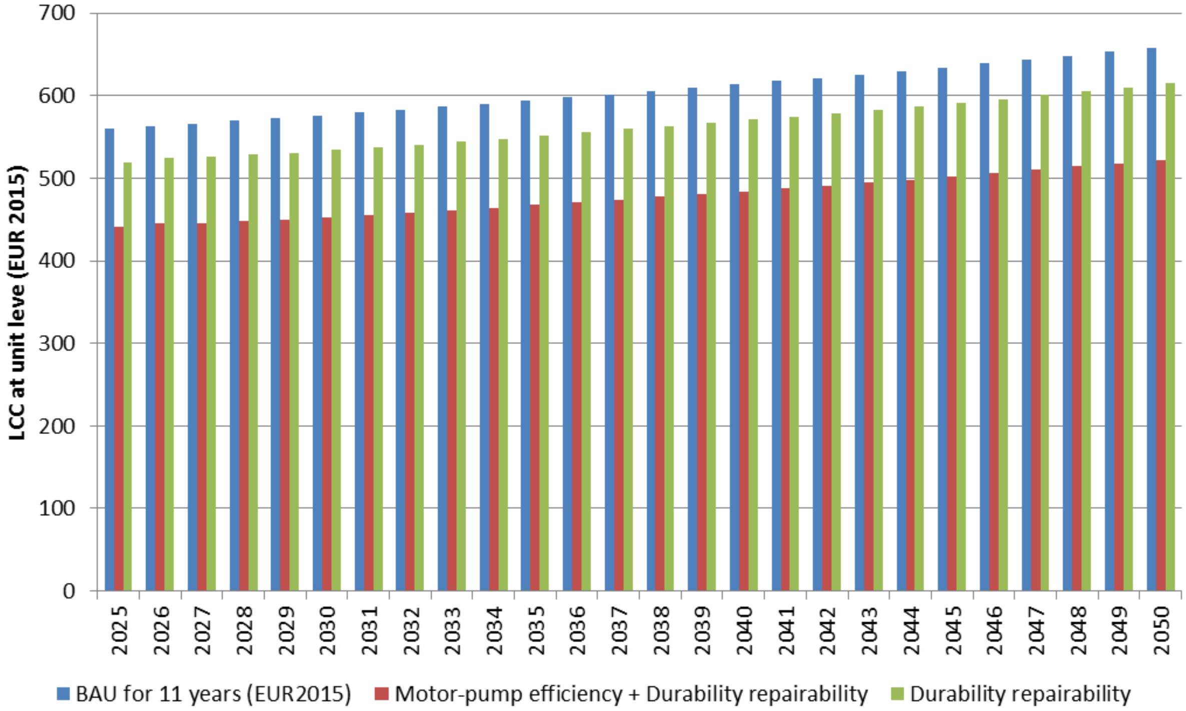
| | 2030 | 2040 | 2050 | Cumulative (2025 - 2050) |
|---|---|---|---|---|
| Scenario PROF 1 | 0.02 / 0.58% | 0.06 / 1.74% | 0.06 / 1.62% | 1.08 |
| Scenario PROF 2 | 0.005 / 0.30% | 0.06 / 1.78% | 0.06 / 1.66% | 0.95 |
| Scenario PROF 3 | 0.009 / 0.3% | 0.018 / 0.52% | 0.018 / 0.50% | 0.37 |

Similar to primary energy savings, Scenario PROF 1 would lead result in the largest saving potentials, due to benefit of an earlier implementation compared to PROF 2. Scenario PROF 3 would bring the lowest savings in GHG emissions, resulting in 0.37 Mton CO2eq in cumulative savings.

## 7.4 Impacts on industry and end-users

The different policy options described in this report have an impact on industry and end user. In the case of end uses, this impact can be quantified in terms of LCC. The evolution of the LCC at unit level for domestic units is shown in Figure 40.

Figure 40. Evolution of BC1 LCC at unit level for BAU, Motor-pump efficiency and Durability reparability policy options.



