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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

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Part: Washing Machines and Dryers

Task 1: Definition

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For reasons of better readability, two Task 1 reports were prepared.

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

The Task 1 report on *professional dishwashers*
is published separately.

For the benefit of the environment, this document has been optimised for **double-sided printing**.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 General objective of the preparatory study

Many aspects of energy-using products (EuPs) have a negative impact on the environment (emissions to air including greenhouse gases, to soil, recycling, water consumption…). In line with the Integrated Product Policy (which promotes the principle that requirements on the environmental performance of products should address all environmental aspects during the complete lifecycle of the product), the Commission decided in August 2003 to propose an integrated framework for setting "eco-design" requirements for EuPs (including energy efficiency requirements) while avoiding fragmentation of the market.

By adopting Directive 2009/125/EC[1], the European Parliament and the Council have granted a mandate to the Commission, assisted by a committee and after consultation of the stakeholders forum, to regulate the environmental characteristics of energy-using products (except vehicles) through adopting implementing measures (e.g. decisions, regulations or directives) laying down eco-design requirements for particular EuPs.

First step in considering whether and which eco-design requirements should be set for a particular product is a preparatory study identifying and recommending ways to improve at the design phase the environmental performance of the product throughout its lifecycle.

Preparatory studies should provide the necessary information to prepare for the next phases (carried out by the Commission) and in particular the impact assessment, the consultation of the Forum and the possible draft implementing measure.

Each product specific preparatory study follows a defined methodology especially developed for the European Commission (Methodology Study for the Eco-design of Energy-using Products (MEEuP)[2]). The MEEuP approach covers the following tasks:

- Task 1: Definition,
- Task 2: Economic and market data,
- Task 3: Consumer behaviour and local infrastructure,
- Task 4: Technical analysis of existing products,
- Task 5: Definition of base case,
- Task 6: Technical analysis of best available technology (BAT),
- Task 7: Improvement potential,
- Task 8: Scenario-, policy-, impact- and sensitivity analysis.

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1 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:EN:PDF

2 http://ec.europa.eu/energy/efficiency/studies/doc/ecodesign/2005_11_28_methodoly_report.pdf

1.2 Objective of Task 1

Within Task 1, the product category and system boundaries of the 'playing field' for eco-design shall be defined. This is important for a realistic definition of design options and improvement potential and is also relevant in the context of technically defining any implementing legislation or voluntary measures (if any).

Subtask 1.1 – Product category and performance assessment

The following classification schemes and documents shall be analysed to define the product categories for Lot 24:

- Prodcom category or categories (Eurostat);
- Categories according to EN- or ISO-standard(s);
- Labelling categories (EU Energy Label or Eco-label), if not defined by the above.

Categorisation will often be linked to the assessment of the primary product performance parameters (the "functional unit"). If needed, a further segmentation can be applied on the basis of secondary product performance parameters, referring to functional performance characteristics but not to technology.

Subtask 1.2 – Test Standards

Subtask 1.2 will identify and shortly describe the harmonised test standards and additional sector-specific directions for product-testing regarding the test procedures for:

- the primary and secondary functional performance parameters mentioned above;
- resources used (energy, water, detergent etc.) and emissions (NOx, CO, particulate matter) during product life;
- safety (gas, oil, electricity, EMC, stability of the product etc.);
- noise and vibrations (if applicable);
- other product-specific test procedures.

Apart from mentioning these standards, including a short description, it should also be reported which new standards are being developed, which problems exist (e.g. regarding tolerances etc.) and which alternatives are being developed. Furthermore, the (ongoing) work on an eco-design standard, mandated by the European Commission to standardisation bodies, shall be considered.

Subtask 1.3 – Existing legislation

Task 1.3 should identify the relevant legislation for the product. This task can be subdivided in three parts:

Subtask 1.3.1 – Legislation and Agreements at European Community level

Apart from the obvious environmental directives (RoHS, WEEE, Packaging directive), relevant regulations could be such on building (e.g. developed under the Performance of Buildings Directive), on health and labour conditions (e.g. for air conditioners, copiers), minimum efficiency directives (boilers, refrigerators, ballasts etc.), regulations on product liability, safety, EMC etc. Also, EU Voluntary Agreements and already existing eco-design standards (e.g. ECMA, EIA) for the sector or related sectors need to be identified. And finally, especially in a business-to-business context, it needs to be described which quality requirements (e.g. “proven design”, maximum failure rate) are customary.

Subtask 1.3.2 – Legislation at Member State level

This section deals with the subjects as above, but for legislation that has been indicated as being relevant for the Member States.

Subtask 1.3.3 – Third Country Legislation

Again, this section deals with the subjects as above, but for legislation and measures in Third Countries (extra-EU) that have been indicated by stakeholders (NGOs, industry, consumers) as being relevant for the product group.

2 Product category and performance assessment

2.1 Scope of Task 1 report, part 'Professional washing machines and dryers'

Objective of this task is to present and discuss the definition and scope of the product family "Lot 24: Professional washing machines, dryers and dishwashers".

In previous preparatory studies on household appliances, washing machines and dishwashers have been jointly discussed as "wet appliances" within Lot 14, whereas laundry dryers have been dealt with in a different study (Lot 16). In Lot 24, we consider dryers as one module of the whole laundry process and therefore integrate the discussion on washing machines and dryers, whereas the research on professional dishwashers will be presented separately.

For reasons of better readability two Lot 24 reports are prepared. The report at hand covers professional washing machines and dryers. The report on professional dishwashers is published separately.

2.2 The professional laundry process

2.2.1 Wet-cleaning process

The entire washing and drying process, e.g. in a commercial laundry, consists of several steps which are depicted in the following figure[3] and specified subsequently.

[3] Own figure on the basis of BDEW-brochure "Erdgas in Wäschereien" (natural gas in laundries) 2007, www.bdew.de; and Electrolux Laundry Know How, www.laundrysystems.electrolux.com/Files/Laundryknowhow/HTML/71-0-1.htm

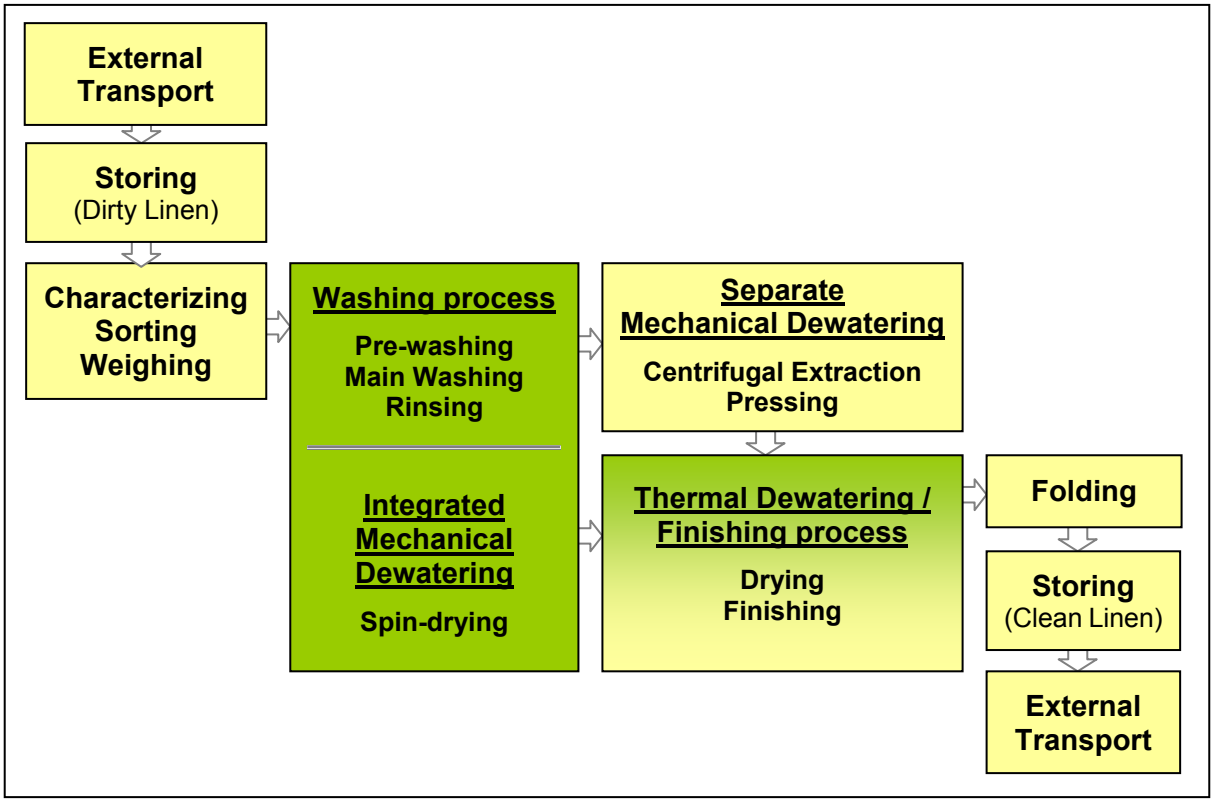


Figure 1 Different steps of a professional laundry process

- **Sorting**: Before loading a washing machine, laundry has to be sorted to avoid failures in the washing process. This can be done according to the different types of textiles (characterised by washing symbols in the garment labelling, textile materials, and colour of the laundry), and/or according to the type of dirt and degree of soiling.
- **Washing**: The purpose of washing laundry is to loosen dirt from the textile fibres and to rinse it off by using water as solvent. Depending on the laundry type and the degree of soiling, professional washing machines often provide a large number of different either adjustable or pre-defined washing programmes. They vary e.g. in terms of using pre-washing, the number of rinsing cycles, the temperature or the programme duration.
- **Dewatering**: After the laundry has been washed, it has to be dewatered to achieve a faster drying process at a later stage. This can be realised either by mechanical or thermal energy at different stages in the laundry process.
  - **Mechanical dewatering** can be done by different appliances:
    - Spin-dryer being integrated in the washing machine ("washer-extractor").
    - Separate hydro-extractor or pressing appliances.
      - Squeeze press: Machine for the mechanical extraction of moisture from textile fabrics by the application of pressure.

- Centrifugal extraction machine = spin-extractor: Machine containing a perforated cage to and from which successive loads is transferred and within which the loads are subjected to a centrifugal force due to the rotation of the cage for the purpose of extracting moisture.

– **Thermal dewatering / drying:** After mechanically dewatering the linen, the remaining moisture has to be evaporated to fully dry the laundry. Functions to be delivered by these processes are to dry, to soften and/or flatten as well as to stretch the fabrics. Depending on the type of textile, thermal evaporation of the remaining moisture is done in a tumble dryer, flatwork ironer, utility press or garment finisher.

  - Drying by rotating or tilting tumble dryers: They are used to dry garments, mostly for terry garments. The water evaporates due to the high temperature caused by hot air injected through the perforated shell of the drum.

- **Finishing** by ironing, pressing or garment finishing: irons and presses generally have the same function: To soften and flatten the damp[4] fabric, as well as to remove creases. At the same time, the fabric is dried.

  – Ironing: This process is performed by contact drying and calendaring of flat linen. The flat pieces are led, either manually or automatically by a feeding machine, between the rotating rolls and stable heated beds of the ironer. The evaporated water is vacuumed out through the perforation holes on the rolls. Due to the rotation the flat linen pieces are conveyed further into the machine.

  – Pressing: This process is used for most garments like shirts, overall, coats etc. A piece of garment is steamed and dried between two pressing plates. The steam and evaporated water are removed by an integrated suction system.

  – Garment finishers: Garments have to be de-wrinkled and re-shaped. This process is called “conditioning”. While domestic washing will normally utilise an iron to finish shirts and the like, for industrial purposes this process is performed with several kinds of steam air finishers. To soften the fabric, steam is injected either directly into the garment or into the bag on which the garments are dressed. After that, hot air inflates the bag which presses the garment from the inside while also drying the fabric.

- **Folding**: The linen can be folded by hand, or automatically using a folding machine. Small and big pieces of flat linen, once ironed, are length and cross folded by synchronised units.

[4] Depending on the efficiency of the mechanical dewatering by laundry machinery (e.g. spin-extractor), the material of the textiles and the type of following finishing, fabrics have a residual moisture of about 20 to 40%.

- **Storing**: The finished and folded laundry is stacked on shelves or hung on garment racks or similar. Before using the linen, the textiles have to re-absorb a certain amount of moisture to smooth out creases.

Within the different steps of an entire laundry process as described above, professional washing machines and dryers – the formal focus of Lot 24 according to the technical specifications of Tender No TREN/D3/91-2007 – only come into operation within the sub-processes washing and dewatering. The processes storing, sorting and folding will be out of the scope of this study.

Further, according to Porter et al. (1984),[5] "drying" generally refers to the 'removal of a liquid from a solid by evaporation. Mechanical methods for separating a liquid from a solid are generally not considered as drying, although they often precede a drying operation, since it is less expensive and frequently easier to use mechanical methods than to use thermal methods'. Thus, only the technical washing and thermal drying processes, including the spinning phase, and the machines used for these are within the scope of the preparatory study at hand. Further, systems for softening the water[6] by reducing the concentration of calcium, magnesium, and other ions in hard water, are not in the scope of the study as they are not part of the laundry machinery but separate processes. Machines which are or can be equipped with a separate water treatment system, such as tanks for water recovery or waste water systems, will be introduced in Task 6.

In the professional context, a variety of items may be cleaned by a professional washing machine or dried by a professional dryer, e.g. clothes, shoes, tablecloths, napkins, hand towel rolls, towels, bed clothes, pillows, mattress toppers, sleeping bags, surgical scrubs, mats, mops, etc.. Their shape and material must be suitable for wet-cleaning or drying by machine.

In our study, we will use the term "laundry" as superordinated term for these different kinds of items to be washed and dried in a professional washing machine or dryer.

2.2.2 Dry-cleaning process

In the Commission Regulation with regard to eco-design requirements for household washing machines,[7] washing machines are defined as a "machine which cleans and rinses tex-

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5 Porter, H.F.; Schurr, G.A.; Wells, D.F.; Semrau, K.T.; Solids Drying and Gas-Solid Systems; in: Perry's Chemical Engineers' Handbook; Perry, R.H. and Green, D.W. (Eds.); 6th Edition, McGraw-Hill, New York, 1984

6 "Hardness ions" can cause a variety of undesired effects including interfering with the action of soaps, the build up of limescale, which can foul plumbing, and galvanic corrosion (source: Stephen Lower (July 2007). "Hard water and water softening" (http://www.chem1.com/CQ/hardwater.html). Water-softening appliances depend on an ion-exchange resin or reverse osmosis in which hardness ions are exchanged for sodium ions.

7 COMMISSION REGULATION (EU) No 1015/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines. Official Journal of the European Union L 293/21 from 11.11.2010.

tiles using water […]". However, the removal of stain from laundry could not only be realised by water-using wet-cleaning machinery, but also in a dry-cleaning process. While water can be chemically classified as a polar solvent, dry-cleaning uses non-aqueous non-polar, mostly organic solvents like perchlorethylene (perchlor), hydrocarbon, cyclosiloxane, or CO_2 instead of water in contrast.

The most important reason for dry-cleaning instead of washing textiles is that some materials, especially wool, are very sensitive to water; their fibres swell and get deformed by water in combination with heat (felting or shrinkage). Dry-cleaning provides shape permanence: Folds and pleats are not damaged; flatwork like linen or tablecloth keeps its stiffness. Furthermore, the risk of discolouration is normally negligible. Another reason for using different processes is that wet- and dry-cleaning each remove different types of stain. While dry-cleaning is better for removing grease, ink, oil, or paint, water-based stains are best removed in a washing process.

Besides the different cleaning agent (non-aqueous non-polar solvents versus water), there are significant differences in the machine technology (for example, in contrast to washing machines, dry-cleaning machines operate with a completely closed circuit regarding the solvent). Furthermore, dry-cleaning machines are fabricated by different manufacturers and cover a different market segment.

For an extensive description of the dry-cleaning process and equipment, see Annex 7.3.1 of this document; a detailed market analysis for dry-cleaning machinery is annexed to Task 2.

2.3 Detergents for professional washing machines and dryers

Laundry detergents for professional use mean products intended for laundering textiles in water by professional users like institutional or industrial users and other large-scale consumers. Generally, various types of professional textile detergents exist – acid or alkaline.

The following constituent substances occur: Surfactants, alkalines, bleaching agents, enzymes, fillers, colour protection agents, colour complexing agents, preservatives, anticorrosion compounds, optical brighteners, fragrance, protective colloids and foam inhibitors.

Various auxiliary products are also available, such as pre-wash agents, stain removers, antistatic agents, fabric conditioners, softeners, washing strengtheners, wash enhancers for heavily soiled laundry (for example work clothes), special detergents for laundering delicates, proofing agents for water-repellent textiles, mop detergents, detergents for microfibers, bleaches, and rinsing agents.

The product group covers complete powders and liquid detergents as well as multi-component systems. A multi-component system is a detergent system based on components used to build up a complete detergent, a stock solution or a laundering programme for automatic dosing. This system incorporates basic detergents plus a number of auxiliary products.

Professional textile detergents are dosed both manually and automatically. Achieving the correct dosage is essential, as is maintaining the dosage devices so that they function efficiently and provide the optimum dose (Nordic Ecolabelling 2009)[8].

2.4 Delimitation of professional washing machines and dryers

Washing machines and laundry dryers have already been object of research in previous preparatory studies,[9] however focussing on domestic appliances (Lot 14: Domestic Washing Machines and Dishwashers; Lot 16: Laundry Dryers). Nevertheless, the following general definition for washing machines of Lot 14 and laundry dryers of Lot 16 can also be applied to professional laundry machinery:

> *"Washing machines are defined as machines which clean and rinses textiles using water which also have a spin extraction function." (Lot 14)*
> *"Tumble dryers are defined as machines in which textiles are dried by tumbling in a rotating drum through which heated air is passed." (Lot 16)*

Lot 24 focuses on professional appliances. They are used to clean, rinse and dry textiles in commercial customer and market segments.

Professional washing machines and dryers are always connected to the mains (electricity used for motor and electronics). The heating of the water or air can be realised by electricity or by other alternative energy sources like steam or gas. Professional washing machines may or may not have a specific drying operation at the end of the washing phase of a washing program resulting in different kinds of machinery (washing machines, washer extractors, washer dryers, for details cf. Section 2.5.5.1):

In the following the basic differences between professional and household washing machines and dryers are described to properly define the scope of this preparatory study on professional appliances.

2.4.1 Eco-design regulations on household washing machines and dryers

The Commission Regulation[10] with regard to eco-design requirements for household washing machines provides the following definition: "household washing machine means a […] machine […] which is designed to be used principally for non-professional purposes." This

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8 Swan labelling of laundry detergents for professional use. Background document for ecolabelling. Consultative proposal – 16 March 2009. http://www.ecolabel.no/sfiles/60/20/1/file/Bakgr_TekstilvaskeProf_ENG.pdf

9 Further information: www.ecowet-domestic.org and www.ecodryers.org/ , sighted on 12 January 2010

10 COMMISSION REGULATION (EU) No 1015/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines. Official Journal of the European Union L 293/21 from 11.11.2010.

distinction on basis of the intended use of a machine equates the Machinery Directive (cf. next section). The draft Commission implementing Regulation with regard to eco-design requirements for household tumble dryers, defines a household tumble dryer as an appliance in which textiles are dried by tumbling in a rotating drum, through which heated air is passed and which is designed to be used principally for non-professional purposes."

2.4.2 Distinction according to Machinery Directive

A possible general differentiation gives the amended version of the Machinery Directive 2006/42/EC[11], in force since 29th December 2009. It clarifies the borderline between machinery for household and for professional use in order to provide greater legal certainty. Whereas for the latter machinery the scope of the Machinery Directive applies, in Article 1 (2) k 'household appliances intended for domestic use' are explicitly excluded therefrom. They belong to low voltage electrical and electronic machinery with an electrical supply within the voltage limits of the Low Voltage Directive (between 50 and 1000 V for alternating current or between 75 and 1500 V for direct current) and therefore must fulfil the safety objectives of the Low Voltage Directive 2006/95/EC20[12].

Concerning the exclusion of household appliances respectively intended for domestic use from the scope of this study, the following clarifications are given in the '*Guide to application of the Machinery Directive 2006/42/EC*'[13]:

- The expression 'household appliances' designates equipment intended for housekeeping functions such as washing, cleaning, heating, cooling, cooking, etc. Examples of household appliances include washing machines, dishwashers, vacuum cleaners and machinery for food preparation and cooking.
- The exclusion concerns appliances 'intended for domestic use', in other words, intended for use by private persons (consumers) in the home environment. Thus appliances for the housekeeping functions mentioned above that are intended for commercial or industrial use are not excluded from the scope of the Machinery Directive.

While it is possible for a private consumer to acquire and operate an appliance intended for commercial use or for a commerce to acquire an appliance intended for domestic use, the criterion to be taken into account for determining the 'intended use' is the use intended and stated by the manufacturer of the appliance in his product information or his Declaration of

11 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2006L0042:20091215:EN:PDF

12 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

13 Ian Fraser (General Editor): Guide to application of the Machinery Directive 2006/42/EC. Brussels, 1st Edition December 2009; revised by 2nd edition from June 2010 http://ec.europa.eu/enterprise/sectors/mechanical/files/machinery/guide_application_directive_2006-42-ec-2nd_edit_6-2010_en.pdf sighted at 15.02.2011

Conformity (DoC). Evidently, this statement must accurately reflect the foreseeable use of the product.[14]

In general, the design and construction of machinery must take account of the intended use. Recital 15 of the Machinery Directive stresses that the machinery manufacturer must consider whether the machinery is intended to be used by a professional or a non-professional operator or is intended to provide a service to consumers. Annex I of the Directive describes essential health and safety requirements relating to the design and construction of machinery, i.e. of appliances for commercial or industrial use.

In summary, the machinery directive provides a legal principle to distinguish between devices for usage in households on the one side and professional use on the other side on the basis of the intended use of the machinery as declared by the manufacturer.

2.4.3 Definition of professional washing machines and dryers within Lot 24

To date, there is no official or standardised definition or delimitation between the terms professional, commercial, and industrial. CENELEC TC59X[15] proposed that the term "commercial" shall be used in connection with *market and market segments*. The term "professional", however, shall be used in connection with *equipment* designed for use in commercial segments.

In our study, we will follow this distinction and apply the term "professional" as superordinated term for washing and drying appliances used in commercial and / or industrial market segments. However, please note that for example in existing standards, the term commercial or industrial might be used based on another approach (cf. Section 3)[16]. Therefore, an accurate delimitation and standardised definition of industrial equipment or market segments in comparison to other professional appliances would still be necessary.