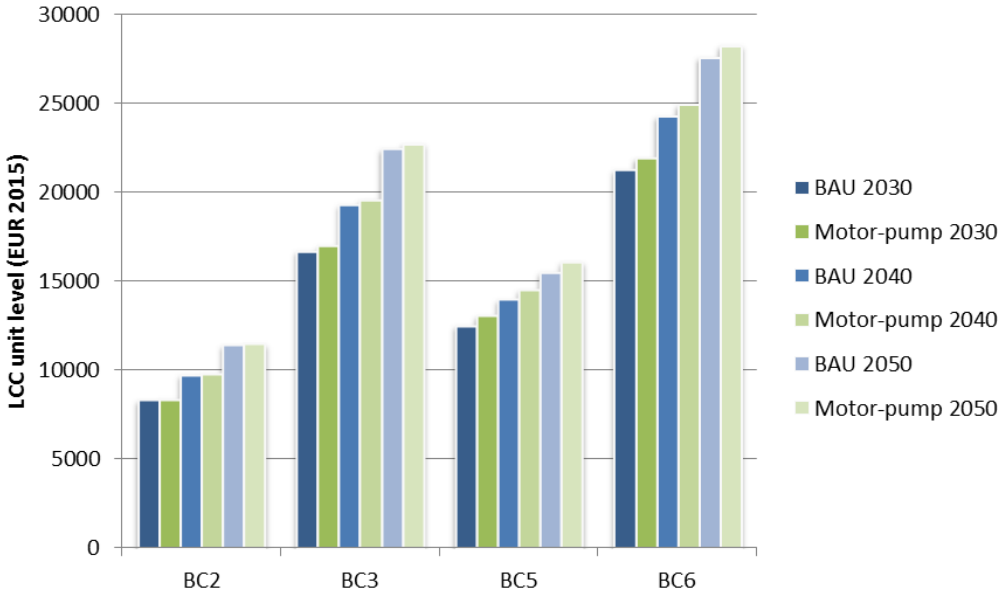

As can be observed, motor-pump efficiency requirements could potentially decrease the LCC up to 26%. The policy option based on cleaning performance has not been modelled in this section due to high uncertainty linked to the lack of data. Durability and repairability requirements would also reduce the LCC around 10%. This policy option would probably impact the sales of domestic units by decreasing them, due to a lower replacement rate. This is displayed in Figure 35.

Due to this potential reduction of sales, employment may be also affected by the Durability and reparability policy options, however, the project team need data from stakeholders to quantify this impact, among other, the following:

- Working hours per year per employee
- Man-hours needed to produce one unit
- Share of production within EU and outside EU
- Share of employment in manufacture, retail and repair sub-sectors.

In the professional sector, motor-pump efficiency requirements would have a significant impact for industry. According to stakeholders, the additional manufacture cost of improving the efficiency of induction motors can be estimated as 20% to 30% of the unit cost. The LCC at unit level for the different professional case is plotted in Figure 41.

Figure 41. Evolution of LCC at unit level of professional cases for BAU and Motor-pump efficiency policy option




The figure shows that all cases would result in increase of LCC: BC2 would increase 0.5%, BC3 would increase 1.3%, BC5 2.3% and BC6 3.6%.

## 7.5 Sensitivity analysis

All the above analysis of Task 7 is based on the conservative 'Low usage scenario' as presented in Task 3. As the direct energy and water consumption at the use phase of HPC depends on the usage pattern, Figure 42 and Figure 43 provides the uncertainty range of low versus high usage scenarios (see Task 3), of the direct energy and water consumption of HPC at EU level, and for the period 2020-2050.

Figure 42. Total energy consumption (use phase) uncertainty range (low versus high usage scenario) for the period of 2020-2050 at EU level.