On the basis of the Eco-design Regulation on household washing machines and the draft Eco-design Regulation on household dryers and the Machinery Directive, within Lot 24 we define professional washing machines and dryers as follows:

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[14] l.c., page 54/337

[15] CENELEC TC59X settled a Sub Working Group 1.12 (CLC/TC59X/SWG1.12 which decided to clarify their understanding of the terms commercial, professional, industrial, and to decide which of them are inside the scope of SWG 1.12 on one of their next meetings (cf. Section 3.1.3).

[16] For example, "industrial" laundry machinery is covered by ISO 9398 (definitions and testing of capacity and consumption characteristics) and by ISO 10472 (safety requirements). In this context, however, the term "industrial" also covers semi-professional and professional machines, e.g. quite small appliances with a capacity of 6 kg.

'Professional washing machine' means a machine which cleans and rinses laundry like clothes, tablecloths, bedclothes, towels, and other textiles or items by using water, chemical, mechanical, and thermal means; which might also have a spin extraction or drying function and which is designed to be used principally for commercial and industrial purposes as stated by the manufacturer.

'Professional dryer' means a machine which dries laundry like clothes, tablecloths, bedclothes, towels, and other textiles or items by thermally removing the moisture (evaporation) and which is designed to be used principally for commercial and industrial purposes as stated by the manufacturer.

2.4.4 Distinction according to functional performance and technological differences

With regard to functional performance and technological differences, the boundary between household and professional use is fluent. There is a semi-professional context, where some requirements of the household and some of the professional context apply.

In *private households,* a washing machine and/or dryer usually runs on average 220 cycles per year, i.e. more than 4 times per week.[17] Household washing machines have cycle times of up to 3 hours. They are designed to clean various kinds of textiles (e.g. cotton, wool, synthetics, or silk). Besides some specific programmes for sensitive textiles, they usually have programmes for general use.

In the *professional context*, the specific requirements according to space or type of laundry differ considerably compared to household use, leading to a variety of different types of professional washing machines and dryers varying in e.g. size and capacity (weight of laundry to be cleaned per cycle). Compared to household use, usually a higher load of laundry has to be washed and dried in professional washing machines and dryers. Besides larger capacities, professional washing machines and dryers are also operated more often (in case of machines where the different steps of the washing or drying process are conducted consecutively in time and the textiles stay in the same position during the whole programme) or for longer times (in case of pass-through or tunnel appliances[18]). Moreover, in the professional context the programmes are required to be faster than in private households.

[17] Total number of standard washing cycles per year as used in the "Method for calculating the Energy Efficiency Index, Washing Efficiency Index, water consumption and remaining moisture content" in the COMMISSION REGULATION (EU) No 1015/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines. Official Journal of the European Union L 293/21 from 11.11.2010

[18] Appliances where the different steps of the washing or drying process are allocated to several individual treatment zones, i.e. the textiles are transported through these zones, which are constructed as chambers, with openings in the transport direction. They are operated continuously within a certain period of time.

Sometimes only one specific type of laundry has to be washed and dried or there is enough space and needed capacity to use several washing machines and/or dryers in parallel, resulting in much more specialised appliances compared to household use. In speciality laundry (SL), for example, dust mats or functional garments (fire and rescue service) have to be cleaned, in health care laundry (HCL), high hygiene standards have to be met. Therefore, special appliances or programmes are used.

Further differences between appliances for household and professional use are:

- The rated capacity (professional washing machines and dryers are available with higher rated capacity and three phases connectivity (400 V));
- The detergent dosage (mainly manual dosing of cleaning agent in case of household washing machines, versus mainly automatic detergent dosage in case of professional washing machines; only few exemptions, e.g. automatic dosing in high-end household washing machines or manual dosing in launderettes);
- The distribution channels (professional appliances are sold directly by the manufacturers or via specialized trade);
- The price (professional appliances usually have a higher price than household washing machines and dryers).

Delimitation between household and professional appliances

The Product-Life Institute (1989)[19] analysed the possible product-life extension of large appliances on the basis of a household and a (semi-)professional washing machine, providing the following distinctions.

[19] http://product-life.org/en/archive/case-studies/washing-machines, sighted at 14 January 2010

Table 1 Delimitation between household and (semi-) professional washing machines (own compilation according to Product-Life Institute (1989))

	Household washing machines	(Semi-) professional
Target group	Private households	Communal laundries, small on-premises laundries and self-service laundromats
Functions / design	Household washing machine or fully automatic washing machine for use in private households. Washing at 30-90/95°C, rinsing, and spinning.	Semi-professional washing machines are automatic washing and spinning machines that, like household washing machines, wash, rinse, and spin dry laundry; they have a similar capacity of 5 to about 7 kg of laundry, a much shorter washing time, and a slightly larger washing drum.
Wear parts	The motor, bearings, and timer (programming switches) in a household washing machine are designed to have a certain theoretical technical life. On the other hand, lack of maintenance by the user (regular cleaning of the filter, for example, and cleaning out the detergent) or improper use (using too little detergent may in the case of hard water cause calcification of the heating elements) may cause breakdowns.	Semi-professional and professional machines are built more robustly and often have no filter. They are sturdy and easy to maintain.
Useful life	The mathematical average, calculated from the total inventory and replacement sales, is about 10 years[20]. The household washing machine is designed for a theoretical technical life of at least 2 500 washing cycles with a full programme at 90/95°C, or 3 500 cycles at 60°C.	Semi-professional machines reach up to 15 000 hours, depending on the manufacturer. Professional machines reach 30 000 operating hours or more.
Distribution	Household washing machines are distributed via wholesalers and retailers, as well as via mail order and cash-and-carry outlets.	Semi-professional and professional washing machines are distributed via specialized retailers and specialized factory advisors.

Distinction between appliances in commercial and industrial market segments

On the other hand, some professional appliances are explicitly marketed or indicated as 'industrial' machinery. However, there is no clear and approved delimitation or definition.

The screening of manufacturers' range of products provided no clarification. The following table exemplifies the product divisions of Girbau, a manufacturer of professional laundry equipment.[21] Girbau explicitly differentiates between 'commercial' and a 'heavy duty'[22] laundry division. However, it is noticeable that washer extractors, drying tumblers and flatwork ironers are offered in both divisions, though partly with different functional performance parameters.

[20] More recent sources like ErP preparatory study Lot 14 on household washing machines identified an average lifetime of 15 years.

[21] http://www.girbau.de/grup/home, sighted on 11 February 2010

[22] Heavy duty is mainly corresponding to the term industrial

Table 2 Product classification according to the commercial and the heavy duty laundry division at Girbau

Commercial laundry division	Heavy duty laundry division
Washer extractor (9-120 kg)	Batch washer (tunnel washing machine)
Drying tumblers (7-77 kg)	Batch dryer
Barrier Washer (15-84 kg)	Water extraction press
Flatwork ironers (wall type)	Conveyor system
Finishing items (Form finishing, ironing table, utility press)	Barrier Washer
	Flatwork ironers line

PRODCOM and the European Customs Classification statistics do not provide a separate definition for industrial laundry appliances (see Sections 2.5.1 and 2.5.2).

There are two ISO standard series (ISO 9398 and ISO 10472) explicitly being in force for 'industrial laundry machines'.[23] According to the definition of ISO 10472,

> *"Industrial laundry machinery are machines used for the purpose of washing, extracting, drying or finishing of flat and shaped textile items in an industrial laundry. This definition includes machines intended for use in hotels, hospitals, nursing homes, prisons and similar premises."*

For some of the product categories covered by ISO 9398 and ISO 10472 on industrial laundry machinery, minimum capacities are given:

- ISO 9398, Part 2: Batch drying tumblers. Details: Batch drying tumblers whose net usable cage volume is greater than 160 dm³ (litres). This equals an approximate capacity of 6 to 7 kg dry linen.
- ISO 9398, Part 4: Washer-extractors: Details: Washer-extractors whose net usable cage volume is greater than 60 dm³ (litres). This equals an approximate capacity of 6 kg dry linen.
- ISO 10472, Part 2: Washing machines and washer extractors. Scope: This part of ISO 10472 covers, together with common requirements in part 1, most significant hazards associated with washing machines and washer-extractors of all configurations with a net usable cage volume > 60 l. This equals an approximate capacity of 6 kg dry linen.
- ISO 10472, Part 4: Air dryers. Scope: This part of ISO 10472 covers, together with common requirements in part 1, most significant hazards associated with air dryers, and in particular with tumble dryers with a net usable cage volume >160 l. This equals an approximate capacity of 6 to 7 kg dry linen.

[23] The Technical Committee of the International Organisation for Standardisation ISO/TC 72 generally deals with 'textile machinery and accessories'. TC 72 consists of seven subcommittees (SC). In the context of this study, the subcommittee SC 5 (industrial laundry and dry-cleaning machinery) is of particular interest.

The term “industrial” gives the impression of covering mainly heavy duty appliances; however, there are also commercial market segments like hotels, hospitals etc. in the general definition of industrial machinery, as well as the quite small capacities being in the scope of ISO 10472.

According to personal information by the Convenor of TC27/SC5/WG3, the issue of a distinguishing line between commercial and industrial machinery within the standard series EN ISO 10472-x has been discussed several times over the past years by working group CEN/TC 214/WG3 "Safety requirements for industrial laundering machinery". Finally, the working group came to the conclusion that it is not possible to define a clear, technically justifiable line between these sectors, neither from the point of view of manufacturers nor from the point of view of customers. Neither data regarding the size of the company (e.g. number of employees), the amount of the laundry treated daily, nor any data regarding the operational mode or the type of the machinery has been considered as suitable for the purposes of differentiating between the commercial and industrial appliances. There is always a transitional area with companies (customers) either being "commercial" or "industrial"; both types of commercial and industrial machines can perform heavy duty tasks for the same customer.

The members of the German VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.; German Engineering Federation) – working group “Garment and Leather Technology” subsume under “industrial machinery” mainly heavy duty appliances (i.e. tunnel washing machines, heavy duty dryers, heavy duty washer extractors) which are designed customer (operator) specific (see also stakeholder feedback, Section 7.1). From their view, industrial laundry equipment is mostly integrated in a comprehensive system of different laundry processes. Therefore, improvements on a single-product basis might not lead to an overall improvement of energy consumption. An environmental improvement could rather only be made on a system basis, i.e. considering all connected equipment (e.g. overall energy management, recovery management etc.). Moreover, heavy duty/industrial machines can not be operated by laymen but only by trained operators.

In our study, as described in Section 2.4.3, we will apply the term “professional” as superordinated term for washing and drying appliances used in commercial and/or industrial market segments. Table 3 gives an overview of a possible delimitation between household, semi-professional and professional washing machines and dryers.[24]

[24] The information is gained from the previous sections, secondary literature and product portfolios of several manufacturers (see Section 6): Girbau, Ipso, Miele, Primus, Electrolux, Kannegiesser

Table 3 Main product characteristics of domestic, semi-professional and professional washing machines and dryers

Group	Domestic washing machines and dryers	Semi-professional washing machines and dryers	Professional washing machines and dryers
Target group / Applications	Private households	▪ Coin & Card laundry (CCL) ▪ Apartment Household Laundry (AHL) ▪ Hospitality Laundry (HPL)	▪ Coin & Card laundry (CCL) ▪ Apartment Household Laundry (AHL) ▪ Hospitality Laundry (HPL); Health Care Laundry (HCL) ▪ Commercial Industrial Laundry (CIL) ▪ Speciality Laundry (SP)
Operating principle	Discontinuous operation in cycles	Discontinuous operation in cycles	Discontinuous operation in cycles or continuous operation
Typical load capacities	4–10 kg	< 7kg	Washing machines: 8–120 kg (commercial use) up to 400 kg (industrial use) Dryers: 8–77 kg (commercial use) n.a. (industrial use)
Programme options	Mostly fix programmes (some high end electronic household washing machines are partly programmable)	Partly programmable	Fully programmable + operated
Detergent dosage	Most often manual detergent dosing	Manual or automatic detergent dosing	Automatic detergent dosing
Drying time	60–150 minutes	30–60 minutes	40-60 min (commercial use) 20 min (industrial use)
Power supply, heating system	Normal rated capacity	Normal or high rated capacity	Usually high rated capacity and three phases (400 V) connection; partly additionally other energy sources (heat, steam)
Life time in cycles	2 500–4 000	10 000–15 000	<30 000 (commercial use) >30 000 cycles / 40 000 hours (industrial use)
Product dimensions	Typical dimension: height x width x depth 850 x 600 x 600 mm	Typical dimension: height x width x depth 850 x 600 x 600 mm	Dimensions are very variable depending on amount / type of textiles to be washed and dried and spatial possibilities.

The table shows that there are only minor differences between household and semi-professional washing machines and dryers (main differences are the shorter running times of the programmes, the possibility to connect to higher load in case of semi-professional washing machines and dryers and the longer life times in cycles). However, there are significant differences between household and semi-professional appliances on the one hand and professional ones on the other hand.

After this general delimitation of professional laundry machines, the following sections describe the individual professional products in more details.

2.5 Classification of professional washing machines and dryers

2.5.1 The European PRODCOM classification[25]

PRODCOM is a system for the collection and dissemination of statistics on the production of manufactured goods. It is based on a product classification called the Prodcom List of the European Community[26] which consists of about 4 500 headings relating to manufactured products. The products are detailed on an 8-digit level; digits 1 to 4 refer to the NACE classification in which the producing enterprise is normally classified. In 2008, the NACE codes have been revised; the following table lists both code classifications.

Table 4 Extract from PRODCOM lists 2008 and 2007 (Source: Eurostat)

Code since 2008	Code 2007	Description
28.94	**29.54**	**Manufacture of machinery for textile, apparel and leather production**
28.94.21	**29.54.21**	**Machinery for washing, cleaning, wringing, ironing, pressing, dyeing, reeling and the like of textile yarn and fabrics; machinery for finishing of felt**
28.94.21.30	29.54.21.30	Ironing machines and presses (including fusing presses; excluding calendering machines)
28.94.21.50	29.54.21.50	Washing, bleaching or dyeing machines (including wringers and mangles, shaker-tumblers; excluding household or laundry-type washing machines)
28.94.21.70	29.54.21.70	Machines for reeling, unreeling, folding, cutting or pinking textile fabrics
28.94.21.80	29.54.21.83	Machines used in the manufacture of linoleum or other floor coverings for applying the paste to the base fabric or other support
	29.54.21.85	Machines for dressing, finishing, wringing, drying, coating or impregnating textile yarns, fabrics or made up textile articles
28.94.22	**29.54.22**	**Laundry-type washing machines; dry-cleaning machines; drying machines, with a capacity > 10 kg**
28.94.22.30	29.54.22.30	Household or laundry-type washing machines of a dry linen capacity > 10 kg (including machines that both wash and dry)
28.94.22.70	29.54.22.70	Drying machines, of a dry linen capacity > 10 kg
28.94.23	**29.56.21**	**Centrifugal clothes-dryers**
28.94.23.00	29.56.21.00	Centrifugal clothes-dryers
28.94.52	**29.54.42**	**Parts of machinery for other production of textiles and apparel and for the working of leather**
28.94.52.10	29.54.42.10	Parts for household or laundry-type washing machines (including for those that both wash and dry)

[25] http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction

[26] http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction

From a practical point of view and against the overall aim of the preparatory study, the table shows that PRODCOM categorisations will be too rough to provide a basis for defining a clear scope of professional washing machines and dryers. For example, among the washing machines or dryers there is no further differentiation with regard to capacity or other functional performance parameters.

2.5.2 The European Customs Classification

The *Harmonized Commodity Description and Coding System (HS)* of tariff nomenclature is an internationally standardized system of names and numbers for classifying traded products developed and maintained by the World Customs Organization (WCO). The HS Nomenclature comprises about 5 000 commodity groups. The HS is a six-digit nomenclature. The first four digits are referred to as the heading. The first six digits are known as a subheading. Individual countries may extend a HS number to eight or ten digits for customs or export purposes. On the basis of the Harmonized System nomenclature, there is further comprised the *Combined nomenclature (CN)*[27] which is used to classify goods when being declared to customs in the Community. Each CN subdivision has an eight digit code number, the CN code, followed by a description. The CN also include preliminary provisions, additional section or chapter notes and footnotes relating to CN subdivisions.

Table 5 Classification of washing machines and dryers according to the HS-Classification (Source: World Customs Organisation[28])

Code	Description
8419	**Machinery, plant or laboratory equipment, whether or not electrically heated (excluding furnaces, ovens and other equipment of heading 8514), for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, distilling, rectifying, sterilising, pasteurising, steaming, drying, evaporating, vaporising, condensing or cooling, other than machinery or plant of a kind used for domestic purposes; instantaneous or storage water heaters, non-electric**
8419.3x	Dryers
8419.39	Other
8420	**Calendering or other rolling machines, other than for metals or glass, and cylinders therefore**
8420.10	Calendering or other rolling machines
8420.10.10	Of a kind used in the textile industry
8420.91 / 8420.99	Parts: Cylinders / Other

[27] http://ec.europa.eu/taxation_customs/customs/customs_duties/tariff_aspects/combined_nomenclature/index_en.htm

[28] Source: www.wcoomd.org/files/1.%20Public%20files/PDFandDocuments/HarmonizedSystem/2007/1684_2007E.pdf

Code	Description
8421	**Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus, for liquids or gases**
8421.1x	Centrifuges, including centrifugal dryers
8421.12	Clothes dryers
8450	**Household or laundry-type washing machines, including machines which both wash and dry**
8450.1x	Machines, each of a dry linen capacity not exceeding 10 kg
8450.11	Fully-automatic machines
8450.11.11	*Each of a dry linen capacity not exceeding 6 kg*
8450.11.11	Front-loading machines
8450.11.19	Top-loading machines
8450.11.90	*Each of a dry linen capacity exceeding 6 kg but not exceeding 10 kg*
8450.12	Other machines, with built-in centrifugal dryer
8450.19	Other
8450.20	Machines, each of a dry linen capacity exceeding 10 kg
8450.90	Parts
8451	**Machinery (other than machines of heading 8450) for washing, cleaning, wringing, drying, ironing, pressing (including fusing presses), bleaching, dyeing, dressing, finishing, coating or impregnating textile yarns, fabrics or made-up textile articles and machines for applying the paste to the base fabric or other support used in the manufacture of floor coverings such as linoleum; machines for reeling, unreeling, folding, cutting or pinking textile fabrics**
8451.21	Drying machines, each of a dry linen capacity not exceeding 10 kg
8451.21.10	Each of a dry linen capacity not exceeding 6 kg
8451.21.90	Each of a dry linen capacity exceeding 6 kg but not exceeding 10 kg
8451.29	Other
8451.30	Ironing machines and presses (including fusing presses)
8451.30.00	Electrically heated, of a power…
8451.30.10	…not exceeding 2 500 W
8451.30.30	…exceeding 2 500 W
8451.30.80	Other
8451.40	Washing, bleaching or dyeing machines
8451.50	Machines for reeling, unreeling, folding, cutting or pinking textile fabrics
8451.80	Other machinery
8451.80.30	Machines for dressing or finishing
8451.80.80	Other
8451.90	Parts

The European Customs Classification will be too rough to provide a basis for defining a clear scope of professional washing machines and dryers. For example, there is no further differentiation with regard to capacity or other functional performance parameters; some relevant categories like tumble dryers and batch system dryers are merged into the category “Other”.

2.5.3 The International Patent Classification

The International Patent Classification (IPC) is a hierarchical patent classification system created under the Strasbourg Agreement (1971) and updated on a regular basis by a Committee of Experts, consisting of representatives of the Contracting States of that Agreement and observers from other organisations, such as the European Patent Office. The Strasbourg Agreement is one of a number of treaties administered by the World Intellectual Property Organization (WIPO). Patent publications from all of the Contracting States (and also most others) are each assigned at least one classification term, indicating the subject to which the invention relates, and may also be assigned further classification and indexing terms to give further details of the contents.

Each classification term consists of a symbol, such as A01B 1/00. The first letter is the "section symbol" consisting of a letter from A to H.[29] This is followed by a two digit number to give a "class symbol". The second letter indicates the "subclass" which is then followed by a 1 to 3 digit "group number", an oblique stroke and a number of at least two digits representing a "main group" or "subgroup".[30]

Table 6 Classification of washing machines and dryers according to International Patent Classification

D06F	**LAUNDERING, DRYING, IRONING, PRESSING OR FOLDING TEXTILE ARTICLES (apparatus for blocking, pressing, steaming, or stretching hats A42C; treating textile materials by liquids, gases or vapours D06B; chemical matters, seeD06L, D06M)**
	Note(s) This subclass covers: domestic or laundry dry-cleaning apparatus using volatile solvents; domestic laundry, or tailors' ironing or other hot-pressing of clothes, linen, or other textile articles. This subclass does not cover apparatus for wringing, washing, dry-cleaning, ironing, or other hot-pressing of textiles in manufacturing operations, which is covered by subclasses D06B, D06C.
Washing; Rinsing; Dry-cleaning	
D06F 9/00	Brushing-type washing machines
D06F 11/00	Washing machines using rollers, e.g. of the mangle type
D06F 13/00	Washing machines having receptacles, stationary for washing purposes, with agitators therein contacting the articles being washed (plungers or the like adapted for removable mounting on receptacles D06F 5/04; washing devices adapted to be used independently of any particular receptacle D06F 7/00)
D06F 15/00	Washing machines having beating, rubbing, or squeezing means in receptacles stationary for washing purposes (plungers or the like adapted for removable mounting on receptacles D06F 5/04; mangle-type washing machines D06F 11/00)

[29] A: Human Necessities; B: Performing Operations, Transporting; C: Chemistry, Metallurgy; D: Textiles, Paper; E: Fixed Constructions; F: Mechanical Engineering, Lighting, Heating, Weapons; G: Physics; H: Electricity

[30] Sources: http://www.wipo.int/export/sites/www/classifications/ipc/en/guide/guide_ipc_2009.pdf, http://en.wikipedia.org/wiki/International_Patent_Classification,

D06F 17/00	Washing machines having receptacles, stationary for washing purposes, wherein the washing action is effected solely by circulation or agitation of the washing liquid (washing devices adapted to be used independently of any particular receptacle D06F 7/00; using vibrations for washing purposes D06F 19/00)
D06F 18/00	Washing machines having receptacles, stationary for washing purposes, and having further drying means (details concerning drying only D06F 58/00) [3]
D06F 19/00	Washing machines using vibrations for washing purposes (devices of the vibrator type adapted to be used independently of any particular receptacle D06F 7/04)
D06F 21/00	Washing machines with receptacles, e.g. perforated, having a rotary movement, e.g. oscillatory movement (with receptacles serving both for washing and centrifugally draining D06F 23/00, D06F 25/00; with receptacles moving bodily about an axis D06F 27/00; programme control aspects D06F 33/00)
D06F 23/00	Washing machines with receptacles, e.g. perforated, having a rotary movement, e.g. oscillatory movement, the receptacle serving both for washing and centrifugally draining (with further drying means D06F 25/00; programme control aspects D06F 33/00)
D06F 25/00	Washing machines with receptacles, e.g. perforated, having a rotary movement, e.g. oscillatory movement, the receptacle serving both for washing and centrifugally draining and having further drying means, e.g. using hot air (programme-control aspects D06F 33/00; details concerning drying only D06F 58/00)
D06F 27/00	Washing machines with receptacles moving bodily, e.g. reciprocating, swinging
D06F 29/00	Combinations of a washing machine with other separate apparatus in a common frame or the like, e.g. with rinsing apparatus
D06F 31/00	Washing installations comprising an assembly of several washing machines or washing units, e.g. continuous flow assemblies
D06F 33/00	Controlling a series of operations in washing machines, e.g. programme-control arrangements for washing and drying cycles (D06F 31/00 takes precedence)
D06F 35/00	Washing machines, apparatus, or methods not otherwise provided for
D06F 39/00	Details of washing machines in so far as such details are not special to washing machines of groups D06F 21/00-D06F 25/00 or to any particular type of washing machine defined in groups D06F 9/00-D06F 19/00 or D06F 27/00
D06F 39/02	. Devices for adding soap or other washing agents
D06F 39/04	. Heating arrangements
D06F 39/06	. Arrangements for preventing or destroying scum
D06F 39/08	. Liquid supply or discharge arrangements (supplying liquid detergent D06F 39/02)
D06F 39/10	. Filtering arrangements
D06F 39/12	. Casings; Tubs
D06F 41/00	Rinsing apparatus
D06F 43/00	Dry-cleaning apparatus using volatile solvents (D06F 9/00-D06F 41/00 take precedence)
D06F 43/02	. having one rotary cleaning receptacle only
D06F 43/04	. having more than one rotary cleaning receptacle
D06F 43/06	. wherein the articles to be cleaned are passed through a cleaning chamber or bath
D06F 43/08	. Associated apparatus for handling and recovering the solvents (separate apparatus for purifying dry-cleaning solvents B01D)
Expelling water from the linen; Smoothing by cold rolling	
D06F 45/00	Wringing machines with two or more co-operating rollers; Similar cold-smoothing apparatus
D06F 47/00	Apparatus of the press type for expelling water from the linen
D06F 49/00	Domestic or similar spin-dryers not suitable for industrial use (centrifuges in general B04B)
D06F 51/00	Apparatus for expelling or draining water from the linen, not provided for in groups D06F 45/00-D06F 49/00

Drying; Airing	
D06F 57/00	Supporting means, other than simple clothes-lines, for linen or garments to be dried or aired (in combination with means for heating or positive air circulation D06F 58/00, F26B; adapted to retain the shape of particular articles being dried D06F 59/00; clothing hangers, e.g. suit hangers, A47G 25/14)
D06F 57/02	. mounted on pillar, e.g. rotatable
D06F 57/06	. comprising vertical members connected by horizontal bars
D06F 57/08	. Folding stands (D06F 57/06 takes precedence)
D06F 58/00	Domestic laundry dryers (drying in general F26B)
D06F 58/02	. having dryer drums rotating about a horizontal axis
D06F 58/10	. Drying cabinets or drying chambers having heating or ventilating means
D06F 58/16	. having heatable surfaces for contacting the laundry (D06F 59/00 takes precedence)
D06F 58/18	. Detachable or door-mounted drying arrangements for washing machines
D06F 58/20	. General details of domestic laundry dryers (D06F 59/00 takes precedence)
D06F 59/00	Supports adapted to retain the shape of particular articles being dried, e.g. incorporating heating means
D06F 60/00	Drying not provided for in groups D06F 53/00-D06F 59/00
Ironing; Pressing	
D06F 61/00	Ironing machines using two or more co-operating pressing rollers
D06F 63/00	Ironing machines having a roller or rollers co-acting with a fixed or moving flat bed or table (coverings or pads D06F 83/00)
D06F 65/00	Ironing machines with rollers rotating against curved surfaces
D06F 67/00	Details of ironing machines provided for in groups D06F 61/00, D06F 63/00, or D06F 65/00 (coverings or pads for ironing or pressing members D06F 83/00)
D06F 67/02	. Rollers; Heating arrangements therefore
D06F 67/04	. Arrangements for feeding or spreading the linen
D06F 67/06	. Means for stripping the linen from the rollers
D06F 67/08	. Beds; Heating arrangements therefore
D06F 67/10	. Driving arrangements
D06F 69/00	Ironing machines not otherwise provided for
D06F 69/02	. using endless or other ironing or pressing belts or aprons
D06F 69/04	. with relatively-sliding flat surfaces
D06F 71/00	Apparatus for hot-pressing clothes, linen, or other textile articles, i.e. wherein there is substantially no relative movement between pressing element and article while pressure is being applied to the article; Similar machines for cold-pressing clothes, linen or other textile articles (smoothing by cold rolling between two or more co-operating rollers D06F 45/00; devices, for household use, for cold-pressing garments A47G)
D06F 73/00	Apparatus for smoothing or removing creases from garments or other textile articles by formers, cores, stretchers, or internal frames, with the application of heat or steam (stretchers for drying purposes D06F 59/00; combined with external pressure means D06F 71/00; stretchers for use with presses D06F 71/40; dress forms for the tailoring trade A41H; garment stretchers without the application of heat A47G 25/00)
D06F 81/00	Ironing boards (coverings or pads therefore D06F 83/00; combined with tables, mounted in kitchen cabinets A47B; tables in general A47B; combined with ladders E06C)

Other laundry apparatus or systems	
D06F 87/00	Apparatus for moistening or otherwise conditioning the article to be ironed or pressed (apparatus for smoothing or removing creases from garments or other textile articles by formers, cores, stretchers or internal frames, with the application of heat or steam D06F 73/00)
D06F 89/00	Apparatus for folding textile articles with or without stapling
D06F 93/00	Counting, sorting, or marking arrangements specially adapted for laundry purposes
D06F 95/00	Laundry systems or arrangements of apparatus or machines; Mobile laundries (D06F 31/00 takes precedence; laundries as buildings E04H)

The comparison with the former statistical product classification schemes European PRODCOM and Customs classification clearly shows that the IPC scheme offers the most detailed graduation by product design and applications.[31] For example, items D06F 39/00 to D06F 39/12 being parts of professional washing machines are supplementary parts even not supplied by manufacturers of washing machines but by different suppliers (e.g. devices for adding soap or other washing agents are produced by special manufacturers of dosing equipment). The IPC classification provides an overview of the diversity of professional laundry appliances. It distinguishes for example ten different subclasses for washing machines (D06F 13/00 – D06F 27/00).

2.5.4 Categories according to standards and labelling

The U.S. ENERGY STAR (cf. Section 4.3.1) distinguishes the following categorisations of professional washing machines (there are no ENERGY STAR requirements for professional dryers): front and top loader clothes washers with capacities of greater than 1.6 ft^3 (45.3 litres)[32].

There are two ISO standards for professional or industrial washing machines and dryers: ISO 9398: Specifications for industrial laundry machines – definitions and testing of capacity and consumption characteristics, and ISO 10472: Safety requirements. Both standards provide different product categories according to the function they offer (for details, see Chapters 3.1.1 and 3.2.1). ISO 9398 distinguishes four different categories of professional washing machines and dryers:

- Washer extractors
- Washing tunnels
- Batch drying tumblers
- Flatwork ironing machines

The following table provides an overview of product categories being in the scope of ISO 10472.

[31] Further subcategories: cf. http://depatisnet.dpma.de/ipc/ => IPC symbol “D06F”

[32] 1 cubic foot (ft^3) equates 28.32 litres

Table 7 Classification of washing machines and dryers according to ISO 10472

Washing machines and washer extractors > 60 litres (ISO 10472-2) with definitions for the following sub-categories:	
Washing machine	Washing machine: Machines performing only those operations required for washing textiles.
Washer extractor	Machines which combines the functions of textile washing and moisture extraction by centrifugal action.
Fixed washer-extractor	Washer-extractor in which the drum is rigidly mounted in the frame.
Suspended washer-extractor	Washer-extractor in which the drum is not rigidly connected to the frame but is secured by means of a vibration-reducing system.
Tilting washer-extractor	Fixed or suspended washer-extractor in which the drum tilts during loading and/or unloading.
Drawer-type washer-extractor	Fixed or suspended washer-extractor in which two half-cages slide horizontally out from the frame, in the low position for loading and the high position for unloading.
Top-loading, vertical axis washer-extractor	Washer-extractor in which the plane of the loading door is at a right angle to the vertical axis of the rotation of the cage.
Front-loading machine	Washing machine or washer-extractor in which the plane of the loading door is at a right angle to the horizontal axis of rotation of the cage.
Side-loading machine	Washing machine or washer-extractor in which the plane of the loading door is parallel to the horizontal axis of rotation of the cage.
Barrier machine	Washing machine or washer-extractor without direct contact between the loading and unloading positions (e.g. separated by a wall).
Aseptic machine	Washing machine or washer-extractor used for processing infected work.
Washing tunnel lines including component machines (ISO 10472-3) with definitions for the following sub-categories	
Washing tunnel line	Complete integrated systems of linked machines for the washing, moisture extraction and drying or disentangling of discrete batches of textile fabric, including all necessary equipment for supply of water, steam, gas, electricity and chemicals.
Continuous tunnel washing machine	Machines designed to wash items in successive loads as a continuous process. NOTE: These machines may consist of one cage rotating around a longitudinal axis and subdivided into separate compartments, or several cages or several machines linked by means of a transfer system.
Squeeze press	Machine for the mechanical extraction of moisture from textile fabrics by the application of pressure (component machine within a washing tunnel line) Note: It is designed to receive loads of textile material automatically from a tunnel washing machine and to remove moisture by applying pressure (e.g. by a flexible membrane). Such a machine may with one or two pressure stations where the pressure may be applied hydraulically, mechanically or pneumatically
Centrifugal extraction machine	Machine containing a perforated cage to and from which successive loads are transferred and within which the loads are subjected to a centrifugal force due to the rotation of the cage the purpose of extracting moisture (component machine within a washing tunnel line)
Automatic transfer tumble dryer	Machine for moisture extraction from a load of damp textile material by tumbling in a rotating cage in an atmosphere of hot air (component machine within a washing tunnel line).

Air dryers > 160 litres (ISO 10472-4) with definitions for the following sub-categories	
Tumble dryer	Machine for moisture extraction from a load of damp textile material by tumbling in a rotating cage in an atmosphere of hot air produced by the tumble dryer.
Front-loaded tumble dryer	Tumble dryer in which the plane of the loading door is at a right angle to the axis of rotation of the cage.
Pass-through tumble dryer	Tumble dryer having the loading and unloading doors on opposite sides.
Tilting tumble dryer	Tumble dryer, which tilts for loading and/or unloading.
Automatic tilting tumble dryer	Tilting tumble dryer with the tilting motion to load and unload, and opening and closing doors, under automatic (not manual) control.
Tunnel finisher	Machine for the drying and finishing of shaped garments within which damp garments arranged on hangers are loaded onto an overhead conveyor for transport through the machine in an atmosphere of high humidity followed by an atmosphere of hot dry air produced by the tunnel finisher.
Cabinet dryer	Heated cabinet within which shaped garments are suspended on hangers for the purpose of drying, without being conveyed during the drying cycle.
Flatwork ironers, feeders and folders (ISO 10472-5) with definitions for the following sub-categories	
Bed ironer	Machine for the ironing of flatwork generally providing a heated bed against which the work is pressed by one or several fabric-covered roller(s).
Cylinder ironer	Machine for the ironing of flatwork in which the work to be treated is drawn against one or more heated cylinder(s) where it is held by means of an appropriate system, for example by bands.
Flatwork feeding machine	Machine, into which operator(s) load damp unfinished flatwork items, that presents the items, tensioned and spread to the feed-bands of an ironer or to a folding machine.
Flatwork folding machine	Machine generally fitted in conjunction with an ironer which will automatically fold flatwork items. NOTE: This machine is also used for folding blankets, polyester sheets and similar items.
Folding machine for small pieces	Machine for automatically folding towels, pillow cases and similar items.
Multi-function	machine which combines feeding, ironing and folding in one unit
Ironing and fusing presses (ISO 10472-6) with definitions for the following sub-categories	
Ironing press	Machine for the smoothing or shaping of fabric items by pressing them between two components, at least one of which is heated and, if required, equipped with a steaming device.
Fusing press	Machine for the fusing of two textile layers by pressing them between two components, at least one of which is heated to a temperature such that the coating of one layer becomes adhesive.
Scissor press	Ironing or fusing press whose head is moved on a circular path or a combination of circular and linear paths against a stationary buck.
Cabinet press	Machine into which a garment is placed on a vertical buck (or former) which is moved to a position between two or more vertical press heads which move horizontally to press the garment against the buck. NOTE: A cabinet press may have one or more vertical bucks which travel horizontally such that the entire equipment may be operated by two or more operators in concert.
Drawer press	Ironing or fusing press whose horizontal buck is moved on a horizontal linear path under the head, then the buck (or head) is pressed against the head (or buck) on a vertical, linear path.
Rotary press	Press in which the loading, unloading and pressing operations are assigned to different positions of the movement of a turntable carrying the bucks.

Upstroke press	Press comprising an upper head and a lower buck, upon which the fabric item is prepared, after which the action of the press raises the lower buck to the press head either mechanically or pneumatically.
Multiple-buck press	Press similar to a rotary press in which the bucks can travel in a straight path.

From a practical point of view and considering the overall aim of the preparatory study, the table shows that ISO categorisation provides a good basis for defining a categorisation of professional washing machines and dryers within Lot 24.

As highlighted in the previous section, it has to be noted that in this context, the term "industrial" includes also rather small semi-professional and professional machines. There is no further differentiation between washing machines or dryers with regard to professional / commercial and industrial equipment, e.g. capacity or other functional performance parameters (see also Sections 2.4.3 and 0).

2.5.5 Functional performance classification

Product definitions in international standards already give a differentiated overview of the variety of professional laundry appliances on the market (see Section 2.5.4). In this section, professional washing machines and dryers are further classified according to functional performance parameters.

2.5.5.1 Functional performance classification of professional washing machines

To better understand the differences between the above described categories, first of all an overview of the primary and secondary functions and important framework requirements of professional washing machines is given. Then the main properties to distinguish between the different categories within professional washing machines are described in a more detailed way.[33] Finally, seven product categories were identified as a result of this analysis of functions and the respective properties of professional washing machines.

Primary and secondary functions of professional washing machines

In general, the *primary function* of a washing machine is to clean and rinse textiles by using water as solvent (washing function). The washing machine may also have an integrated means for extracting excess water from the textiles (spinning/dewatering function). Apart from these functions, important requirements of customers for professional washing machines are:

[33] This further product information is gathered from secondary literature and the product portfolios of several manufacturers.

- Low energy, water and detergent consumption, and
- high hygiene performance.

In contrast to household washing machines there are some framework requirements for professional washing machines that have to be taken into account and that vary to a great extent for different customer groups:

- High capacities and shorter running cycles;
- amount of laundry to be cleaned;
- types of fabrics to be cleaned, and
- spatial / infrastructural requirements.

These framework requirements might be very different depending on the respective application; they are the main reason for a range of different product categories for professional washing machines on the market compared to e.g. washing machines for the household use which are quite similar regarding the principal design (i.e. mainly free-standing or built-in front loaders with capacities of 4 to 10 kilograms of laundry and spin speeds between 1 200 and 1 800 rpm).

Main properties of professional washing machines

Based on Table 7 ("Classification of washing machines and dryers according to ISO 10472"), the following main properties can be used to distinguish between the categories of professional washing machines (see next section).

- Machines combining the functions of textile washing and moisture extraction by centrifugal action (**washer extractors**);
  - Washer extractor without direct contact between the loading and unloading positions e.g. separated by a wall (**barrier washers**);
- Machines combining the functions of textile washing and moisture extraction by evaporation (**washer dryers**);
- Machines designed to wash items in successive loads as a continuous process (**tunnel washing machines**).

Within washer extractors there is a great variety regarding further functional performance parameters. For example, ISO 10472-2 classifies the following sub-categories:

Table 8 Sub-categories of washer extractors according to ISO 10472-2

Technical and construction characteristics	Sub-categories of washer extractors
A) Connection of the drum	**A.1 Fixed washer-extractor**: Washer-extractor in which the drum is rigidly mounted in the frame. **A.2 Suspended washer-extractor**: Washer-extractor in which the drum is not rigidly connected to the frame but is secured by means of a vibration-reducing system.
B) System for the support of loading and/or unloading	**B.1 Tilting washer-extractor**: Fixed or suspended washer-extractor in which the drum tilts during loading and/or unloading. **B.2 Drawer-type washer-extractor**: Fixed or suspended washer-extractor in which two half-cages slide horizontally out from the frame, in the low position for loading and the high position for unloading.
C) Type of loading	**C.1 Top-loading, vertical axis washer-extractor**: Washer-extractor in which the plane of the loading door is at a right angle to the vertical axis of the rotation of the cage. **C.2 Front-loading machine**: Washer-extractor in which the plane of the loading door is at a right angle to the horizontal axis of rotation of the cage. **C.3 Side-loading machine**: Washer-extractor in which the plane of the loading door is parallel to the horizontal axis of rotation of the cage.
D) Machines for special hygiene requirements	**D.1 Barrier machine**: Washer-extractor without direct contact between the loading and unloading positions (e.g. separated by a wall). **D.2 Aseptic machine**: Washer-extractor used for processing infected work.

Additionally, further technical parameters of professional washer extractors were gathered from secondary literature and product portfolios of several manufacturers:

- **Extraction speed / spin speed / g-factor**: The residual moisture of laundry is depending on the spin speed and the drum diameter thus resulting in the G-force[34] of washer extractors. The residual moisture of the laundry coming from the washing process has an effect on the energy consumption required for the subsequent thermal drying process.
- **Load capacities** of washer extractors: The typical range is between 6 and 120 kilograms. Furthermore, some washer extractors come with load capacities of e.g. 200, 230, 240, 270 and 280 kilograms. Beyond that, at least one manufacturer even offers 300 kg machines for work wear garments, respectively 400 kg machines for dust mats.[35]

Some examples for spin speeds and the associated G-forces, as well as other design and technical parameters (different spin speeds as normal, fast and high spin) of washer extractors are summarised in the following table.

[34] G-force (gravitational force):..The g-factor is a measure of centrifugal force which has a significant effect on laundry during spinning. G equates to 9.81 m/s² (acceleration as a result of the pull of gravity) (Source: Miele professional)

[35] Source: http://www.kannegiesser.de/900.0.html?&L=1, sighted on 26 January 2010

Table 9 Overview of design parameters of washer extractors

	Washer extractors, product examples
Capacities	6-400 kg per cycle
Technical parameters	Extraction speed / G-force: 415-550 rpm / 80-90 (normal spin[36]) 600-700 rpm / 150 (fast spin) 700-1 250 rpm / 250-475 (high spin)
Washing programmes	Up to 99 different washing programmes
Construction options	Front / side / top loaders; barrier wall / non barrier wall
Heating options*	▪ Electric heating, ▪ Hot water (boiler fed), ▪ Steam (direct steam injection / indirect steam heating) or thermo oil ▪ Combo-version: direct steam heating being switchable to electric heating ▪ Gas

** heating the water for the washing process*

Regarding the purposes of EuP Lot 24, the different capacities have proved as most dominating parameter influencing the categorisation of machines within washing machines with integrated moisture extraction by centrifugal action (so called “washer extractors”). Therefore, a further differentiation into sub-categories based on capacities has been chosen. The respective capacity ranges have been derived from current market categorisations as well as from stakeholder feedback during the course of this study.

Categories of professional washing machines used in Lot 24

The following table gives a summarizing overview of the professional washing machine categories which will be used as input for the following tasks:

[36] Source: http://www.ipso.be/products/category.asp?pageid=2&c=1

Table 10 Overview of the scope of professional washing machines categories within Lot 24

Washing machine category	Load capacity[37]	Water heating options	Programme options and operating principle	Type of loading
WM1: Semi-professional washer extractor	up to 7 kg	Electric	Fix programmes, manual programme, automat, Hot and cold water connection	Manual, front / loading
WM2 Professional washer extractor, <15 kg	up to 15 kg	Electric, hot water, steam (direct or indirect), combo: direct steam and electric, gas	Partly programmable Manual programme automat, Hot and cold water connection	Manual, front / side loading
WM3 Professional washer extractor, 15-40 kg	15-40 kg	Electric, hot water, steam (direct or indirect), combo: direct steam and electric, gas	Partly programmable Manual programme automat, Hot and cold water connection	Manual, front / side loading
WM4 Professional washer extractor, >40 kg	40-400 kg	Electric (only with maximal 62 kg batch size, hot water, steam (direct or indirect), combo: direct steam and electric, gas	Partly programmable / fully programmable, manual programme automat, Hot and cold water connection for most applications with a large variety of additional equipment	Front / side / top loading manual or automatic top, loading and tilt unloading
WM5 Professional washer dryer	15/33 kg[38] (up to 240 dm³)	Electric	Partly programmable, Washing and drying in one machine, no re-loading, used also as regular dryer or washer	Manual, front loading
WM6 Professional barrier washer	15-240 kg	Electric (only with maximal 62 kg batch size), Steam (direct or indirect), gas	Fully programmable, ensure highest hygienic standards, barrier wall, doors on opposites sides	Front / side loading; manual or automatic top, loading and tilt unloading
WM7 Washing tunnel machine	250-4 000 kg/h Number of compartments (5-20); length (4.7-18 m)	Steam (or thermo oil, gas	Fully programmable + operated, batch (by items) continuous washing, laundry pass each compartment	Automatically, conveyor, pass through, bottom or centre transfer

[37] The product capacity of professional washing machines is usually given in kilograms instead of volume. A differentiation based on volumes would not be clear as it may vary depending on the kind of the textiles. The load capacity depends on the drum volume and the filling ratio; the latter in turn depends on the density of the laundry to be washed.

[38] Washing / Drying capacity

2.5.5.2 Functional performance classification of professional dryers

Product definitions in international standards already give a differentiated overview of the variety of professional dryers on the market (see Section 2.5.4). In this section, we will categorize the comprehensive list of definitions in a more structured way according to functional performance parameters provided by standards. Additionally, the main properties to distinguish between the different categories of professional dryers are described in a more detailed way. This further product information is gathered from secondary literature and the product portfolios of several manufacturers.[39]

Primary and secondary functions of professional dryers

The *primary function* of a (professional) laundry dryer is to thermally remove moisture from laundry, generally shortly after it has been cleaned in a washing machine (drying efficiency).

Porter et al. (1984)[40] provide a classification of dryers used in chemical technology dividing them into direct and indirect dryers, based on the method of heat transfer:

- **Direct dryers**: Heat transfer for drying is accomplished by direct contact between the wet solid and hot gases. The vaporized liquid is carried away by the drying medium; i.e. the hot gases. Direct dryers might also be termed *convection* dryers.
- **Indirect dryers**: Heat for drying is transferred to the wet material by conduction through a solid retaining wall, usually metallic. The vaporized liquid is removed independently of the heating medium. Rate of drying depends on the contacting of the wet material with hot surfaces. Indirect dryers are also termed *conduction* or contact dryers.