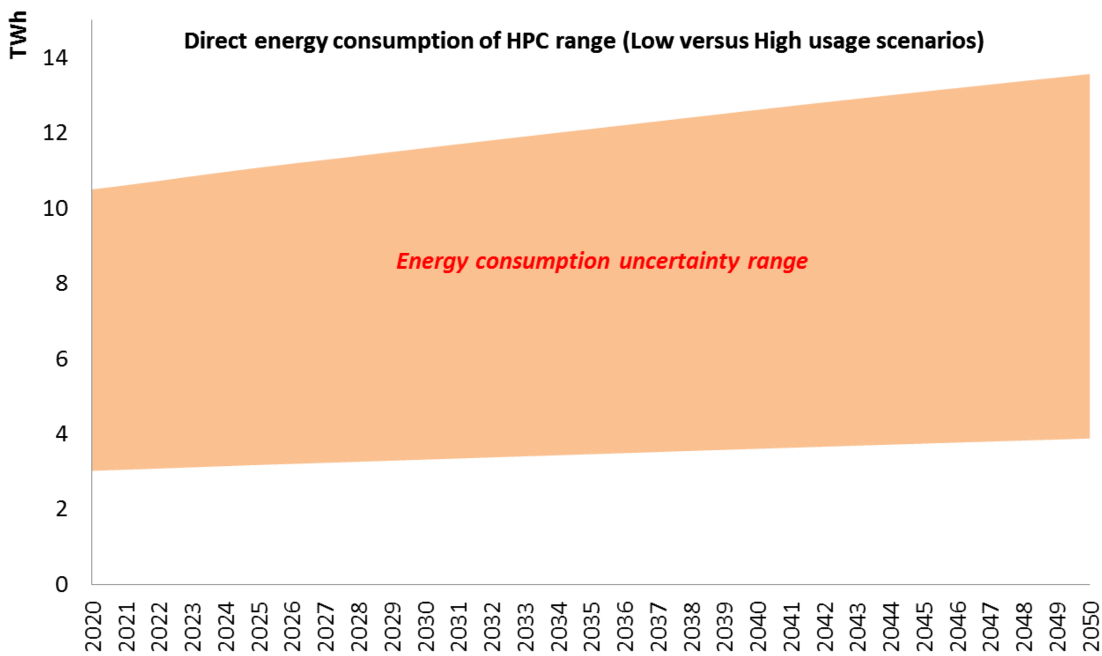
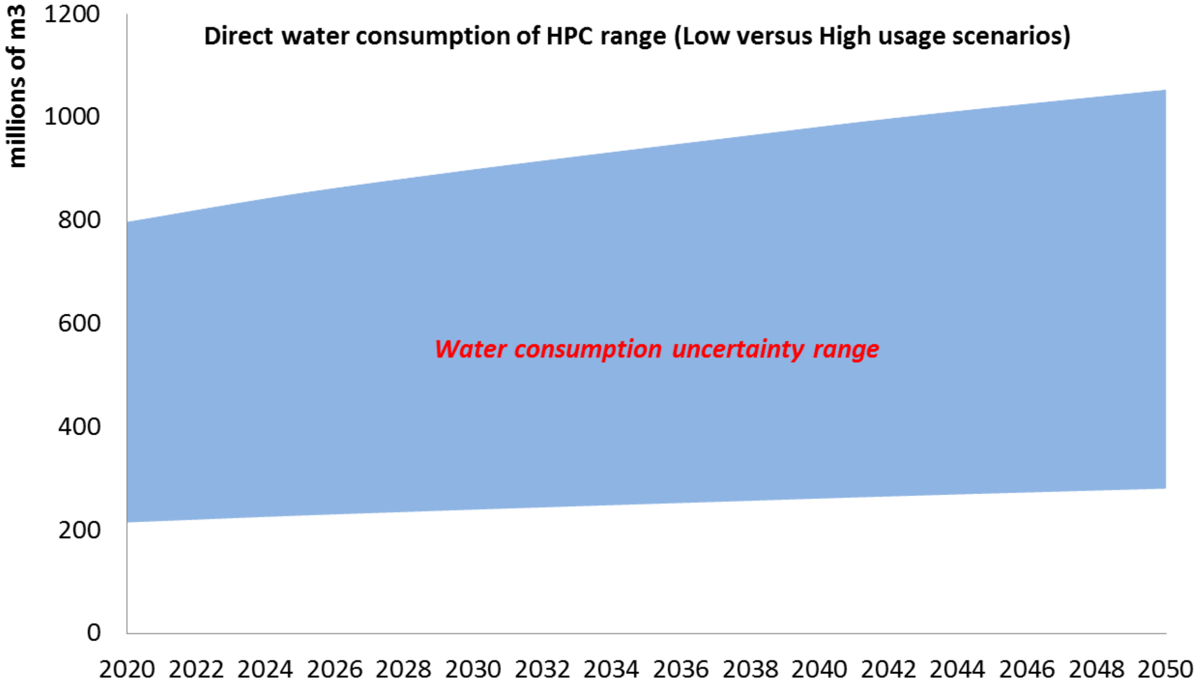