Apart from drying, important requirements of customers for professional dryers are

- energy efficiency,
- wear resistance,
- finishing, calendering (by ironing, pressing or garment finishing).

Some dewatering machines, however, combine both the functions calendering (i.e. flattening) and drying, e.g. garment finishers, flatwork ironing machines, or presses. From customers' perspective and according to stakeholders, the primary function of these appliances is the removal of creases and, in case of finishers, the relaxing of the textiles, including desired changes of the surface structure. Drying is only a secondary or even less important function.

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[39] Sources (see Section 6): Girbau, Ipso, Miele, Primus, Stahl, Kannegiesser; http://tunnelfinisher.com/, sighted on 23 February 2010

[40] Porter, H.F.; Schurr, G.A.; Wells, D.F.; Semrau, K.T.; Solids Drying and Gas-Solid Systems; in: Perry's Chemical Engineers' Handbook; Perry, R.H. and Green, D.W. (Eds.); 6th Edition, McGraw-Hill, New York, 1984.

Main properties of professional dryers

Based on the classification of dryers by Porter et al. (1984) as well as additional literature research, the following main properties can be used to distinguish between the categories of professional dryers (see next section: "Categories of professional dryers used in Lot 24").

Table 11 General classification of dryers

Method of heat transfer	**Direct heat transfer**		Indirect heat transfer	
Primary function	**Removal of moisture**	Removal of creases, relaxing of textiles	Removal of creases	Removal of creases
Product categories	**Air dryer**	Finisher	Flatwork ironers	Ironing and fusing presses
Product sub-categories	▪ **Tumble dryers** ▪ **Cabinet dryers**	Steam air finisher Tunnel finisher		

For the purposes of Lot 24 only those products where classified as dryers falling under the scope of the study which use a direct method for heat transfer and for which the removal of moisture is the primary function (i.e. air dryers). Nevertheless, for the benefit of completeness, the further listed appliances are described in the Annex, Section 7.3.

From ISO 10473, following sub-categories for air dryers can be derived:

- **Cabinet dryers** are heated cabinets within which shaped garments are suspended on hangers for the purpose of drying, without being conveyed during the drying cycle.
- **Tumble dryers** are machines for moisture extraction from a load of damp textile material by tumbling in a rotating cage in an atmosphere of hot air produced by the tumble dryer.

Within tumble dryers there is a great variety regarding further functional performance parameters. For example, ISO 10472-4 classifies the following sub-categories:

Table 12 Sub-categories and definitions of tumble dryers according to ISO 10472-4

Technical/construction characteristics	**Sub-categories of tumble dryers**
A) Type of loading	**A.1 Front-loaded tumble dryer**: Tumble dryer in which the plane of the loading door is at a right angle to the axis of rotation of the cage. **A.2 Pass-through tumble dryer**: Tumble dryer having the loading and unloading doors on opposite sides.
B) System for the support of loading and/or unloading	**B.1 Tilting tumble dryer**: Tumble dryer, which tilts for loading and/or unloading. **B.2 Automatic tilting tumble dryer**: Tilting tumble dryer with the tilting motion to load and unload, and opening and closing doors, under automatic (not manual) control.

Additionally, the following further technical characteristics of professional tumble dryers were derived from literature as well as product portfolios of several manufacturers:

- *Air-vented tumble dryers*: They continuously draw in the cool, dry, ambient air around them and heat it by an electrical heating (electric, steam, gas) element before passing it through the moist laundry in the tumbler. The resulting hot, humid air is simply vented outside to make room for more dry air to continue the drying process. Therefore they require an external duct out to open air (open system). Variant:
- *Condenser tumble dryers*: They also pass air which is heated by an electrical heating element through the load. However, instead of exhausting this air, the dryer uses a heat exchanger to cool the air and condense the water vapour into either a drain pipe or a collection tank. Afterwards, this air is run through the loop again. The heat exchanger typically uses ambient air as its coolant, therefore the heat produced by the dryer will go into the immediate surroundings instead of the outside, increasing the room temperature slightly. They do not require an external duct but they do need fresh air ventilation to operate effectively. Condenser dryers represent an appropriate solution in circumstances where no form of external ventilation is available. Variant:

Finally, regarding the purposes of EuP Lot 24, the different capacities have proved as further dominating parameter influencing the categorisation of machines within tumble dryers. Therefore, a further differentiation into sub-categories based on capacities has been chosen. The respective capacity ranges have been derived from current market categorisations as well as from stakeholder feedback during the course of this study.

Categories of professional dryers used in Lot 24

The following table gives a summarizing overview of the professional dryer categories which will be used as input for the following tasks:

Table 13 Overview of the scope of professional dryer categories within Lot 24

Dryer category	Load capacity[41]	Drying control	Heating options	Type of loading	Further design options
D1 Semi-professional dryer, condenser	<8 kg	Temperature or time control, residual moisture controlled	Electric, heat pump	Front loading	Substructures
D2 Semi-professional dryer, air vented	<8 kg	Temperature or time control, separate heat and cool down timers, residual moisture control	Electric, steam, gas	Front loading	Drum interior lighting

[41] Load capacity depends on the drum volume and the filling factor (the filling factor for typically professional dryer is from 1:18 to 1:25)

Dryer category	Load capacity[41]	Drying control	Heating options	Type of loading	Further design options
D3 Professional cabinet dryer	3-30 kg	Humidity sensor Overheat protection	Electric, steam, heat pump	Hangers, Front loading	Drain for excessive water drippings, bar for hangers, pull-out hangers, glove rack and hanger rod on door, shoe rack, combination of heat and steam injection
D4 Professional tumble dryer <15 kg	<15 kg	Temperature or time control, separate heat and cool down timers, residual moisture controlled, heat recycling	Electric, steam, gas, heat pump	Front loading Stacker tumbler loading	Air recycling, reverse action, New Air Control system, central air intake, large-surface fluff filter, all kinds of linen, heat exchanger, condensing unit
D5 Professional tumble dryer 15-40 kg	15-40 kg	Temperature or time control, separate heat and cool down timers, residual moisture controlled, heat recycling	Steam, gas, heat pump	Front loading	Air recycling, reverse action, New Air Control system, central air intake, large-surface fluff filter, all kinds of linen, heat exchanger, condensing unit
D6 Professional tumble dryer >40 kg	>40 kg	Temperature or time control, separate heat and cool down timers, residual moisture controlled, heat recycling	Steam, gas, heat pump	Front loading	Air recycling, reverse action, New Air Control system, central air intake, large-surface fluff filter, all kinds of linen, heat exchanger, condensing unit
D7 Pass-through (transfer) tumble dryer	40-240 kg	Temperature or time control, heat and cool down timers, residual moisture controlled, heat recycling	Electric, steam, gas, hot oil	Automatically, loading and unloading doors on opposite sides	Automatic lint cleaning system and infra touch, all kinds of linen

2.5.6 Classification according to market/customer segments

Professional washing machines and dryers are used in a large range of applications. In this section, we give an overview of the variety of customer segments and corresponding types of laundry on the basis of an analysis compiled from product information and personal information by manufactures.[42]

Different market areas have unique requirements that are fulfilled with help of tailored solutions, such as options, changeable programmes etc. Thus, the professional laundry equipment could be categorized in following main customer segments:

[42] Source see Section 6: by Miele Professional, Electrolux Professional, http://www.commerciallaundryequipment.girbau.com/segments

- **Coin & Card Laundry (CCL)**: laundrette, camping, student dorms, real estate etc. and **Apartment Household Laundry (AHL)**: household, real estate, old people's homes etc; the users are not the owners and therefore safety and easy handling are the most important issues.
- **Hospitality Laundry (HPL)**: hotels, restaurants, quick service restaurants etc.
- **Healthcare Laundry (HCL):**
  - **Healthcare Nursing Home (HN)** with hygiene demands**.**
  - **Healthcare Hospital (HH)** with very high hygiene demands
- **Commercial Industrial Laundry (CIL)**: service providers, textile rent cleaning, small or heavy duty laundries etc.
- **Speciality Laundry (SP)** including high-tech industries (mops, functional garments like fire and rescue service or offshore, pharmaceutical and electronic factories).
- Others: airlines, convenience stores, work camps, military establishments, car repair shops, farms, prisons, leisure and sports, etc.

The type of laundry and degree of contamination (e.g. fat, protein, oil, blood etc.) in commercial and industrial laundries differ greatly. The following main types of laundry are identified:

- Apartment household textiles;
- Work wear – all types;
- Hotel and restaurant linen, towels, roller towels;
- Healthcare linen, clean room linen (special hygienic requirements);
- Special laundry (e.g. dust mats, mops, wipers, terry cloth, microfiber, laminated fabric);
- High visibility garments, functional garments (e.g. firemen etc.);

Depending on the particular type of laundry and specific treatment requirements (e.g. hygienic requirements in the sanitary field, preservation of the protective function of fire protection suits etc.), different product and programme solutions exist.

3 Test standards of professional washing machines and dryers

This subtask aims to specify the relevant test standards for professional washing machines and dryers concerning test procedures for functional performance parameters, resource use, safety and hygiene as well as noise and vibration and (if any) other specific test procedures. A short overview of existing test standards is given, including household standards whose scope has currently been modified to 'household and similar electrical appliances' thus including standardisation work on professional machines.

3.1 Performance

3.1.1 ISO 9398 (International)

ISO 9398 Specifications for industrial laundry machines – Definitions and testing of capacity and consumption characteristics

- ISO 9398-1:2003 Specifications for industrial laundry machines – Definitions and testing of capacity and consumption characteristics, Part 1: Flatwork ironing machines

  Part 1 defines the characteristics of flatwork ironing machines and gives the usual test methods for determining these characteristics with regard to machine capacity power consumption and hourly productivity. It is applicable for use as a reference in the drafting of purchasing orders for flatwork ironing machines having a contact surface area greater than 0.25 m^2. It does not cover safety requirements (see ISO 10472-5).

  The energy consumption of a flatwork ironing machine is defined as the number of kilojoules or kilowatt hours of steam, gas, electricity or heat-transport fluid energy required for flat-ironing one test load having a residual moisture level on discharge from the flatwork ironing machine.
- ISO 9398-2:2003 Specifications for industrial laundry machines – Definitions and testing of capacity and consumption characteristics, Part 2: Batch drying tumblers

  Part 2 defines the characteristics of a batch drying tumbler and gives the usual test methods for these characteristics with regard to machine capacity, power consumption and productivity. It is applicable for use as a reference in the drafting of purchasing orders for batch drying tumblers whose net usable cage volume is greater than 160 dm^3 (litres) (corresponding 6 kg to 7 kg dry linen capacity). It does not cover safety requirements (see ISO 10472-4).

  The energy consumption of batch drying tumblers is defined as the number of kilojoules or kilowatt hours of steam, gas, electricity or heat-transport fluid energy required for the drying of a test load to obtain residual moisture content after drying.
- ISO 9398-3:2003 Specifications for industrial laundry machines – Definitions and testing of capacity and consumption characteristics, Part 3: Washing tunnels

  Part 3 defines the characteristics of washing tunnels and gives test methods for determining machine power consumption and hourly productivity. It is applicable for use as a reference in the drafting of purchasing orders for washing tunnels. It does not cover safety requirements (see ISO 10472-3).

  The energy consumption of a washing tunnel is defined as the number of kilojoules or kilowatt hours of steam, gas, electricity or heat-transport fluid energy required for the washing of one test load in machine operating at its nominal capacity during one cycle.

- ISO 9398-4:2003 Specifications for industrial laundry machines – Definitions and testing of capacity and consumption characteristics, Part 4: Washer-extractors

  Part 4 defines the characteristics of washer-extractors and gives test methods for these characteristics with regard to machine capacity, power and water consumption, and hourly productivity. Parameters are measured in three specified programmes (programmable timers needed); no measurement method for the washing and rinsing performance is available in the test standard (e.g. no types of soiling are given), see also Table 14. The energy for the test shall be supplied by steam, gas, electricity or heat-transport fluid, as specified by the manufacturer. The standard is applicable for use as a reference in the drafting of purchasing orders for washer-extractors whose net usable cage volume is greater than 60 dm^3 (litres). It does not cover safety requirements (see ISO 10472-2).

  The energy consumption of a washer-extractor is defined as the number of kilojoules or kilowatt hours of steam, gas, electricity or heat-transport fluid energy required during washing and extraction of a test load in machine operating at its nominal capacity during the time corresponding to three different described cycles.

These four standards for professional laundry machinery define the measurement method for the energy and water consumption; the standards do not include the washing and rinsing performance measurement and are thus not used by most manufacturers.[43]

Instead, manufacturers use internal test procedures which allow direct comparison between models of similar performance characteristic. These are not suitable for a performance classification of professional washing machines and dryers due to insufficient reproducibility; however, manufacturers feed their experiences into the work on the development of new performance standards for professional laundry machines (sub working group CLC/TC59X/SWG1.12 of CENELEC TC59X, see Section 3.1.3).

3.1.2 IEC and European harmonised standards EN 60456 and EN 61121

EN 60456:2005 Clothes washing machines for household use – Methods for measuring the performance (IEC 60456:2010)

This standard deals with methods for measuring the performance of clothes washing machines for household use, with or without heating devices and for cold and/or hot water supply. Also included are appliances for water extraction by centrifugal force and appliances for both washing and drying textiles (called washer-dryers) with respect to their washing per-

[43] See also Section 3.1.5); according to Electrolux professional, Kannegiesser, Miele professional

formance. The object is to state and define the principal performance characteristics of household electric washing machines and spin extractors and to describe the standard methods for the measuring of the performance.

EN 61121:2005 Tumble dryers for household use – Methods for measuring the performance (IEC 61121:2005)

This international standard is applicable to household electric tumble dryers of the automatic and non-automatic type, with or without a cold water supply and incorporating a heating device. The object is to state and define the principal performance characteristics of household electric tumble dryers of interest to users and to describe standard methods for measuring the performance.

These two standards are the main harmonised international standards regarding the performance measurement of washing machines and tumble dryers for *household use*. They are valid for electric mains-operated household washing machines and tumble dryers. The standards are used to measure the information required by Commission Directives 95/12/EC and 95/13/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household washing machines and tumble dryers. In summary these standards define the general test conditions and specific test methods for the following information:

- Household washing machines:
  - Washing performance, rinsing performance, spin extraction performance
  - Energy consumption, water consumption, programme time, and
  - Shrinkage during the wool wash programme
- Household tumble dryers:
  - Drying performance, condensation efficiency (for condenser dryers)
  - Energy consumption, programme time, and
  - Evenness of drying.

For measuring each of the information, the same programme has to be used.

Since adoption of IEC 60456 and 61121, the standards have repeatedly been amended and modified, currently IEC 60436 edition 5.0 from 11.02.2010 and IEC 61121 edition 3.1 consolidated with amendment 1 from 21.07.2005 being in effect.

3.1.3 Work on development of new performance standards for professional laundry machines

In 2009, CENELEC TC59X settled two Sub Working Groups with the scope to develop performance standards for laundry machines for commercial use (CLC/TC59X/SWG1.12) and for dishwashing machines for commercial use (CLC/TC59X/SWG2.1).

Scope of SWG 1.12 is to develop performance standards for laundry machines (washing machines and tumble dryers) for commercial use based on current and coming versions of household standards EN60456 and EN 61121.

The constitutional meeting of this sub-working group has taken place in November 2009.[44] For the members of SWG 1.12 it is evident that the content from EN 60456 and EN 61121 has to be revised and in some cases totally changed in order to fulfil the requirements for professional appliances. Discussions were held on the scope of a new standard for professional laundry machines and possible equipment and variants that might not be covered by the developed standards.[45] Further, members of SWG 1.12 provided a definition of the terms "commercial" and "professional" (cf. Section 2.4.3) and proposed that a possible standard for professional laundry machinery should follow market segments instead of machine size.[46]

Work is still in progress.

3.1.4 Further used or adopted performance testing methods

In the context of the modification of the scope of EN 60456, the Danish Technological Institute (DTI) already performed examples of test methods and programmes for professional washing machines. The energy and water consumption as well as washing and rinsing performance of professional washing machines have been measured for different programmes, temperatures and loads. The data have been measured following the test standard EN 60456. Data sheets of the tests are available on the web site belonging to the Danish Energy Association[47].

3.1.5 Conclusion: Comparison of different performance standards

The following tables show the differences between the several standard conditions defined in the European measurement methods to evaluate the consumption and the performance of appliances.

Currently, there is no commonly applied performance measurement standard for professional washing machines and dryers in Europe. ISO 9398 series for professional laundry machinery defines a measurement method for the energy and water consumption; however, does not include a performance measurement (washing and spin extraction performance for washing machines, drying performance and condensation efficiency for dryers). IEC/EN standards

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44 Source: input by CENELEC

45 See Annex, Section 7.2 (Reflections and concerns of CENELEC/TC59X/SWG 1.12 regarding the outcome of performance standards for commercial laundry machines)

46 Presentation "CENELEC 59X SWG 1:12 - Proposal about definitions and way of direction for future standards for Professional laundry equipment" at the LOT 24 stakeholder meeting from 01.10.2010, downloadable at http://www.ecowet-commercial.org/meetings.php

47 Source: http://faellesvaskeri.dk

60456 and 61121 currently only apply for washing machines and dryers for household use. They might be the basis for performance standards for professional appliances, however, the condition parameters and measurement methods have to be adapted accordingly - a work that is still ongoing within CENELEC TC59X/SWG1.12.

Washing machines

Table 14 Consumer behaviour and differences may be identified with the standard conditions for washing machines

General test condition parameters	Household test standard conditions EN 60456 (IEC 60456) in coming Eco-design version	Test conditions for professional machines as performed at Danish Technological Institute	Industrial standard conditions (ISO 9398-4)
Number of cycle per week	220/52	~20-40 (1000-2000 cycles per year)	Not defined
Number of loads	One load divided in parts	One load divided in parts	Two identical loads
Loading of washing machine	As described in EN 60456	As in EN 60456	Nominal capacity
Type of fabrics	Cotton base load (for energy label testing)	Cotton base load as EN 60456	Decatized white cotton sheets (mass per unit area of (140 ± 20) g/m^2 and dimensions of (240 ± 20) cm x (180 ± 20) cm)
Washing programme (Length, temperature, load size)	60°C cotton programme at full load; 60°C cotton programme at half load; 40°C cotton programme at half load. All with standard detergent A* All with standard soiled test strips	60°C cotton programme at full load; 60°C cotton programme at half load; 40°C cotton programme at half load. All with standard detergent A* All with standard soiled test strips 30°C cotton programme, 60% load, with low temperature detergent and standard soiled test strips 40°C cotton programme, 20% load for consumption measurement with small load	Test cycle A: 76 min (detergent A) Test cycle B: 43 min (detergent B) Test cycle C: 22 min (detergent B)
Other specification	Reference machine for measuring: washing performance	Reference machine for measuring: washing performance and rinsing performance	Not defined
Location of the washer extractor: Ambient temperatures and humidity Conditioning of cotton load: Ambient temperatures and humidity as in ISO standard	Ambient temperature: (23 ± 2)°C Ambient temperature: (20 ± 2)°C Ambient humidity: (65 ± 5)%RH	Ambient temperature: (23 ± 2)°C Ambient temperature: (20 ± 2)°C Ambient humidity: (65 ± 5)%RH	Ambient temperature: 24 ± 6°C Ambient humidity: 50 ± 10%

General test condition parameters	Household test standard conditions EN 60456 (IEC 60456) in coming Eco-design version	Test conditions for professional machines as performed at Danish Technological Institute	Industrial standard conditions (ISO 9398-4)
Types of soiling	Mineral oil/carbon black, blood, chocolate and milk, red wine	Mineral oil/carbon black, blood, chocolate and milk, red wine	Not included
Behaviour at the end of the washing programme:	Measurement of power consumption in low power modes	In future probably: Measurement of power consumption in low power modes	Not included
Load ratio	Rated capacity in kg dry cotton declared by the manufacturer	Rated capacity in kg dry cotton declared by the manufacturer	1:10
Condition of the machine	Installation according to the manufacture's instructions if not specially described in the standard.	Installation according to the manufacture's instructions if not specially described in the standard.	Installation according to the manufacture's instructions, and it shall be clean
Type of energy heating	Electricity 230V±1% or 400V±1%, 50 Hz ±1%	Electricity 230V±1% or 400V±1%, 50 Hz ±1%	By steam, gas, electricity or heat transport fluid, as specified by manufacturer
Water conditions	Cold water (15 ± 2) °C Hot water (60 ± 2) °C Hardness (2.5 ± 0.2) mmol/l Pressure (240 ± 50) kPa	Cold water (15 ± 2) °C Hot water (60 ± 2) °C Hardness (2.5 ± 0.2) mmol/l Pressure (240 ± 50) kPa	17 ± 3°C (For tropical countries, a temperature of 25 ± 5°C for the rinse water is allowed)
Standard foresees the following measurements			
Washing performance	X	X	Not possible
Spin extraction performance	X	X	X
Rinsing performance	Not used in label test	X	
Temperature		X	
Energy, water and programme time	X	X	X

Table 15 Consumer behaviour and differences may be identified with the standard conditions for dryers

General test condition parameters	Household test standard conditions EN 61121 (IEC 61121) in coming Eco-design version	Possible test conditions for professional machines in ongoing project at Danish Technological Institute	Standard conditions (ISO 9398-2)
Number of cycle per week	160/52	~20-40 (1000-2000 cycles per year)	Not defined
Number of loads	One load divided in parts	One load divided in parts	Two identical loads
Loading of dryer	As described in EN61121	As described in EN61121	Nominal capacity
Type of fabrics	Cotton load (for energy label testing)	Cotton load as EN 61121	Decatized cotton towels (mass per unit area of (420 ± 25) g/m^2 and dimensions of (90 +/- 10) cm x (60 ± 10) cm)
Drying programme (Length, temperature, load size)	Cotton programme at full load; Cotton programme at half load; Programme continues until 0% humidity reached (for energy label testing)	Max temperature cotton programme at full load; Max temperature cotton programme at half load; And probably: Reduced temperature cotton programme at half load. Reduced temperature cotton programme at 20% load for consumption measurement with small load Programme continues until 0% humidity reached	Not defined
Remaining humidity after spin (=nominal initial moisture content)	Cotton (60 ± 1)% (for energy label testing)	Cotton (60 ± 1)% or (50 ± 1)%	55 ± 1%
Location of the washer extractor: Ambient temperatures and humidity Conditioning of cotton load: Ambient temperatures and humidity as in ISO standard	Ambient temperature: (23 ± 2)°C Ambient humidity: (55 ± 5)%RH Ambient temperature: (20 ± 2)°C Ambient humidity: (65 ± 5)%RH	Ambient temperature: (23 ± 2)°C Ambient humidity: (55 ± 5)%RH Ambient temperature: (20 ± 2)°C Ambient humidity: (65 ± 5)%RH	Ambient temperature: 24 ± 6°C Ambient humidity: 50 ± 10%
Behaviour at the end of the drying programme:	Measurement of power consumption in low power modes	In future probably: Measurement of power consumption in low power modes	Not included
Load ratio	Rated capacity in kg dry cotton declared by the manufacturer	Rated capacity in kg dry cotton declared by the manufacturer	1:25

General test condition parameters	Household test standard conditions EN 61121 (IEC 61121) in coming Eco-design version	Possible test conditions for professional machines in ongoing project at Danish Technological Institute	Standard conditions (ISO 9398-2)
Condition of the machine	Installation according to the manufacture's instructions if not specially described in the standard.	Installation according to the manufacture's instructions if not specially described in the standard.	Installation according to the manufacture's instructions and it shall be clean
Other specification			Not defined
Type of energy heating	Electricity 230V±1% or 400V±1%, 50 Hz ±1%	Electricity 230V±1% or 400V±1%, 50 Hz ±1% and probably gas	By steam, gas, electricity or heat transport fluid, as specified by the manufacture
Temperature of rinse water before extraction	Water (15 ± 2) °C Hardness (2.5 ± 0.2) mmol/l Conductivity (75 ± 15) mS/m	Water (15 ± 2) °C Hardness (2.5 ± 0.2) mmol/l Conductivity (75 ± 15) mS/m	17 ± 3°C (For tropical countries, a temperature of 25 ± 5°C is allowed)
	Standard foresees the following measurements		
Drying temperature		X	
Condensation efficiency	X	X	
Equality of drying	Not for label test		
Initial moisture content	X	X	
Final moisture content	X	X	
Energy and programme time	X	X	X

3.2 Safety

3.2.1 ISO 10472 (International)

ISO 10472 Safety requirements for industrial laundry machinery

- ISO 10472-1:1997 Safety requirements for industrial laundry machinery, Part 1: Common requirements (see also EN ISO 10472-1:2008; DIN EN ISO 10472-1 with publication date 10/2009).

  The individual parts of ISO 10472 identify all significant hazards (mechanical, electrical, thermal hazards, hazards generated by noise; hazards associated with materials and substances processed, used or exhausted by machinery; hazards due to neglect of ergonomic principles in machine design; failure of energy supply, breakdown of machin-

ery parts and other malfunction; hazards arising during maintenance and/or elimination of process faults) associated with laundry machinery designed for use in industrial laundry premises, which includes hotels, hospitals, nursing homes, prisons and similar premises, as well as machines designed for use in self-service establishments subject to the minimum capacities stated in the separate parts of ISO 10472. Dry-cleaning presses and garment presses are also included.

- ISO 10472-2:1997 Safety requirements for industrial laundry machinery, Part 2: Washing machines and washer-extractors (see also EN ISO 10472-2:2008; DIN EN ISO 10472-2 with publication date 10/2009)

  This part of ISO 10472 covers, together with ISO 10472-1, most significant hazards associated with washing machines and washer-extractors of all configurations having a net usable cage volume > 60 l (i.e. capacity of 6 kg of dry linen). This part of ISO 10472 does not cover particular hazards for drawer-type washer-extractors as well the hazards caused by processing work may create an explosive or flammable atmosphere inside the machine. Furthermore, it does not apply to ancillary equipment, e.g. chemical supply pumps, steam valves and supply pipe work, vent systems, work feed systems and discharge systems and ducting to the atmosphere.
- ISO 10472-3:1997 Safety requirements for industrial laundry machinery, Part 3: Washing tunnel lines including component machines (see also EN ISO 10472-3:2008; DIN EN ISO 10472-3 with publication date 10/2009)

  This part of ISO 10472 covers, together with ISO 10472-1, most significant hazards associated with washing tunnel lines including component machines such as:

  – continuous tunnel washing machines;
  – squeeze presses or centrifugal extraction machines;
  – transfer conveyor systems;
  – automatic transfer tumblers;
  – loading or unloading system interfaces;
  – access platform and ladders.

  This part of ISO 10472 does not cover particular hazards for continuous stand-alone washing lines for endless towels as well the hazards caused by processing work may create an explosive or flammable atmosphere inside the machine.
- ISO 10472-4:1997 Safety requirements for industrial laundry machinery, Part 4: Air dryers (EN ISO 10472-4:2008; DIN EN ISO 10472-4 with publication date 09/2009)

  This part of ISO 10472 covers, together with ISO 10472-1, most significant hazards associated with air dryers, and in particular with tumble dryers having a net usable cage volume > 160 l (i.e. capacity of 6 to 7 kg of dry linen) and tunnel finishers including as-

sociated conveyors and cabinet dryers. This part of ISO 10472 does not apply to ancillary equipment.

- ISO 10472-5:1997 Safety requirements for industrial laundry machinery, Part 5: Flatwork ironers, feeders and folders (see also EN ISO 10472-5:2008; DIN EN ISO 10472-5 with publication date 09/2009)

  This part of ISO 10472 covers, together with ISO 10472-1, most significant hazards associated with flatwork ironers, feeders and folders, such as:

  – cylinder and bed ironers for flatwork finishing having a contact area (for bed ironers under pressure) > 0.25 m²;
  – flatwork feeding machines for the automatic feeding of flatwork into bed or cylinder ironers, or directly to folders;
  – flatwork folding machines for the automatic folding of flatwork in association with cylinder and bed ironers;
  – folding machines for the automatic folding of small pieces (excluding endless towels);
  – multi-function machines.

- ISO 10472-6:1997 Safety requirements for industrial laundry machinery, Part 6: Ironing and fusing presses (see also EN ISO 10472-6:2008; DIN EN ISO 10472-6 with publication date 10/2009)

  This part of ISO 10472 covers, together with ISO 10472-1, most significant hazards associated with ironing and fusing presses used in the laundry, garment and dry-cleaning industry, and in particular:

  – scissor presses;
  – cabinet presses;
  – drawer presses;
  – rotary presses (carousel) and other presses with multiple bucks.

These standards give the most relevant product definitions of all sources identified providing a first basis for conclusion of the products classification (see Section 2.4). The ISO standards 10472 are also widely used by manufacturers.

3.2.2 IEC 60335 (International)

IEC 60335 Household and similar electrical appliances – Safety

- IEC 60335-1: Household and similar electrical appliances – Safety, Part 1: General requirements

  The Standard covers safety issues of household and similar electrical appliances. Part 1 defines general elements and is common to all electric motor appliances. Product specific issues are addressed in the Part 2-series. The relevant Standards of Part 2 for professional washing machines and dryers are listed in the following.
- IEC 60335-2: Household and similar electrical appliances – Safety, Part 2
  - IEC 60335-2-4:2008: Household and similar electrical appliances – Safety, Part 2-4: Particular requirements for spin extractors

    Deals with the safety of spin extractors incorporated in washing machines that have separate containers for washing and spin extraction for household and similar purposes that have a capacity not exceeding 10 kg of dry cloth and a drum peripheral speed not exceeding 50 m/s, their rated voltages being not more than 250 V for single-phase appliances and 480 V for other appliances.
  - IEC 60335-2-7:2008: Household and similar electrical appliances – Safety, Part 2-7: Particular requirements for washing machines

    Deals with the safety of electric washing machines for household and similar use, that are intended for washing clothes and textiles, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances. This standard also deals with the safety of electric washing machines for household and similar use employing an electrolyte instead of detergent. Additional requirements for these appliances are given in Annex CC of the standard.
  - IEC 60335-2-11:2008: Household and similar electrical appliances – Safety, Part 2-11: Particular requirements for tumble dryers

    Deals with the safety of electric tumble dryers intended for household and similar purposes, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances. This standard also applies to the drying function of washing machines having a drying cycle, as well as the safety of tumble dryers that use a refrigerating system incorporating sealed motor-compressors, for drying textile material. These appliances may use flammable refrigerants.
  - IEC 60335-2-43:2008 Household and similar electrical appliances – Safety, Part 2-43: Particular requirements for clothes dryers and towel rails

    Deals with the safety of electric clothes dryers for drying textiles on racks located in a warm airflow and to electric towel rails, for household and similar purposes,

their rated voltage being not more than 250 V. Appliances not intended for normal household use but that nevertheless may be a source of danger to the public, such as appliances intended to be used by laymen in shops, in light industry and on farms, are within the scope of this standard.

– IEC 60335-2-44:2008 Household and similar electrical appliances – Safety, Part 2-44: Particular requirements for ironers

  This International Standard deals with the safety of electric ironers for household and similar purposes, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances. Appliances not intended for normal household use but which nevertheless may be a source of danger to the public, such as appliances intended to be used by laymen in shops, in light industry and on farms, are within the scope of this standard. Examples of appliances within the scope of this standard are ironing presses for one-person operation; mangles; rotary ironers for one-person operation; trouser presses.

– IEC 60335-2-85:2008 Household and similar electrical appliances – Safety, Part 2-85: Particular requirements for fabric steamers

  Deals with the safety of electric fabric steamers intended for household and similar purposes, their rated voltage being not more than 250 V. Appliances not intended for normal household use, such as appliances to be used by laymen in laundries and dry cleaners, are within the scope of this standard.

3.2.3 IEC 60204

IEC 60204-1:2005 Safety of machinery – Electrical equipment of machines – Part 1: General requirements

This part of IEC 60204 applies to the application of electrical, electronic and programmable electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a co-ordinated manner. This standard is applicable to the electrical equipment or parts of the electrical equipment that operate with nominal supply voltages not exceeding 1 000 V for alternating current (a.c.) and not exceeding 1 500 V for direct current (d.c.), and with nominal supply frequencies not exceeding 200 Hz.

The standard provides requirements and recommendations relating to the electrical equipment of machines so as to promote: safety of persons and property; consistency of control response; – ease of maintenance.

According to the Convenor of TC27/SC5/WG3 all machines constructed in accordance with the standard series EN 10472, in combination with EN 60204-1, fall into the industrial sector. All machines constructed in accordance with EN 60335-1, in combination with the machine-specific parts of this standard series, fall into the commercial/professional sector. EN ISO 10472-1 points this fact out in 5.2: "The electrical equipment of machines shall be designed in accordance with EN 60204-1 … or IEC 60335 …, depending on the intended use of the machine." This normative specification, which refers to the different scopes of the before-mentioned standards, results in a clear distinction of the industrial sector.

3.2.4 BGR 500 (German)

BGR 500 (Berufsgenossenschaftliche Regeln für Sicherheit und Gesundheit bei der Arbeit) – Chapter 2.6 provides safety regulations for the operation of laundries.

3.2.5 UL 1206 / 1240 / 2157 / 2158 (USA / Canada)

UL 1206 Electric Commercial Clothes-Washing Equipment (USA / Canada)

These requirements cover electric commercial, industrial, and institutional clothes-washing equipment intended for use in accordance with the National Electrical Code. Equipment covered by this Standard is not intended for use by the general public, but only by trained or supervised personnel. These requirements do not cover clothes dryers, coin-operated clothes washing appliances, flatirons, ironing machines, water heaters, water softeners, dry-cleaning machines, garment-finishing machines, appliances employing wringer mechanisms, or other equipment covered by requirements separate from this standard.

UL 1240 Electric Commercial Clothes-Drying Equipment (USA / Canada)

These requirements cover electric commercial, industrial, and institutional clothes-drying equipment intended for use in accordance with the National Electrical Code, NFPA 70. Equipment covered by this Standard is not intended for use by the general public, but only by trained or supervised personnel. These requirements do not cover coin-operated clothes-drying equipment, flatirons, ironing machines, water heaters, water softeners, dry-cleaning machines, garment-finishing machines, clothes washers, or other equipment covered by requirements separate from this standard.

UL 2157 Electric Clothes Washing Machines and Extractors (USA / Canada)

This Standard applies to electric clothes washing machines and extractors intended to be used in nonhazardous locations in accordance with the Canadian Electrical Code, Part I (CEC), and the (U.S.) National Electrical Code (NEC), on circuits having a nominal voltage not exceeding 600 V. Note: Wherever practical, for convenience, the term "appliance" has been used in lieu of "clothes washer" or "machine". This standard applies to both cord-

connected and permanently connected appliances. The appliances covered by this standard are intended for use by the general public not specifically trained in the use of the appliance, regardless of the mode by which its operation is initiated.

They are for use in household and commercial purposes, including appliances provided with coin-, ticket-, or card-operated mechanisms, wringer washers, tumbler, agitator and spinner machines, combination washer-dryers, and extractors of the centrifugal type. This Standard does not apply to industrial and institutional type appliances. Industrial or institutional appliances are covered under the scope of Electric Commercial Clothes-Washing Equipment, UL 1206.

UL 2158 Electric Clothes Dryers (USA / Canada)

This standard applies to electric clothes dryers intended to be used in nonhazardous locations in accordance with the Canadian Electrical Code, Part I (CEC), and the (U.S.) National Electrical Code (NEC), on circuits having a nominal voltage not exceeding 600 Note: Wherever practical, for convenience, the term "appliance" has been used in lieu of "clothes dryer" or "machine".

This standard applies to both cord-connected and permanently connected appliances. The appliances covered by this standard are intended for use by the general public not specifically trained in the use of the appliance, regardless of the mode by which its operation is initiated. They are for use in households and for commercial purposes, including appliances provided with coin-, ticket-, or card-operated mechanisms, and combination washer-dryers. This standard does not apply to industrial and institutional type appliances. Industrial or institutional appliances are covered under the scope of Electric Commercial Clothes-Drying Equipment, UL 1240.

Test standards for household equipment around the world are mostly based on EN standards (which in turn are mostly based on IEC standards) whereas in North America (USA/CANADA) they are based on UL-standards. The UL-standards are usually slightly modified to suit local conditions and set requirements in the areas of construction, safety and mainly for on hardware issues. These standards provide no relevant product definitions for providing a good basis for a product classification.

3.3 Hygiene

Laundry from medical services (e.g. operation material, bed linen or work wear of nurses) as well as laundry from food businesses underlies several regulations for its hygienic treatment. The soiled textiles delivered to the laundries are contaminated with a multitude of micro-organisms.

The aim of reprocessing is for example to decontaminate the textiles in a disinfecting process (= to reduce microorganisms in a way that there is no more risk of infection) and protect it against recontamination (re-soiling with microorganisms) until they go back to the customers. According to the field of application, different requirements exist for the processing (washing, drying and finishing) and microbiological quality of the textiles. However, not only the textiles but also the surroundings within and the personnel of the laundry services have to fulfil hygienic regimentations. Objective for the appropriate handling of textiles from medical services is to avoid infectious diseases and to minimise the risk of infections, respectively. Objective for the handling of textiles from food businesses is to avoid any harmful impact on the food caused by inappropriate work wear.

3.3.1 IFS – International Food Standard (International)

The IFS Food (version 5 which is applicable since 1st January 2008) is a standard for auditing retailer and wholesaler branded food product suppliers and only concerns food processing companies or companies that pack loose food products. The IFS Food can only be used when a product is “processed” or when there is a hazard for product contamination during the primary packing.[48] The food processing industry generally requires evidence of hygienic harmlessness of the processed textiles from laundry services. Version 5 of the International Food Standard contains requirements regarding the hygiene of textiles.

3.3.2 EN 13795 (European)

EN 13795 Surgical drapes, gowns and clean air suits, used as medical devices, for patients, clinical staff and equipment

- EN 13795-1+A1 2009-07: Surgical drapes, gowns and clean air suits, used as medical devices, for patients, clinical staff and equipment, Part 1: General requirements for manufacturers, processors and products
- EN 13795-2+A1 2009-07: Surgical drapes, gowns and clean air suits, used as medical devices for patients, clinical staff and equipment, Part 2: Test methods
- EN 13795-3+A1 2009-07: Surgical drapes, gowns and clean air suits, used as medical devices for patients, clinical staff and equipment, Part 3: Performance requirements and performance levels

[48] Source: http://www.ifs-certification.com/, sighted on 12 January 2010

3.3.3 EN 14065 (European)

EN 14065 Textiles – Laundry processed textiles – Biocontamination control system

This European standard describes a system for Risk Analysis and Biocontamination Control (so-called RABC system) during the processing of textiles in laundries. Prevention of microbiological contamination is of significant importance in all steps of the reprocessing of textiles. The so-called RABC system ensures that a pre-agreed level of microbiological quality will be set to match the needs of the intended use.

The RABC-System is a hygiene- and quality-management-system respectively, with risk analysis, comparable to the HACCP concept for the food area. According to the worldwide approved HACCP concept (developed 1959 and published 1971), the EN 14065 was developed.[49]

3.3.4 DIN 10524 (German)

DIN 10524 Lebensmittelhygiene – Arbeitsbekleidung in Lebensmittelbetrieben (Food hygiene – Work wear in food business, German)

Work wear in food businesses have to fulfil hygienic requirements during their whole expected useful life. According to DIN 10524, the textiles have to be treatable under the conditions of a professional laundry service, i.e. being able to wash, disinfect and finish. The DIN standard describes the hygienic requirements for work wear in food businesses. Further, it provides details for the selection, treatment and cleaning of the work wear.

3.3.5 RKI-Guidelines (German)

Guidelines for hospital hygiene and prevention of infectious diseases (Robert Koch Institute, Germany)[50]

The guidelines comprise hygienic requirements for textiles of medical service institutions, for the laundry, the washing process, and requirements for giving away textiles to professional laundry services.

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[49] Source: http://rabc-wfk.com/module6/index.php?lang=eng

[50] Richtlinie für Krankenhaushygiene und Infektionsprävention: Anforderungen der Hygiene an die Wäsche aus Einrichtungen des Gesundheitsdienstes, die Wäscherei und den Waschvorgang und Bedingungen für die Vergabe von Wäsche an gewerbliche Wäschereien.
http://www.rki.de/cln_091/nn_201414/DE/Content/Infekt/Krankenhaushygiene/Kommission/Downloads/Altanl_Rili,templateId=raw,property=publicationFile.pdf/Altanl_Rili.pdf

3.4 Noise

3.4.1 IEC 60704 (International)

IEC 60704:1997 Household and similar electrical appliances – Test code for the determination of airborne acoustical noise

- IEC 60704-1: Household and similar electrical appliances – Test code for the determination of airborne acoustical noise, Part 1: General requirements
  Applies to the methods of determination of airborne acoustical noise emitted by household and similar electrical appliances supplied from mains or from batteries.
- IEC 60704-2-4 Ed. 2.0 b:2001: Household and similar electrical appliances – Test code for the determination of airborne acoustical noise, Part 2-4: Particular requirements for washing machines and spin extractors
  These particular requirements apply to single unit electric washing machines, the washing and spinning function of combined appliances for household and similar use, and to spin extractors.
- IEC 60704-2-6 2005: Household and similar electrical appliances – Test code for the determination of airborne acoustical noise, Part 2-6: Particular requirements for tumble dryers

  Applies to the methods of determination of airborne acoustical noise emitted by tumble dryers for household and similar use. This standard applies to single unit electric tumble dryers intended for placing on the floor against a wall, for building in or placing under a counter, a kitchen work-top or under a sink, for wall-mounting or for mounting on a counter. For the purpose of this standard, washer-dryer combinations, when operated as a dryer, are considered as a tumble dryer.

3.4.2 ISO 3744 (International)

ISO 3744:2010 Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane

ISO 3744:2010 specifies methods for determining the sound power level or sound energy level of a noise source from sound pressure levels measured on a surface enveloping the noise source (machinery or equipment) in an environment that approximates to an acoustic free field near one or more reflecting planes. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source, in frequency bands or with frequency A-weighting applied, is calculated using those measurements. The methods specified in ISO 3744:2010 are suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001.

ISO 3744:2010 is applicable to all types and sizes of noise source (e.g. stationary or slowly moving plant, installation, machine, component or sub-assembly), provided the conditions for the measurements can be met.

The test environments that are applicable for measurements made in accordance with ISO 3744:2010 can be located indoors or outdoors, with one or more sound-reflecting planes present on or near which the noise source under test is mounted. The ideal environment is a completely open space with no bounding or reflecting surfaces other than the reflecting plane(s) (such as that provided by a qualified hemi-anechoic chamber), but procedures are given for applying corrections (within limits that are specified) in the case of environments that are less than ideal.

Information is given on the uncertainty of the sound power levels and sound energy levels determined in accordance with ISO 3744:2010, for measurements made in limited bands of frequency and with frequency A-weighting applied. The uncertainty conforms to ISO 12001:1996, accuracy grade 2 (engineering grade).

3.4.3 ISO 3746 (International)

ISO 3746:2010 Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane

ISO 3746:2010 specifies methods for determining the sound power level or sound energy level of a noise source from sound pressure levels measured on a surface enveloping a noise source (machinery or equipment) in a test environment for which requirements are given. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source with frequency A-weighting applied is calculated using those measurements. The methods specified in ISO 3746:2010 are suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001. ISO 3746:2010 is applicable to all types and sizes of noise source (e.g. stationary or slowly moving plant, installation, machine, component or sub-assembly), provided the conditions for the measurements can be met.

The test environments that are applicable for measurements made in accordance with ISO 3746:2010 can be located indoors or outdoors, with one or more sound-reflecting planes present on or near which the noise source under test is mounted.

Information is given on the uncertainty of the sound power levels and sound energy levels determined in accordance with ISO 3746:2010, for measurements made with frequency A-weighting applied. The uncertainty conforms to that of ISO 12001:1996, accuracy grade 3 (survey grade).

3.4.4 ISO 4871 (International)

ISO 4871:1996 Acoustics – Declaration and verification of noise emission values of machinery and equipment

Gives information on the declaration of noise emission values, describes acoustical information to be presented in technical documents and specifies a method for verifying the noise emission declaration.

3.4.5 ISO 9614 (International)

ISO 9614-2:1996 Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning

Specifies a method for measuring the component of sound intensity normal to a measurement surface which is chosen so as to enclose the noise source(s) of which the sound power level is to be determined.

3.4.6 ISO 11204 (International)

ISO 11204:2010 Acoustics – Noise emitted by machinery and equipment – Determination of emission sound pressure levels at a work station and at other specified positions applying accurate environmental corrections

ISO 11204:2010 specifies a method for determining the emission sound pressure levels of machinery or equipment, at a work station and at other specified positions nearby, in any environment which meets certain qualification requirements. A work station is occupied by an operator and may be located in open space, in the room where the source under test operates, in a cab fixed to the source under test, or in an enclosure remote from the source under test. One or more specified positions may be located in the vicinity of a work station, or in the vicinity of an attended or unattended machine. Such positions are sometimes referred to as bystander positions. Emission sound pressure levels are determined as A-weighted levels. Additionally, levels in frequency bands and C-weighted peak emission sound pressure levels can be determined in accordance with ISO 11204:2010, if required.