Figure 43. Total direct water consumption (use phase) uncertainty range (low versus high usage scenario) for the period of 2020-2050 at EU level




As can be seen from Figure 18, the overall energy consumption of HPC for the year 2020 is estimated among 3-10.5 TWh (final energy at use phase); with water consumption among 215-797 million of $m^3$.

**Professional sector**

The main parameter that can affect the results of the professional scenarios is the market share of non-compliant products (new sales) with the proposed threshold for motor-pump efficiency.

Table 19 shows the results of primary energy savings increasing and reducing that parameter.

Table 19. Results of primary energy cumulative savings varying market share of non-compliant motor-pumps (TWh / % variation compared to 50% market share)

| | **Primary energy cumulative savings (2025 – 2050)** | | |
|---|---|---|---|
| | 25% market share | 50% market share<br>(assumption in modelling) | 75% market share |
| Scenario PROF 1 | 4.3 (-52%) | 8.5 | 12.7 (+49%) |
| Scenario PROF 2 | 3.8 (-49%) | 7.5 | 11.3 (+34%) |

These results indicate that there is a significant uncertainty of +/-50%, which needs to be considered. However, it could be reduced by means of a better knowledge of the market which may be provided by stakeholders input.

## 7.6 Conclusions

**Domestic sector**

In the domestic sector, the policy option with the largest saving potential is Durability and reparability. Durability requirements would require the development of a test method or the adaptation of the endurance test within the safety standards. A longer lifetime of HPCs may cause a reduction in the sales of new units, which in turn could affect the employment in the manufacture and retail sub-sectors. But it may also justify a higher purchase price for products, compensating for the reduced revenues of manufacturers. On the other hand, the reparability requirements could increase the employment in the repair or service sub-sectors.

The policy options motor-pump efficiency and ecodesign or energy labelling based on cleaning performance could deliver 2 TWh of cumulative savings in 2050. Motor-pump efficiency would require a test method to measure flow, pressure and input power. It seems feasible to develop a transitional method until a cleaning performance standard to measure the efficiency at product level is in place. According to stakeholder input, a cleaning performance standard would require a more complicated test method that needs to be developed, possibly in response to a standardisation request.

Scenario 1 will potentially provide the largest energy and GHG savings, while the life cycle cost would also be reduced.

**Professional sector**

In the professional sector, the largest savings could be achieved by the combination of ecodesign or energy labelling based on cleaning performance and motor-pump requirements. As mentioned above, the motor-pump efficiency would be easier to implement, while a cleaning performance test method would need to be developed, possibly in response to a standardisation request. The scenario PROF 1 would represent an interim solution that would bring energy savings while the cleaning performance test method in under development. This policy option would require an additional manufacture cost for improving the motor-pump efficiency that would affect manufacturers and end users, but on the other hand provide savings by means of reduced energy use for the end users. The additional environmental benefits of this policy option represent 1 TWh cumulative savings.