A method is given for determining a local environmental correction (subject to a specified limiting maximum value) to be applied to the measured sound pressure levels to exclude the effects of reflections from reflecting surfaces other than the plane on which the source under test is placed. This correction is based upon the mean sound pressure level on a measurement surface, the sound pressure level measured at a specified position, and either an environmental correction or the equivalent absorption area of the test room.

With the method specified in ISO 11204:2010 results of accuracy grade 2 (engineering grade) or accuracy grade 3 (survey grade) are obtained. Corrections are applied for background noise and, as described above, for the acoustic environment. Instructions are given

for the mounting and operation of the source under test and for the choice of microphone positions for the work station and for other specified positions. One purpose of the measurements is to permit comparison of the performance of different units of a given family of machines, under defined environmental conditions and standardized mounting and operating conditions.

The method specified in ISO 11204:2010 is suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001. The method specified in ISO 11204:2010 is applicable to all types and sizes of noise sources.

The type of test environment influences the accuracy of the determination of emission sound pressure levels. ISO 11204:2010 is applicable to an indoor or outdoor environment with one or more reflecting planes present, meeting specified requirements. These requirements on the room are less strict than those of ISO 11201, in particular regarding the acoustical quality of the environment. ISO 11204:2010 is applicable to work stations and other specified positions where emission sound pressure levels are to be determined.

Appropriate positions where measurements may be made include the following: a) work station located in the vicinity of the source under test; this is the case for many industrial machines and domestic appliances; b) work station within a cab which is an integral part of the source under test; this is the case for many industrial trucks and earth-moving machines; c) work station within a partial or total enclosure (or behind a screen) supplied by the manufacturer as an integral part of the source under test; d) work station partially or totally enclosed by the source under test – this situation may be encountered with some large industrial machines; e) bystander positions occupied by individuals not responsible for the operation of the source under test, but who may be in its immediate vicinity, either occasionally or continuously; f) other specified positions, not necessarily work stations or bystander positions.

The work station may also lie on a specified path along which an operator moves.

3.5 Electromagnetic fields / Electromagnetic compatibility (EMC)

3.5.1 IEC 62233 (International)

IEC 62233:2005 Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure

Deals with electromagnetic fields up to 300 GHz and defines methods for evaluating the electric field strength and magnetic flux density around household and similar electrical appliances, including the conditions during testing as well as measuring distances and positions. Appliances may incorporate motors, heating elements or their combination, may contain electric or electronic circuitry, and may be powered by the mains, by batteries, or by any other electrical power source. Appliances include such equipment as household electrical

appliances, electric tools and electric toys. Appliances not intended for normal household use but which nevertheless may be approached by the public, or may be used by laymen, are within the scope of this standard. This standard includes specific elements to assess human exposure:

- definition of sensor,
- definition of measuring methods,
- definition of operating mode for appliance under test,
- definition of measuring distance and position

The measurement methods specified are valid from 10 Hz to 400 kHz. In the frequency range above 400 kHz and below 10 Hz appliances in the scope of this standard are deemed to comply without testing unless otherwise specified in IEC 60335 series.

3.5.2 IEC 61000 (International)

IEC 61000 Electromagnetic compatibility

- IEC 61000-3-2 ed3.2 Consol. with am1&2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)
- IEC 61000-3-3 ed2.0: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

3.5.3 EN 50366 (European)

EN 50366:2003 Household and similar electrical appliances – Electromagnetic fields – Methods for evaluation and measurement

Several test methods by which the magnetic field emissions from products can be compared to the general public restrictions and levels over the frequency range of 10Hz to 400 kHz.

3.5.4 EN 55014 (European)

EN 55014 Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus

- EN 55014-1:2007 Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus, Part 1: Emission (IEC/CISPR 14-1:2005)
- EN 55014-2:2009 Electromagnetic compatibility – Requirements for household appliances , electric tools and similar apparatus, Part 2: Immunity – Product family standard (IEC/CISPR 14-2:1997 + A1:2001 + A2:2008)

3.6 Gas

3.6.1 EN 12752 (European)

EN 12752 Gas-fired type B tumble dryers of nominal heat input not exceeding 20 kW

- EN 12752-1:1999 Gas-fired type B tumble dryers of nominal heat input not exceeding 20 kW – Part 1: Safety
- EN 12752-2:1999 Gas-fired type B tumble dryers of nominal heat input not exceeding 20 kW – Part 2: Rational use of energy

3.6.2 DIN 30682 (Germany)

DIN 30682:1982 Gas-appliances for laundry-machinery

3.6.3 NF G45-106 (France)

NF G45-106 1997 Laundry equipment: Drying and ironing machine, rotating dryers, spinner-washers, with atmospheric burners of output not exceeding 120 kW using gaseous fuels

Provides product definitions, an equipment classification and specifications for construction characteristics, operating and performance testing of gas laundry equipment.

4 Existing legislation and environmental labelling

Aim of this work package is to identify the relevant existing legislation for professional washing machines and dryers subdivided in four parts:

- Legislation and Agreements at European Community level,
- Legislation at Member State level,
- Third Country Legislation,
- Environmental Labelling.

A short overview of existing legislation and environmental labelling is given, also including legislation on household appliances whose scope has currently been modified to ‘household and similar electrical appliances’ thus including professional machines.

4.1 European legislation

4.1.1 Machinery Directive (MD) 2006/42/EC (replacing 98/37/EC)

The new Machinery Directive 2006/42/EC[51] is a revised version of Directive 98/37/EC, and is applicable since 29th December 2009. The Directive has the dual aim of harmonising the health and safety requirements applicable to machinery, while ensuring the free circulation of machinery on the Community market. Machinery is defined as an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application.

The manufacturer or his authorised representative shall ensure that a risk assessment is carried out for the machinery which he wishes to place on the market. For this purpose, he should determine which are the essential health and safety requirements applicable to his machinery and in respect of which he must take measures. The CE marking should be fully recognised as being the only marking which guarantees that machinery conforms to the requirements of this Directive. All other markings which are likely to mislead third parties as to the meaning or the form of the CE marking, or both, are prohibited.

One of the objectives of the revision of the Machinery Directive was to clarify the borderline between the scope of the Machinery Directive (MD) and the Low Voltage Directive (LVD) 2006/95/EC20[52] (formerly Directive 73/23/EEC as amended) in order to provide greater legal certainty. Article 1 (2) (k) lists the categories of low voltage electrical and electronic machinery that are excluded from the scope of the Machinery Directive, amongst others 'household appliances intended for domestic use'. When such machinery has an electrical supply within the voltage limits of the Low Voltage Directive (between 50 and 1000 V for alternating current or between 75 and 1500 V for direct current), it must fulfil the safety objectives of the LVD instead. For machinery beyond these voltage limits the requirements of the Machinery Directive apply.

The Machinery Directive applies to all professional washing machine and dryer categories being in the scope of Lot 24 (for the borderline between machinery for household and professional use, see also Section 2.4). The requirements of the Directive are sufficient to cover all health and safety aspects related to those appliances.

[51] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2006L0042:20091215:EN:PDF

[52] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

4.1.2 Low Voltage Directive (LVD) 2006/95/EC

The Low Voltage Directive (LVD) 2006/95/EC[53] (formerly Directive 73/23/EEC as amended) seeks to ensure that electrical equipment within certain voltage limits both provides a high level of protection for European citizens and enjoys a Single Market in the European Union.

The Directive requires electrical equipment to have protection against hazards that could arise from within the electrical equipment itself or from external influences. The directive covers all risks arising from the use of electrical equipment, including mechanical, chemical (such as, in particular, emission of aggressive substances). The LVD also covers noise and vibration, and ergonomic aspects which could cause hazards within the scope of the Directive. The LVD covers electrical equipment designed for use with a voltage rating of between 50 V and 1000 V for alternating current and between 75 V and 1500 V for direct current. It should be noted that these voltage ratings refer to the voltage of the electrical input or output, not to voltages that may appear inside the equipment.

Since 29th December 2009 (revision of the Machinery Directive, see also Sections 2.4 and 4.1.1), washing machines and dryers being stated by the manufacturer for professional use in the Declaration of Conformity, do clearly not fall under the Low Voltage Directive any more.

4.1.3 Electromagnetic Compatibility (EMC) 2004/108/EC

Directive 2004/108/EC[54] on the approximation of the laws of Member States regulates the electromagnetic compatibility (EMC) of both apparatus and fixed installations. The Directive applies to most electrical and electronic apparatuses including professional washing machines and dryers, which are finished products and systems that include electrical and electronic equipment that may generate or be affected by electromagnetic disturbance.

The main objective of the EMC Directive, thus, is to regulate the compatibility of equipment regarding EMC. In order to achieve this objective, provisions have been put in place so that equipment needs to comply with the requirements of the EMC Directive when it is placed on the market and/or taken into service. On the one hand it has to be ensured that the electromagnetic emissions of this equipment in its intended use do not disturb radio and telecommunication as well as other equipment. On the other hand the Directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions normally present used as intended.

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53 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

54 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024:0037:en:PDF

4.1.4 Restriction of Hazardous Substances Directive (RoHS) 2002/95/EC

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC[55] (commonly referred to as the Restriction of Hazardous Substances Directive or RoHS) restricts the use of six hazardous substances in the manufacture of various types of electronic and electrical equipment (EEE).

The restrictions apply to EEE belonging to several categories as set out in Annex I A to Directive 2002/96/EC (WEEE). One of the categories of Annex I A falling under the RoHS Directive is category 1 “Large Household Appliances”, covering inter alia washing machines, clothes dryers and dish washing machines.

According to the Commission's "Frequently Asked Questions on Directive 2002/95/EC on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) and Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE)"[56] professional equipment, like professional washing machines, dryers and dishwashers, is covered by the RoHS Directive.

Article 5(1) (b) of the Directive provides that materials and components can be exempted from the substance restrictions contained in Article 4(1) if their elimination or substitution via design changes or materials and components which do not require any of the materials or substances referred to therein is technically or scientifically impracticable, or where the negative environmental, health and/or consumer safety impacts caused by substitution outweigh the environmental, health and/or consumer safety benefits thereof.

Currently, there are 39 exemptions listed in the Annex of the RoHS Directive. In the course of Task 4 (Technical analysis of existing products) we will evaluate whether there are existing exemptions which are of importance for the scope of Lot 24 “Professional washing machines, dryers and dishwashers”.

Currently (status January 2011), the Commission proposal for a recast of the RoHS Directive is in the co-decision adoption procedure by the Council and the European Parliament (EP). The Parliament voted on a text in November 2010 confirming the first reading agreement with the Council on the revised legislation. It is now needed to be formally adopted by the Council. The new Directive will enter into force 20 days after its publication in the Official Journal of the European Union. Member States will then have 18 months to transpose it into national law. Until then, the existing RoHS Directive (Directive 2002/95/EC) continues to apply.

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55 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0019:0023:EN:PDF

56 http://ec.europa.eu/environment/waste/weee/pdf/faq_weee.pdf, FAQ 1.8 “Do the WEEE and the RoHS Directives apply to electrical and electronic products for professional use?” Answer: “The RoHS Directive does not differentiate between households or professional EEE, so products for professional use are covered by the RoHS Directive.”

The revised Directive aims to improve implementation and enforcement and introduces greater coherence with other EU legislation, such as REACH and the new legislative framework for the marketing of products. Main elements include:[57]

- "The extension of the scope to all electrical and electronic equipment, including medical devices and monitoring and control instruments.
- Electrical and electronic equipment that was outside the scope of the current RoHS Directive but which will be covered by the revised Directive, does not need to comply with the requirements during a transitional period of 8 years, giving producers time to adapt;
- A lighter and more effective mechanism for reviewing or amending the list of banned substances is introduced, enabling further substances to be considered on the basis of scientific evidence and specific criteria, and in line with REACH. Changes may then be made through comitology;
- The rules for granting exemptions from the substance ban are further streamlined to provide legal certainty for the economic operators and to ensure coherence with REACH;
- Important definitions are clarified to ensure the directive is applied in a harmonised manner throughout the EU.
- Better enforcement of the Directive at national level will be achieved through alignment with the marketing of products legislative package."

Should these changes come into force in the near future manufacturers would need to verify whether they still comply with the requirements of the Directive, inter alia:

- If, for example, products were considered out of scope until now, they might be covered by the revision which would possibly entail need for substitution and / or exemption requests.
- In that case, companies will need to link their efforts in respect with REACH to those under the context of RoHS.

4.1.5 Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC

The Waste Electrical and Electronic Equipment Directive (WEEE Directive) is the European Community Directive 2002/96/EC[58] regulating the collection, treatment, recycling and disposal of WEEE as well the financial provisions for this waste stream's treatment which, together with the RoHS Directive 2002/95/EC (cf. Section 4.1.4), came into force in February 2003. The Directive assigns the responsibility for the management of waste electrical and electronic equipment to the manufacturers of such equipment.

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[57] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/1596&format=HTML

[58] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0024:0038:EN:PDF

The Directive applies to the product categories set out in Annex I A that includes “Large household appliances”. Article 5 differentiates between WEEE from private households and WEEE from other than private households. According to the Commission's "Frequently Asked Questions on Directive 2002/95/EC on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) and Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE)"[59] professional equipment, like professional washing machines, dryers and dishwashers, is covered by the WEEE Directive[60].

For WEEE from other than private households, Article 5 (3) points out that “Member States shall ensure that producers or third parties acting on their behalf provide for the collection of such waste.” Also Article 9 on financing applies to WEEE from users other than private households. Article 9 (1) sets out that “Member States shall ensure that […] the financing of the costs for the collection, treatment, recovery and environmentally sound disposal of WEEE from users other than private households from products put on the market after 13 August 2005 is to be provided for by producers.” Article 9 (2) points out, however, that “producers and users other than private households may, without prejudice to this Directive, conclude agreements stipulating other financing methods.”

In parallel to the revision of the RoHS Directive, the WEEE Directive is currently also being revised under the co-decision procedure (status January 2011). The WEEE revision however is progressing at a much slower pace. The European Commission initially wanted to link the RoHS revision to discussions on a strengthening of the WEEE directive, but the Council wanted to keep the two dossiers separate. A parliament first reading vote on the WEEE revision is scheduled for February 2011, and the council will not issue its position until after the vote has taken place. Legislators are thus aiming for a second reading agreement late 2011.

The main issues are the possible shift of burden for reaching collection targets to EEE manufacturers as well as new collection targets that are adapted to country specificities and in relation to the number of products placed on the market. “Currently, the majority of member states are resisting a proposal by the European Commission, backed by the European Parliament's environment committee, to set a 65% collection rate for waste from electrical and

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59 http://ec.europa.eu/environment/waste/weee/pdf/faq_weee.pdf, FAQ 1.8 “Do the WEEE and the RoHS Directives apply to electrical and electronic products for professional use?” Answer: “The WEEE Directive contains provisions that cover WEEE from households and WEEE from users other than private households. WEEE from private households means WEEE which comes from private households and from commercial, industrial, institutional and other sources which, because of its nature and quantity, is similar to that from private households. WEEE from other users than private households can then be all WEEE that is not defined as WEEE from private households. Financing provisions in respect of WEEE from private households are laid down in Article 8 while Article 9 covers WEEE from users other than private households. In addition, Article 10(3) does not specifically limit the marking obligation to electrical and electronic equipment (EEE) for private households because in some cases it is difficult to distinguish between households and professional electrical and electronic equipment. Therefore, the marking obligation also applies to EEE for professional use.”

60 However, e.g. in Germany the general requirements set out in article 9 (1) of WEEE were not yet incorporated into national legislation (ElektroG).

electronic equipment (WEEE) by 2016. According to a progress report from the Council of Ministers, the Belgian presidency has proposed a phased approach according to which a 45% target would be set four years after the rules' entry into force, followed by a 65% target two years later. A majority of delegations favour this approach though some still want a longer transition period, according to the report."[61]

Also the scope of the Directive shall be clarified as currently the scope of the WEEE directive is unclear, e.g. types of appliances shall be categorized as household (B2C – business to consumer) and non-household appliances (B2B – business to business). "Twelve countries support giving the WEEE directive an open scope as demanded by the environment committee. Twelve other states want to limit the law's scope to specific products. As a compromise Belgium suggested a narrow definition of what constitutes EEE equipment, which would limit the number of products falling into an open scope. Other issues of disagreement remain, for example whether a producer of electrical and electronic equipment should be defined at national or EU level and whether the cost of managing WEEE should be displayed on product labels." [61]

Should these changes come into force, industry would be forced to make sure that they control the waste stream more than they do now in order to meet the (more demanding) collection and recycling targets.

4.1.6 Biocide Directive 98/8/EC

This Directive[62] concerns: (a) the authorisation and the placing on the market for use of biocidal products within the Member States; (b) the mutual recognition of authorisations within the Community; and (c) the establishment at Community level of a positive list of active substances which may be used in biocidal products.

Biocidal products are defined as active substances and preparations containing one or more active substances, put up in the form in which they are supplied to the user, intended to destroy, deter, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means.

The guidance document for the Biocidal Products Directive (BPD)[63] provides the following explanations:

- Human hygiene biocidal products: Detergents and cleaning products (auxiliary aids for washing processes like fabric conditioners are included) intended to have a biocidal activity (reliably controlling micro-organisms like fungi and bacteria) are biocidal products.

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61 http://www.endseurope.com/25218?referrer=channel%2Dwaste

62 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:123:0001:0063:EN:PDF

63 Source: Guidance document agreed between the Commission services and the competent authorities of the Member States for the Biocidal Products Directive 98/8/EC (Doc-Biocides-2002/04-Rev3; 31.10.2003); http://ec.europa.eu/environment/biocides/pdf/definitions.pdf

The Commission services and all Member States except Austria agreed to the following clarification: When associated with cleaning products, the word 'hygiene' can be used without immediately causing the product to fall under the scope of the BPD as long as no reference (words, pictures, etc.) to antimicrobial or disinfecting action is made.

- Private area and public health area disinfectants and other biocidal products: Detergents containing in-can preservatives, but not intended to have biocidal effects, are not in the scope of BPD. However, detergents containing a biocidal active substance, *intended to have biocidal effects under conditions of use, with or without biocidal claim*, should be regarded as biocidal products. The definition of a biocidal product in Directive 98/8/EC is that it is "intended" as such and does not necessitate a claim to be made. However, it is reasonable to expect that an intended biocidal action would be reflected in a relevant claim. In the absence of such a claim, on the label or elsewhere, some other relevant matter in the context in which the product is presented beyond its formulation (e.g. presentation of the product, use instruction etc.) would be needed to justify a conclusion that it was 'intended' to be biocidal. The current wording reflects the definition. In case of a divergence of views concerning a particular product between the authorities and the person responsible for placing the product on the market, it is up to the latter to demonstrate that no biocidal effect was intended.

Currently, the approval procedure for biocidal active substances of the product types 1 to 4 (related to disinfectants) is ongoing. Active substances being approved in the EU will be listed in Annex 1 of the BPD in the coming years. Only after that, national product approvals in the Member States will be starting, i.e. the disinfectants with biocidal active substances will be approved at national level according to the BPD. Meanwhile transitional agreements apply.

Both the professional laundry (e.g. in health care laundry) and the dishwashing sector use biocidal detergent systems to achieve a certain level of hygiene; thus being affected by the Biocidal Products Directive. In the washing and drying process, hygienic requirements are usually met by a predefined level of process temperatures, however depending on the use of detergents with or without disinfection components of the detergents.

4.1.7 Gas Appliances Directive (GAD) Directive 2009/142/EC

The Directive regulates appliances burning gaseous fuels used for cooking, heating, hot water production, refrigeration, lighting or washing with (where applicable) a normal water temperature not exceeding 105°C. The GAD applies to all gas heated and combined gas-heated applications. Although the Directive mainly covers common consumer and commercial products, so-called fittings are comprised, too. Appliances specifically designed for use in industrial processes carried out on industrial premises are excluded.

The GAD has been subject to a recent codification which is a process of incorporating a legislative act and all its amendments into a single new act. The new codified version is referred to as Directive 2009/142/EC and came into force on 4 January 2010. From this date, any references to the repealed Directive 90/396/EEC[64] shall be construed as references to Directive 2009/142/EC.

4.1.8 Water Framework Directive (WFD) 2000/60/EC

The Water Framework Directive[65] establishes a legal framework to protect and restore clean water across Europe and ensure its long-term, sustainable use. The directive establishes an innovative approach for water management based on river basins, the natural geographical and hydrological units, and it sets specific deadlines for Member States to protect aquatic ecosystems. The directive addresses inland surface waters, transitional waters, coastal waters and groundwater, and it establishes innovative principles for water management, including public participation in planning and economic approaches, including the recovery of the cost of water services.

Inter alia, the Water Framework Directive introduces two key economic principles. First, it calls on water users – such as industries, farmers and households – to pay for the full costs of the water services they receive. Second, the directive calls on Member States to use economic analysis in the management of their water resources and to assess both the cost-effectiveness and overall costs of alternatives when making key decisions. Under the directive the recovery of costs refers to several elements. The prices users pay for water should cover the operational and maintenance costs of its supply and treatment and the costs invested in infrastructure. The directive goes further and requires that prices paid by users also cover environmental and resource costs. This is a key step towards implementing the economic principle that polluters and users should pay for the natural resources they use and the damage they create.

Further, Articles 4, 10, 11 and 16 and Annexes V, VIII, IX and X of the Directive address chemical pollution. By targeting priority substances, the Water Framework Directive focuses on individual pollutants or groups of pollutants that present significant risk to or via the aquatic environment. The substances are identified through rigorous risk assessments, which involve examining scientific evidence of the hazardous properties of the substances, their contamination of European waters, and other factors such as volumes used. Among the 33 chemicals categorised as priority substances, 13 are designated as priority hazardous substances due to their persistence, bioaccumulation and toxicity. The European Commission will review this list every four years, to allow for the inclusion of additional substances of

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64 http://eur-lex.europa.eu/LexUriServ/site/en/consleg/1990/L/01990L0396-19930802-en.pdf

65 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF
http://ec.europa.eu/environment/water/participation/notes_en.htm

concern. The Water Framework Directive seeks to progressively reduce emissions, discharges and losses of priority substances to waters. Priority hazardous substances are to be phased out completely within 20 years.

None of the 33 listed priority substances is expected to be in detergents used for professional laundry and dishwashing processes. Amongst the 13 substances being designated as priority hazardous substances, EDTA[66] is still used in detergents. In Germany, for example, since 1991 several industrial associations (e.g. IKW and IHO[67]) have voluntarily committed to abandon the use of EDTA to a large extent. Thus, in Germany EDTA is only found in few specialised detergent products of the industrial and institutional (I&I) sector.

In general, the WFD prescribes the creation of incentives for an efficient use of water resources and focuses on improvement of sustainability of production.

4.1.9 Commission Regulation (EC) No. 648/2004 – Detergents

Detergents have to fulfil the requirements laid down by Regulation (EC) No. 648/2004 on detergents.[68] This regulation establishes rules designed to achieve the free movement of detergents and surfactants for detergents in the internal market while, at the same time, ensuring a high degree of protection of the environment and human health. For this purpose, this Regulation harmonises the following rules for the placing on the market of detergents and of surfactants for detergents:

- the biodegradability of surfactants in detergents;
- restrictions or bans on surfactants on grounds of biodegradability;
- the additional labelling[69] of detergents, including fragrance allergens; and
- the information that manufacturers must hold at the disposal of the Member States competent authorities and medical personnel.

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66 EDTA (ethylene-diamino-tetra-acetate): A class of synthetic, phosphate-alternative compounds used to reduce calcium and magnesium hardness in water. EDTA is also used to prevent bleaching agents from becoming active before they're immersed in water and as a foaming stabilizer.

67 IKW: Industrieverband Körperpflege- und Waschmittel; IHO: Industrieverband Hygiene und Oberflächenschutz

68 For the purpose of Regulation (EC) No. 648/2004 ‘detergents’ means any substance or mixture containing soaps and/or other surfactants intended for washing and cleaning processes. Detergents may be in any form (liquid, powder, paste, bar, cake, moulded piece, shape, etc.) and marketed for or used in household, or institutional or industrial purposes. Other products to be considered as detergents are: ‘Auxiliary washing mixture’, ‘Laundry fabric-softener’, ‘Cleaning mixture’, ‘Other cleaning and washing mixtures’, intended for any other washing and cleaning processes.

69 The Detergent Regulation sets the requirement for more specific detergent package labelling on issues including the ingredient datasheet, the number of standard washing machine loads and the enterprise's contact details. The labelling requirements vary depending on whether the product is sold to the general public or for use in the industrial sector only. Specific provisions regarding labelling are laid down in Annex VII to the Regulation. In addition, the packaging of detergents regarded as biocides, such as disinfectants, will be required to have special biocidal product labelling following a transitional period.

4.1.10 Commission Regulation (EC) No. 842/2006 – Fluorinated GHG

The objective of this Regulation[70] is to contain, prevent and thereby reduce emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol. Annex I to this Regulation contains a list of the fluorinated greenhouse gases currently covered by this Regulation, together with their global warming potentials.

Fluorinated gases are powerful greenhouse gases with global warming potentials many times that of natural greenhouse gases such as carbon dioxide. They also tend to remain much longer in the atmosphere than natural greenhouse gases. Because of this, they are included in the basket of gases controlled by the Kyoto Protocol and Parties to the Protocol that have an emissions target are required to control and reduce emissions of Fluorinated gases. Fluorinated gases are man made substances and Regulation 842/2006 defines them as follows: fluorinated greenhouse gases' means hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) as listed in Annex I of the Regulation.

This Regulation addresses the containment, use, recovery and destruction of the fluorinated greenhouse gases listed in Annex I; the labelling and disposal of products and equipment containing those gases; the reporting of information on those gases; the control of uses and the placing on the market prohibitions of the products and equipment; and the training and certification of personnel and companies involved in activities provided for by this Regulation.

For professional washing machines and dryers, this Regulation applies in those cases when the appliances are equipped with heat pumps containing refrigerants.

4.1.11 Commission Regulation (EC) No. 1275/2008 – Standby

The Regulation[71] sets out eco-design requirements for standby and off mode electric power consumption. The application is limited to products corresponding to household and office equipment intended for use in the domestic environment. 'Electrical and electronic household and office equipment' is defined as energy-using products which:

a) are made commercially available as a single functional unit and are intended for the end-user;

b) fall under the list of energy-using products of Annex I of the Directive (inter alia washing machines and dryers);

c) are dependent on energy input from the mains power source in order to work as intended; and

d) are designed for use with a nominal voltage rating of 250 V or below,

also when marketed for non-household or non-office use.

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[70] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:161:0001:0011:EN:PDF

[71] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:339:0045:0052:EN:PDF

The Standby Directive only covers appliances being in the scope of the Low Voltage Directive (LVD). As professional washing machines and dryers do not fall under the LVD but under the Machinery Directive (see Sections 2.4.2 and 4.1.1), they are also not covered by the scope of the Standby Regulation.

4.1.12 European labelling

There is no EU-wide mandatory measure regarding the efficiency of professional washing machines and dryers.

4.2 Legislation at member state level

No legislation at member state level regarding professional washing machines and dryers has been found. Regarding labelling, there are environmental labels for textile respectively wet-cleaning services in Germany and Norway.

German RAL-UZ 104 for Wet Cleaning Services

In cooperation with the Federal Minister for the Environment, Nature Conservation and Nuclear Safety, the Federal Environmental Agency and considering the results of the expert hearings conducted by RAL gGmbH, the Environmental Label Jury has set up these Basic Criteria for the Award of the Environmental Label for Wet Cleaning Services (2009)[72]. They apply to wet cleaning services for the treatment of personal textile or leather outerwear and home textiles which use water as only solvent for the cleaning process.

- The following instrumental requirements must be fulfilled:
  - The special wet-cleaning washing machine must have a minimum drum volume of 100 litres.
  - The wet-cleaning machine must have a programmable control system, a temperature control device as well as a dosing device for the washing agents.
  - Dryers used for the wet-cleaning process must be equipped with a temperature limiting and a time-limiting device a well as with a humidity measurement device.
- Requirements for Water and Energy Consumption:
  - Normal outerware with easily removable soiling: the water consumption of wet cleaning systems must not exceed 12 litres per kg of cleaned goods.
  - For washing and drying programmes the energy consumption of **all-electric wet cleaning systems for heating purposes** must not exceed 0.5 kWh of electric current per kg of goods to be cleaned and 0.2 kWh of electric current per kg of goods to be cleaned for driving and auxiliary units.

[72] http://www.blauer-engel.de/en/products_brands/vergabegrundlage.php?id=21

  - For washing and drying programmes the energy consumption of **steam-heated wet cleaning systems** must not exceed 0.7 kg of steam per kg of goods to be cleaned and 0.2 kWh of electric current per kg of goods to be cleaned for driving and auxiliary units.
  - All other units used for drying purposes shall be named together with the energy consumption data (kWh per kg of cleaned goods).
- Requirements for Cleaning Agents:
  - Solvents: Cleaning must be done without the addition of organic solvents to the bathes (pre-cleaning, main cleaning and rinsing bath).
  - Exclusion of certain ingredients
- Requirements for Waste Water

German RAL[73] Quality Certification Marks for Household and Commercial Linen (RAL-GZ 992/1 – edition of 1953); for Hospital Linen (RAL-GZ 992/2 – edition of 1986); and for Linen from Food Processing Businesses (RAL-GZ 992/3 – edition of 1998)[74]

The RAL Quality Certification Marks RAL-GZ 992/1, RAL-GZ 992/2 and RAL-GZ 992/3 are awarded to the commercial laundries that form the German Certification Association for Professional Textile Services on the basis of standardised quality and control specifications.

Criteria for obtaining the quality label include a membership of the commercial laundry in the quality mark association as well as compliance with the specifications contained in the quality label's quality and inspection provisions:

- General framework conditions, such as a structural separation between "clean" and "non-clean" areas.
- Implementation of a quality management system.
- Microbiological values which must be adhered to. As part of an audit, so-called bio-indicators are used as an additional instrument in hygiene inspections; they run through the laundering process and are used to prove that the selected laundry method achieves the specified disinfectant performance.

[73] RAL, the German Institute for Quality Assurance and Certification, was established in 1925 as a joint initiative by private businesses and the government of the day. Initially, its task was to standardise precise technical terms and conditions of sale in the interests of rationalisation. Today, RAL is the recognised institution for efficient and reliable labelling of products and services of all kinds. RAL Quality Certification Marks are voluntary regulatory measures used by business and are free of any kind of state influence. A comprehensive system of regular self-monitoring and neutral external monitoring helps to ensure that the quality prescribed by the relevant quality specifications is maintained.

[74] Sources: www.waeschereien.de; http://www.hohenstein.de/ximages/1354434_ggralgz992.pdf, sighted on 08 January 2010

- Regular in-house and external audits. The in-house testing of the finished laundry includes the following criteria: cleanliness, degree of whiteness, dryness, smoothness, effectiveness of finishing treatment, quality of laying out and folding, odour and packaging. In particular, dry linen, mangle linen and shaped items are tested separately. The external monitoring covers the washing processes and the whole operation of the company including hygiene.
- Inspection of results from in-house and external audits by external experts and adjustment to specified values.

Nordic Ecolabelling of Textile Services

Criteria document version 2.0 from 27 April 2010,[75] valid from 15 December 2009 to 31 December 2012 defines the following:

Scope: The criteria for textile services are a combination of the criteria that formerly applied to hand towel rolls and laundries. The product group encompasses the full range of textile services and a licence may be awarded to individual production units or multiple units that form part of a chain/group of companies. Each unit must fulfil the requirements. In the case of hand towel rolls, the Nordic Ecolabel may be awarded for the laundry in its entirety or solely to those areas of the laundry operations that apply to hand towel rolls. The criteria do not encompass production units doing only dry cleaning. Such units may apply according to the criteria alternative dry cleaning.

Specification of textile categories: The separate groups of textiles to be washed have special requirements that shall be complied with in order to obtain the license. The requirements on ecolabelling include the following distinct categories of textiles:

[75] http://www.svanen.se/Templates/Criteria/CriteriaGetFile.aspx?fileID=114261001

Table 16 Different groups of textiles according to Nordic Ecolabelling of Laundries

No.	Textile category	Details
1	Work clothes industrial / kitchen / butchering and equivalent use. Kitchen textiles (cloths and towels)	Clothing, such as work clothes for mechanical industrial work, offshore industry, outdoor military clothes and bags, the foodstuffs industry, the medical industry and the like, as well as clothing for butchers, cooks and the like. Kitchen clothes, floor clothes, cooks whites, kitchen towels and the like for restaurants and institutional kitchens etc. These textiles are often characterised by their heavy degree of soiling and may be difficult to clean.
2	Work clothes, institutions / retail / service. Private clothes from households / institutions; shoes	Clothing for use in service industries, retail outlets, hotels, hospitals, nursing homes and other institutions. Indoor military textiles. Private clothes typically from citizens not able to do their own laundry. All kinds of shoes (typical for industrial use) sent to laundering. The category will usually be work clothes with a somewhat smaller degree of soiling than in the previous category and furthermore shoes and light soiled private clothes which requires special sorting and handling in smaller scale machines.
3	Hotels	Bed clothes and towelling from hotels and other overnight accommodation. Often this will involve lightly soiled textiles since they will often have been in limited use before being sent off for laundering.
4	Restaurants	Tablecloths, napkins and the like for use in restaurants, industrial kitchens etc. This will often be textiles with a medium degree of soiling. Although the stains in question may frequently require relaundering.
5	Hospitals/nursing homes	Textiles from hospitals and nursing homes and similar institutions including bedclothes, contour sheets, surgical scrubs, barrier sheets and patient clothing, but excluding the work wear of personnel and the category “comforters and pillows”. Although there will be a wider degree of variation in soiling, on average it can be viewed as of medium intensity.
6	Comforters and pillows	Comforters, pillows, sleeping bags and mattress toppers from for example hospitals, nursing homes, hotels, summer houses, ski lodges and the like. The volume per kilo of these textiles will often be high, which makes for a lower degree of filling. Moreover, it is difficult to remove water from these textiles before drying, which in turn means that the tumble drying process consumes more energy.
7	Mats for offshore industry and mops	Mats used in the heavily soiled offshore industry and mops used for cleaning purposes. Often very heavily soiled, but do not need to be completely clean. Frequently treated after laundering in order to secure enhanced soil retention or other properties.
8	Other mats	Mats for entrance ways and the like for capturing dirt and water. Often heavily soiled, but do not need to be completely clean. Frequently treated after laundering in order to secure enhanced soil retention properties.
9	Textile hand towel rolls	Cotton cloth hand towel rolls for hand drying in toilets and the like.
10	Industrial wiping cloths	Textile cloths for drying in for example the graphic and mechanical industries. Will often be heavily polluted cloths containing traces of printers ink, oils, metal filings
11	Dry cleaning	All textiles that are dry-cleaned internally and/or externally including private clothing. These will typically be delicate textiles not capable of withstanding washing.
12	Other	Textiles that are not encompassed by the above categories and that generally make up a small proportion of the textiles laundered by the laundries.

Ecolabelling criteria for the laundries[76]:

- Energy requirements;
- Requirements on the emission of climate gases;
- Requirements on water consumption;
- Requirements on transport;
- Requirements on laundry chemicals;
- Requirements on constituent substances.

The document describes further requirements on finished washable textiles, on waste water discharge, on waste treatment and collection system and on packaging. Finally, there are requirements on quality control of the laundry, authority requirements for working security, health and environment, requirements on the environmental- and quality assurance as well as marketing criteria to be fulfilled.

4.3 Third country legislation

4.3.1 USA

The Energy Policy Act of 1992 set standards for certain commercial equipment and set schedules requiring the U.S. Department of Energy (DOE) to make, review, and update standards. DOE currently is active in standards development for a range of commercial products. While professional clothes washers are in the scope of the US Energy Conservation Standard,[77] professional dryers are not yet.

Energy Conservation Standards for [….] Certain Commercial and Industrial Equipment (Commercial Clothes Washers)

"Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Microwave Ovens, and Electric and Gas Kitchen Ranges and Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers); Final Rule, Federal Register, 75 FR 1122, January 8, 2010"[78]

The U.S. Department of Energy's Appliances and Commercial Equipment Standards Program develops test procedures and minimum efficiency standards for residential appliances and commercial equipment.

[76] Note: the requirements refer to the whole textile service, not to individual laundry appliances.

[77] http://www1.eere.energy.gov/buildings/appliance_standards/commercial_products.html

[78] http://www1.eere.energy.gov/buildings/appliance_standards/commercial/clothes_washers.html; sighted on 7 September 2010

The Energy Policy and Conservation Act (EPCA) (42 USC 6295 (e)), as amended, requires the U.S. Department of Energy (DOE) to determine whether amended, more stringent standards would be technologically feasible and economically justified. Commercial clothes washers were originally included in the final rule for residential dishwashers, dehumidifiers, and cooking products, and commercial clothes washers. However, DOE needed to conduct supplemental rulemaking analyses to complete the rulemaking. As a result, the standards for commercial clothes washers are under development in a separate rulemaking through a supplemental notice of proposed rulemaking and final rule.

Any such amended energy conservation standard must be designed to ‘‘achieve the maximum improvement in energy efficiency. Furthermore, any new or amended standard must result in significant conservation of energy.’’

Table 17 shows the amended standard levels that DOE is adopting currently. These standards will apply to all commercial clothes washers manufactured for sale in the United States, or imported to the United States, on or after January 8, 2013.

Table 17 Amended energy conservation standards for commercial cloth washers

Criteria/Product Type	Amended energy conservation standards
Top-loading commercial clothes washers	1.60 Modified Energy Factor (MEF) 8.5 Water Factor (WF)
Front-loading commercial clothes washers.	2.00 Modified Energy Factor (WF) 5.5 Water Factor (WF)

Furthermore, California's Appliance Efficiency Regulations were established in 1976 in response to a legislative mandate to reduce California's energy consumption. The regulations are updated periodically to allow consideration and possible incorporation of new energy efficiency technologies and methods. The 2009 Appliance Efficiency Regulations, (California Code of Regulations, Title 20, Sections 1601 through 1608)[79] effective August 9, 2009, were adopted by the California Energy Commission (CEC) on December 3, 2008, and approved by the California Office of Administrative Law on July 10, 2009. The Appliance Efficiency Regulations include standards for both federally-regulated appliances and non-federally-regulated appliances.

While for dryers, the Californian Appliance Efficiency Regulations only include appliances that are federally-regulated consumer products, commercial clothes washers do fall under the scope.

- Definition: “Commercial clothes washer” is defined as a soft mount front-loading or soft mount top-loading clothes washer with clothes container compartment no greater than

[79] Source: http://www.energy.ca.gov/2009publications/CEC-400-2009-013/CEC-400-2009-013.PDF

3.5 ft^3 (99 litres) for horizontal axis clothes washers, or no greater than 4.0 ft^3 (113 litres) for vertical-axis clothes washers,[80] that is designed for use in:

  – applications where the occupants of more than one household will be using it, such as multi-family housing common areas and coin laundries; or
  – other commercial applications.

- Test method: For commercial clothes washers, the test method 10 CFR Section 430.23(j) (Appendix J1 to Subpart B of Part 430) (2008) applies; however being a test programme for consumer products.[81]
- Energy and water efficiency standards: Commercial clothes washers manufactured on or after January 1, 2007 shall have a modified energy factor of at least 1.26 and a water consumption factor of not more than 9.5.

ENERGY STAR Label Commercial Clothes Washers

ENERGY STAR is a joint programme of the U.S. Environmental Protection Agency and the U.S. Department of Energy. Criteria for energy labelling:[82]

- Types: front-loading washer or a top-loading washer.
- Volume: Tub capacity of the clothes washer in cubic feet.[83]
- Energy requirements
  – kWh/year: This is the estimated annual energy use of the washer under typical conditions. It is based on an annual usage of 392 loads per year, or around 8 loads per week. Actual energy consumption will vary depending on the amount of laundry done, the size of the loads, and the temperature settings used. This figure is calculated according to the Department of Energy test procedure, Code of Federal Regulations, Title 10, Section 430. It incorporates the estimated energy consumed by the washer and also the energy needed to heat the water with an electric water heater. Households with a gas water heater will use significantly fewer kilowatt hours but will consume gas to heat the same water.
  – Modified Energy Factor (MEF): MEF is the official energy efficiency metric used to compare relative efficiencies of different clothes washers. MEF considers the en-

80 One cubic foot (ft^3) equates 28.32 litres

81 PART 430: Energy conservation program for consumer products. Appendix J1 to Subpart B of Part 430: Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-Automatic Clothes Washers. For more details, cf. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=6e467fb0b172d3508a249d20c47da096&rgn=div9&view=text&node=10:3.0.1.4.16.2.9.7.17&idno=10

82 http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

83 1 cubic feet: 1 ft^3 = 28.317 litres

ergy used to run the washer, heat the water, and run the dryer. The higher the MEF, the more efficient the clothes washer. ENERGY STAR qualified clothes washers must have a minimum MEF of 2.0. The minimum Federal standard requirement for clothes washers is an MEF of 1.26 (see above).

- Water requirements
  - Water Factor (WF): a measurement of water efficiency that is calculated as gallons[84] of water used per cubic foot[83] of capacity. A clothes washer which needs 30 gallons (113.5 litres) per cycle and which has a tub volume of 3.0 cubic feet (85 litres), for example, will produce a water factor of 10.0. The lower the WF, the more efficient the clothes washer. ENERGY STAR qualified clothes washers must have a maximum WF of 6.0.
  - Annual Water Use (Gallons per year): estimated annual water use of the washer under typical conditions. It is based on an annual usage of 392 loads per year, or around 8 loads per week. Actual water consumption will vary depending on the amount of laundry done.

Table 18 The ENERGY STAR criteria for clothes washers

Criteria/Product Type	Current criteria levels (as of January 1, 2011)	Former criteria levels (as of July 1, 2009)
ENERGY STAR top and front loading	MEF >= 2.0 WF <= 6.0	MEF >= 1.8 WF <= 7.5
Federal Standard top and front loading	MEF >= 1.26 WF <= 9.5	MEF >= 1.26 WF <= 9.5

MEF = modified energy factor, WF = water factor (gallons per cycle per cubic foot)

Since 1 January 2011, the above listed revision has come into force. According to the "Commercial Clothes Washers Qualified Product List" posted on January 20, 2011, around 40 commercial clothes washers have qualified for the ENERGY STAR.[85]

The ENERGY STAR Program Requirements Product Specification for Clothes Washers are based on the test method 10 CFR 430, Subpart B, Appendix J1 (Electronic Code of Federal Regulations), however being a test programme for consumer products.[86]

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84 1 US gallon = 3.78 litres

85 http://www.energystar.gov/ia/products/prod_lists/comm_washers_prod_list.xls

86 PART 430: Energy conservation program for consumer products. Appendix J1 to Subpart B of Part 430: Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-Automatic Clothes Washers. For more details cf. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=6e467fb0b172d3508a249d20c47da096&rgn=div9&view=text&node=10:3.0.1.4.16.2.9.7.17&idno=10

4.3.2 Canada

Regulations under the Energy Efficiency Act,[87] in effect since 1995, set minimum energy-performance levels for a number of energy-using products such as appliances, lighting, and heating and air-conditioning products. Broadening and strengthening the Act means that 80 percent of the energy used in homes and businesses will soon be regulated. Over time, the set of planned new regulations will tighten requirements for 10 products such as residential dishwashers, and will address about 20 currently unregulated products including commercial clothes washers. However, the latest amendment 11 and 12 bulletins published did not yet cover this product group.

ENERGY STAR Canada for commercial clothes washers

Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) promotes the international ENERGY STAR symbol in Canada and monitors its use.[88] This also applies for the Energy Star label for the following categories of commercial clothes washers:

Coin- or card operated, soft-mount front-loading and top loading clothes washers with a tub not greater than 99.3 litres (approx. 9 kg) for front-loading washers or not greater than 113 litres (approx. 11 kg) for top-loading washers, designated for use in applications where the occupants of more than one household will be using it, such as a multi-family housing common areas and coin-laundries, hotels, or in other commercial applications.

4.3.3 Australia

A wide range of products are regulated for energy efficiency in Australia. Also, new products are continually being considered for regulation or other types of programs in order to improve energy efficiency. Other than for commercial refrigeration appliances, professional washing machines or dryers do not fall under the (considered) scope of the Australian energy efficiency regulation so far.[89]

4.3.4 China

The China Standard Certification Center (CSC),[90] formerly known as China Certification Center for Energy Conservation Products (CECP), was officially founded in October 1998, by the former China State Economic and Trade Commission (SETC) with an approval from the former State Bureau of Quality and Technical Supervision. CSC has been administrated by China National Institute of Standardization. Over the past several years, CSC has continuously introduced various product certification programs to promote the use of energy

87 Source: http://oee.nrcan.gc.ca/regulations/home_page.cfm

88 http://oee.nrcan.gc.ca/residential/business/manufacturers/commercial-products.cfm?attr=12

89 Source: http://www.energyrating.gov.au/considered.html

90 http://www.cecp.org.cn/english/index.asp

conservation, water conservation and environmental-friendly products and equipment. In addition to lighting products, CSC's energy conservation certification programs now cover over other 35 product categories, for example home appliances, electronic, industrial, office equipments, building materials, etc. To date, more than 2 000 individual products from approximately 250 manufacturers have participated in the certification program. However, no information on professional washing machines and dryers has been found.

4.3.5 Russia

No information on Russian regulations with regard to professional washing machines and dryers has been found.

4.3.6 Thailand

Thai Green Label TGL-17-98 Laundry services and dry cleaning services (1998)

Laundry services use a large volume of water thus discharging waste water to the environment. Additionally, some chemicals and nutrients from slow or non biodegradable detergents accumulate in the environment causing water and soil pollution. The criteria for laundry services require to have limited water consumption and use high quality detergents which will reduce wastewater load to the environment.