Scenario 1 may increase the life cycle cost at unit level between 1% and 4%. However, this scenario would potentially provide the largest energy and GHG savings, hence it may offset the additional manufacture cost.

## Annex I: Reparability requirements

**Non-destructive access (disassembly) to critical components**

The main components of the HPC should be easily accessible allowing professionals and/or end-users to replace them according to the list of spare parts below.

**Spare parts availability**

Availability of spare parts to **professional repairers** for a min period of 10 years after placing the last unit of the model on the market:

- motor, motor-pump-system and motor brushes
- pump
- combustion engine
- transmission between motor and pump
- heating coil
- burner and burner chamber
- electric heating elements
- fuel tanks and hoses
- internal hoses, pipes, valves and filters
- high pressure hose
- printed circuit boards
- electronic displays
- pressure and flow switches
- motor protection switches and fuses
- pressure reliefs
- thermostats, temperature sensors and pressure switches
- on/off switches
- operator presence controls
- mains cable
- software and firmware including reset software
- cabinet

Spare parts can be replaced with the use of commonly available tools and without permanent damage to the HPC. The list of spare parts and the procedure for ordering them and the repair instructions shall be publicly available on the free access website of the manufacturer, importer or authorised representative, when placing the first unit of a model on the market and until the end of the period of availability of these spare parts.

Availability of spare parts to end-users and professional repairers for a min period of 10 years after placing the last unit of the model on the market:

- detergent tanks and hoses
- other plastic peripherals
- filters
- guns

- nozzles and cleaning attachments
- wheels

  The list of spare parts and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, importer or authorised representative, at the latest two years after the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts.

Maximum delivery time of spare parts: For spare parts mentioned above, the manufacturer, importer or authorized representative shall ensure their delivery within 15 working days after having received the order.

**<u>Repair and maintenance manuals</u>**

After a period of two years after the placing on the market of the first unit of a model and until the end of the ten years period (same as spare parts availability) the manufacturer, importer or authorised representative shall provide access to the HPC repair and maintenance information to professional repairers in the following conditions:

The manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to register for access to information; to accept such a request, the manufacturers, importers or authorised representatives may require the professional repairer to demonstrate that:

- the professional repairer has the technical competence to repair HPCs and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, shall be accepted as proof of compliance with this point;
- the professional repairer is covered by insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State.
- the manufacturers, importers or authorised representatives shall accept or refuse the registration within 5 working days from the date of request;
- manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information.
- once registered, a professional repairer shall have access, within 24 hours one working day after requesting it, to the requested repair and maintenance information for any product model of the manufacturer in the scope of this Regulation. The information may be provided for an equivalent model or model of the same family, if relevant.

Repair and maintenance information shall include:

- the unequivocal HPC identification;
- a disassembly map or exploded view;
- technical manual of instructions for repair;
- list of necessary repair and test equipment;
- component and diagnosis information (such as minimum and maximum theoretical values for measurements);
- wiring and connection diagrams;
- diagnostic fault and error codes (including manufacturer-specific codes, where applicable);

- instructions for installation of relevant software and firmware including reset software;
- information on how to access data records of reported failure incidents stored on the HPC (where applicable).

Manufacturers or importers may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses it.

The user instructions shall also include instructions for the user to perform maintenance operations. Such instructions shall as a minimum include instructions for:

- correct connections to mains, connection to water inlets, cold and/or hot if appropriate
- correct use and dosing of detergent and other additives, and main consequences of incorrect dosage;
- periodic cleaning, including optimal frequency, and limescale prevention and procedure;
- periodic checks of filters, including optimal frequency, and procedure;
- identification of errors, the meaning of the errors, and the action required, including identification of errors requiring professional assistance;
- correct storage when not in use
- how to access professional repair (internet webpages, addresses, contact details);

Such instructions shall also include information on:

- any implications of self-repair or non-professional repair for the safety of the end-user and for the guarantee;
- the minimum period during which the spare parts for the HPCs are available.

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