- Category Definition: This category includes only laundry service in registered shops, hotels and hospitals.
- Green Label Requirements: To be authorized to carry the Green label, a product must meet both the general requirements and the specific requirement listed below:
  - General Requirements: The service process, transportation and disposal must follow to the requirements of all applicable governmental acts and regulation such as Public Health Act, Factory Act etc.
  - Product Specific Requirements: Laundry Services
    - must not use water exceeding 30 litres per washing cycle per 1 kg dry cloth;
    - must have a plan to reuse hangers;
    - must ensure that in industrial service, the chemicals used underlie a suitable storage and handling system;
    - must use Green Label laundry detergent or detergents that meet the requirements of Green Label laundry detergent regarding aerobical and anaerobical biodegradability, pH values, and phosphate content. Furthermore, there are requirements regarding forbidden substances / unused chemicals in the detergents.

5 Conclusions: Scope of the study

5.1 Professional washing machines

Within Lot 24 we define professional washing machines as follows (cf. Section 2.4.3):

> 'Professional washing machine' means a machine which cleans and rinses laundry like clothes, tablecloths, bedclothes, towels, and other textiles or items by using water, chemical, mechanical, and thermal means; which might also have a spin extraction or drying function and which is designed to be used principally for commercial and industrial purposes as stated by the manufacturer in the Declaration of Conformity (DoC).

The delimination of professional washing machines to those for household use is determined from the 'intended use' (domestic or commercial / industrial use) as declared by the manufacturer in the product information or the Declaration of Conformity (cf. Section 2.4.2).

Besides this formal distinction, professional and household washing machines can be distinguished by functional performance and technological differences resulting from different requirements regarding the washing process. Professional washing machines need to take into account important framework requirements (shorter running cycles, high throughput, amount and type of laundry, spatial requirements) to fulfil their primary function (to clean and rinse a certain amount of laundry). Reflecting these framework requirements and taking into account functional and technological differences, professional washing machines can be categorised into the following seven categories (cf Section 2.5.5.1):

- WM1: Semi-professional washer extractor
- WM2: Professional washer extractor, <15 kg
- WM3: Professional washer extractor, 15-40 kg
- WM4: Professional washer extractor, >40 kg
- WM5: Professional washer dryer
- WM6: Professional barrier washer
- WM7: Washing tunnel machine;

Due to the following reasons dry-cleaning machines will fall out of the scope of Lot 24 on professional washing machines:

- In the Eco-design regulation on household washing machines, such appliances are defined as "an automatic washing machine which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes". Thus, washing machines use water for cleaning and

rinsing textiles. Dry cleaning machines, on the other hand, use other solvents for cleaning textiles.

- Dry-cleaning machines do not perform the same function as washing machines. Especially with regard to water-soluble stains, the performance is worse than washing machines. On the other hand, for some types of textiles it is not possible to wash them (i.e. in a washing machine) but only to dry-clean them.
- Dry-cleaning machines are clearly different to washing machines with regard to technology, as outlined in this working paper. It would therefore not be possible to describe a dry-cleaning machine as a washing machine in order to circumvent regulation.
- Dry-cleaning machines are not manufactured by washing machine manufacturers and vice versa.
- Dry-cleaning machines cover a different market segment (chemical dry-cleaning businesses as opposed to professional laundry services or on-premise laundry).
- The number of dry-cleaning machines produced is much smaller than the aggregated figure for other laundry equipment considered in the project; for details, please refer to the annex of Task 2 report).

5.2 Professional dryers

Within Lot 24 we define professional dryers as follows (cf. Section 2.4.3):

'Professional dryer' means a machine which dries laundry like clothes, tablecloths, bedclothes, towels, and other textiles or items by thermally removing the moisture (evaporation) and which is designed to be used principally for commercial and industrial purposes as stated by the manufacturer in the Declaration of Conformity (DoC).

The delimitation of professional dryers to those for household use is determined from the 'intended use' (domestic or commercial / industrial use) as declared by the manufacturer in the product information or the Declaration of Conformity (cf. Section 2.4.2).

Besides this formal distinction, professional and household dryers can be distinguished by functional performance and technological differences resulting from different requirements regarding the drying process. Professional dryers need to take into account important framework requirements (shorter running cycles, high throughput, amount and type of laundry, spatial requirements) to fulfil their primary function (to dry a certain amount of laundry). Reflecting these framework requirements and taking into account functional and technological differences, professional dryers can be categorised into the following seven categories (cf Section 2.5.5.2):

- D1: Semi-professional dryer, condenser
- D2: Semi-professional dryer, air vented
- D3: Professional cabinet dryer
- D4: Professional tumble dryer, <15 kg
- D5: Professional tumble dryer, 15-40 kg
- D6: Professional tumble dryer, >40 kg
- D7: Pass-through (transfer) tumble dryer

According to the above definition of dryers thermally removing the moisture by evaporation, those appliances using only mechanical energy for dewatering will fall out of the scope of Lot 24 on professional dryers.

- Separate hydro-extractor or pressing appliances are set up mainly for further processing behind tunnel washing systems. It is the most widely used method for dewatering the batch tunnel washing machines. Within the tunnel washing system, many individual machines are one behind the other. Each of the individual machines fulfils a certain individual function of the washing and rinsing process. Finally, a centrifugal-extractor or water press is supplied at the end.
- However, washing machines with *integrated* mechanical dewatering modules (e.g. washer extractors) fall under the scope of Lot 24. Effects and impacts caused by products of the other outlined processes still might be indirectly assessed within the whole system analysis.

According to Porter et al. (1985), some appliances meet the definition of dryers, however using an indirect method of heat transfer. Thus, their primary function is not drying of the textiles but the removal of creases. Within Lot 24, we will narrow the scope to direct dryers using heated dry air as medium for the heat and humidity transfer (convection principle, drying as primary function). Hence, the following indirect dryers (conduction principle, drying as secondary function) will fall out of the scope of Lot 24:

- Professional ironing tables,
- Ironing and fusing presses, and
- Flatwork ironers.

Further, there are other appliances using the convection principle for drying; however their primary function is not the drying of textiles but the removal of creases by calendering and relaxing the textiles. Therefore, the following appliances will fall out of the scope of Lot 24:

- Steam air finisher,
- Tunnel finisher.

The laundry appliances being excluded from the scope of Lot 24 are briefly described in the Annex, Section 7.3.

6 Sources

For the categorisation of product types, numerous internet pages and product brochures of manufacturers and industry associations have been analysed:

Table 19 Manufacturers' internet pages being screened within EuP Lot 24

Manufacturer	Internet page
Allied Armstrong	http://www.laundry.ie/
American Dryer Corp. (ADC)	http://amdry.com/products/index.asp
ASKO	http://www.askousa.com/
Broadbent	http://www.broadbent-laundry-systems.co.uk/
Camptel	http://www.camptel.it/english/cat1/main_en.htm
Cissell (Alliance Laundry Systems)	http://www.cissell.com/products/
Continental Girbau	http://www.continentalgirbau.com/products
Danube	http://www.danube-international.com/
Electrolux Professional	http://www.laundrysystems.electrolux.de/
Fimas	http://www.fimassrl.it/en/prodotti-per-lavanderie.asp
Girbau	http://www.commerciallaundryequipment.girbau.com/lc/home http://www.laundryequipment.girbau.com/gi/home
GMP	http://www.gmp.it/enindex.php
Hamony Business	http://www.harmonybusiness.co.uk/Products.html
Hoffman	http://www.hoffman-newyorker.com/products.htm
Hornung GmbH INDUPRESS	http://www.indupress.com / http://tunnelfinisher.com
Huebsch	http://www.huebsch.com/products/
Imesa	http://www.imesa.it/eng/prodotti.php
Ipso	http://www.ipso.be/products/main.asp?pageId=2
IWMIndustrial Washing Machines	http://www.indwash.co.uk/products/
Jensen	http://www.jensen-group.com/products.html
Kannegiesser	http://www.kannegiesser.de/wet.0.html?&L=5
Lavamac	http://www.lavamac.eu/
Maytag	http://www.maytag.com/catalog/all_products.jsp
Miele Professional	http://www.miele-professional.com
Milnor	http://www.milnor.com/category.asp?retid=153
Podab	http://www.podab.se/English_Products_DXNI-827429_.aspx
Primus	http://www.primuslaundry.com/products.aspx?lang=EN&swf=products
Schulthess	http://www.schulthess.ch/en/products.html
Staber	http://www.staber.com/
Stahl Wäschereimaschinen	http://stahl-waeschereimaschinen.de/pages/en/products/overview-of-all-products.php?lang=EN
Unimac	http://www.unimac.com/intl/products/products.asp
Warwick	http://www.warwickdryers.co.uk/
Whirlpool commercial	http://www.coinop.com/products/default.asp?type=1

Further valuable sources have been

- The Electrolux Laundry Know-How provides basic knowledge on the washing process, from sorting the laundry to storing it. This includes knowledge about the quality of water and detergents, and information about common washing methods as well as the finishing process.
  http://www.laundrysystems.electrolux.com/Files/Laundryknowhow/HTML/71-0-1.htm
- Training Modules on the Sustainability of Industrial Laundering Processes – E-learning tool for trainees and employees in laundries. The EU financed Leonardo da Vinci laundry sustainability Internet page comprises six training modules providing basic knowledge about sustainable processing in industrial laundries. Project partners: wfk Forschungsinstitut für Reinigungstechnologie e.V. (D); European Textile Services Ass. (E.T.S.A.) (BE); University of Maribor (SI); Textile Testing Institute (TZU) (CZ); Politechnika Lodzka Katedra (PL); International Committee of Textile Care (CINET) (NL); Herbert Kannegiesser GmbH (D); Unitechnika S.A. (PL); Christeyns (GB).
  http://www.laundry-sustainability.eu/en/
- Expertly guided on-site visits at

  Miele (Germany), Kannegiesser (Germany); Electrolux Professional (Sweden); Central laundry of the University Medical Centre Freiburg (Germany), laundrettes
- Personal information by
  - CENELEC/TC59X, SWG 1.12
  - Danish Technological Institute DTI
  - Electrolux Professional
  - Girbau
  - Miele Professional
  - Primus
  - Schulthess
  - VDMA
    - Kannegiesser,
    - Jensen,
    - Veith
    - SEIBT&Kapp
  - Xeros Ltd.

7 Annex

7.1 Questions to the stakeholders for Task 1

Existing legislation

- Which existing legislation at EU-Member States-Level is being used / observed for professional washing machines and dryers? (please specify between EU Member States)
- Which existing legislation in "third countries" (USA, Australia, Asia etc.) is being used / observed for professional washing machines and dryers? (please specify between States)

General questions regarding ISO 9398

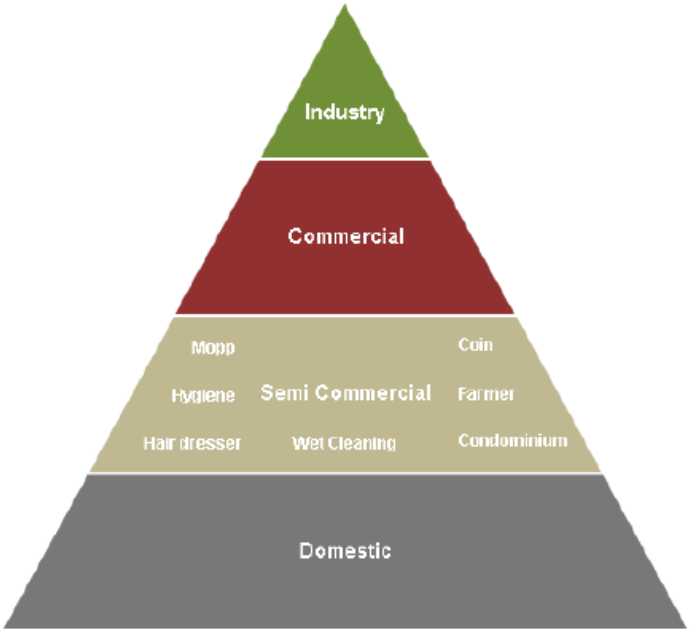
- Are you using those ISO 9398 for measurements?
- For what purpose are the results of the measurements according to the standard used? (i.e. advertising, engineering etc.)?
- Why is there no standard for washing machines (without extraction)? See ISO 10472: washing machines and washer-extractors are combined.

General questions regarding ISO 10472

- What is the purpose of the standards? (i.e. in which context are the standards used?) Mainly development of new products or also advertising etc.?
- Is compliance to ISO 10472 mandatory?
- Are you contributing in the ISO committee TC 72/SC 5 "Industrial laundry and dry-cleaning machinery and accessories?

7.2 Stakeholder feedback to draft versions of Task 1

Please note that the feedback refers to prior versions of Task 1 report; thus the indicated numerations of chapters, tables, figures or pages might have changed.

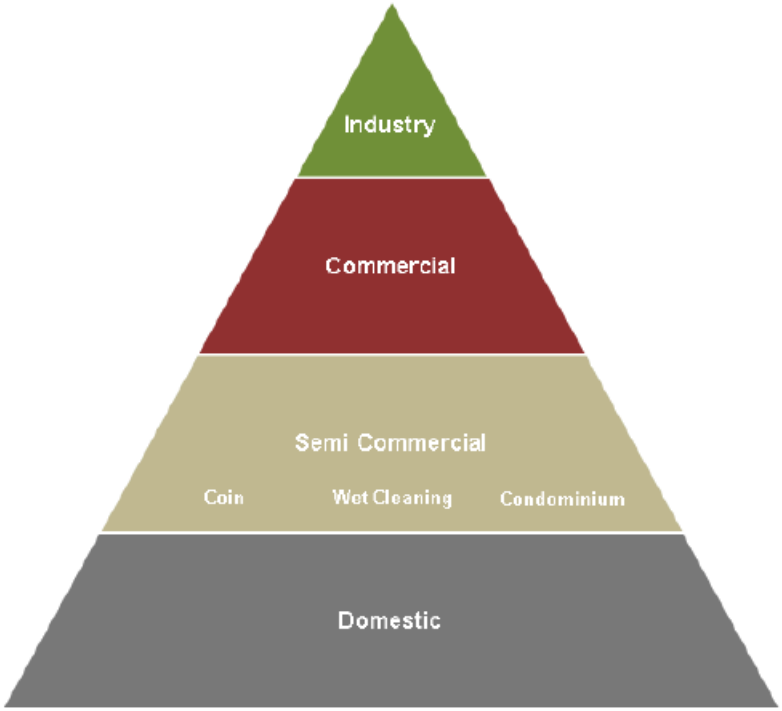
Feedback		Comment
Miele Professional		
	The difference between the Professional products, semi-commercial products, commercial products plus industrial products is not clarified as it should be. This should be done before the different topics are getting discussed and sorted out. We suggest a differentiation like in following pictures: **WASHER** 	Noted

Life cylce	Wash time 60°C CW	Heating device	Capacity	Drum volume	Filling ratio	Electrical connection	G-Force	Spinn speed	Standards/ Norm
30.000 h	~ 45 - 60 min.	Steam Gas	> 40 kg	> 400 l	1:12 1:10	3 phase 380 V	300 - 500	400 - 1000	DIN ISO 9398-4 ROHS Machinery Guideline (2006/42/EG)
30.000 h	~ 45 - 60 min.	Steam Gas EL	8-40 kg	80 - 400 l	1:10 1:9	3 phase 380 V -* 1 phase 230 V 25+ Amps	80 - 540	400 - 1200	DIN ISO 9398-4 ROHS Machinery Guideline (2006/42/EG)
20-25.000 h	~ 45 - 60 min.	EL	5-8 kg	50 - 80 l	1:10 1:9	3 phase 380 V -* 1 phase 230 V 20+ Amps	200 - 540	600 - 1200	DIN ISO 9398-4 ROHS Machinery Guideline (2006/42/EG)
~ 7.500 h	~ 90 - 120 min.	EL	4,5-10 kg	45 - 100 l	1:9 1:7	1 phase 220 V 10 Amps		800 - 1600	ROHS

* OFF Shore > 440V

Feedback		Comment

Dryer



Life cylce	Drying time	Heating device	Capacity	Drum volume	Filling ratio	Electrical connection	Heater Rating	Dryer principle
30.000 cycles	~20 min	Steam Gas	> 40 kg	> 800 l	1:12 to 1:10	3 phase 380 V	Vented	Vented
30.000 cycles	~20 - 30 min	Steam Gas EL H-P	8-40 kg	200 - 800 l	1:10 to 1:9	3 phase 380 V - 1 phase 230 V 25+ Amps	Vented	Vented
20-25.000 cycles	~30 - 40 min	EL GAS H-P	5-8 kg	110 - 190 l	1:10 to 1:9	3 phase 380 V - 1 phase 230 V 20+ Amps	Vented Condens	Vented Condens
~7.500 cycles	~60 - 90 min	EL H-P	4,5-10 kg	100 - 140 l	1:9 to 1:7	1 phase 220 V 10 Amps	Vented	Vented

Because of the missing clarification in between the report, the product groups are getting mixed up and in the discussion can be some difficult to understand what product group is now relevant, (see page 9, 10, 11, 14 etc.).

In Task 1 of Lot 24 is also mentioned that lot16 had included commercial/industrial dryers. This should be clarified related to the picture above.

Feedback		Comment
	For a common understanding a glossary would be very helpful (e.g. batch drying tumblers, batch dryers, drying tumblers, wash extractors, batch washers...). In table 2 on page 10 we see a major difference to the product definition in the market. Under the headline commercial dryers is also mentioned a washer extractor. From our point of few this washer extractor has nothing to do with commercial dryers. On page 14 in the box is mentioned in the last line ...be used for non-professional purposes > the professional washing machine is designed for professional purposes! On page 32 in table 10 is a differentiation regarding the spin speeds. In the market different manufacturers have defined different parameters (rpm) for those different spin levels. It would be better to show them all or even better to define the average. The table shows only the values of one manufacturer. Generally we agree on chapter 4.1, except that industrial appliances should be excluded too (based on the definition). In chapter 4.2 we agree basically on the products, except re the continuous tunnel washing machines and washing tunnel lines. We also would exclude direct continuous dryers.	
VDMA - Garment and Leather Technology, 10 May 2010		
10. Mai 2010 VDMA – Bekleidungs- und Ledertechnik	Maschinen unter der Rubrik „Professional washing machines“ und „Professional dryers“ fallen in den Bereich der industriellen Anwendung und sollten aus dem Lot 24 herausgenommen werden. Begründung: Der Einsatz der Maschinen im industriellen Bereich, ist durch ein sehr breites Anwendungsspektrum und sehr unterschiedlicher Verfahrenstechnik gekennzeichnet. Außerdem sind viele Maschinen individuell auf Kundenwunsch zugeschnitten. Eine einheitliche Festlegung bzw. Vorgabe von Grenzwerten beim Verbrauch, ist daher aus Sicht der Verfasser, nicht möglich. Die Verbrauchswerte ergeben sich im Schwerpunkt, durch sehr unterschiedliche Verfahrenstechniken, für die einzelnen Produktgruppen. Teilweise unterliegen insbesondere Waschverfahren zusätzlich länderspezifischen Vorschriften wie Hygienevorschriften etc. Beispiele Artikelsortiment: • Hospitalwäsche • Hotelwäsche • Berufsbekleidung • Altenheim Oberbekleidung • Reinigungsartikel (Wischbezüge, Schmutzmatten) • usw. Daraus resultierende Einflüsse auf die differenzierten Behandlungsverfahren:	Noted and added to the relevant section in the report.

Feedback		Comment
	• Waschtemperaturen (40–90°C) • Behandlungszeiten • Waschmechanik • Wassereinsatz • Chemieeinsatz • Trockentemperaturen und -zeiten Geräte und Anlagen zum Finishen von Kleidung werden, ebenso wenig wie Bügeleisen, nicht zum Zweck des Trocknens eingesetzt. Hauptzweck ist das Glätten und Entspannen des Textils, einschließlich gewünschter Veränderung der Struktur an der Oberfläche. Hierbei kann, je nach zu behandelndem Textil, eine gewisse Befeuchtung (mit Dampf) sinnvoll sein, ist aber nicht generell nötig. Allein die zu behandelnden Produkte sind extrem vielfältig und reichen von BHs, Poloshirts, Pullovern, Business-Hemden und Anzügen über Kfz-Türverkleidungen bis hin zu kompletten Autositzen. Dazu wird teilweise Dampf benötigt, aber nicht generell. Meist wird die Feuchtigkeit während des Finishprozesses ausgetragen, aber nicht grundsätzlich. Insbesondere bei Nutzung von industriellen Tunnelfinishern ist häufig sogar der Erhalt einer Restfeuchte gewünscht, um das Ende des Finishvorganges auf einen Zeitpunkt nach der Endmontage des zuvor gefinishten Bauteils zu legen. Das Trocknen von Produkten ist also keinesfalls die Hauptaufgabe von Finishern, somit ist die Zuordnung von Finishern in die Gerätekategorie "Trockner" nicht nachvollziehbar. Generell werden professionell genutzte Geräte, ähnlich wie Geräte aus dem Haushaltsbereich, in Serienfertigung, zumindest in Kleinserienfertigung, hergestellt. Ein großes Angebot vergleichbarer Geräte durch eine große Anzahl von Herstellern bedingt meist eine rationelle Serienbauweise von mehr oder weniger standardisierten Geräten. Dagegen werden industriell genutzte Geräte bzw. Anlagen in Einzelanfertigung, in vielen Details eingehend auf die speziellen Bedürfnisse der Kunden, hergestellt. Wir sprechen hier von Maschinen- und Anlagenbau. Dabei wird jede Anlage individuell nach teils sehr spezifischen Vorgaben der Kunden konzipiert und gebaut. Natürlich wiederholen sind die Grundfunktionen meist, die Gewichtung der verschiedenen Teilfunktionen ist aber immer wieder unterschiedlich. Aus diesem Grund ist die Definition eines zu testenden Standards unserer Meinung nach nicht sinnvoll, da es keinen repräsentativen Standard gibt. Diese Vielfalt der beschriebenen Einflussfaktoren und deren Kombinationsmöglichkeiten, haben zu der bereits erwähnten Schlussfolgerung geführt, dass allgemein gültige und verbindliche Grenzwerte für Maschinen- und Anlagen im industriellen Einsatz nicht festgelegt werden können.	
Electrolux Laundry Systems, 20. July 2010		
	LOT 24 Task 1, Comments from Electrolux Laundry Systems Definitions For instance:	Noted and Added to the relevant sec-

Feedback		Comment
	▪ Professional Washing Machines ▪ Professional Dryers ▪ Commercial Appliances ▪ Professional Laundry ▪ Semi-Commercial / Semi-Professional ▪ Industrial Laundry Even though they are discussed a lot in the report, I miss clear definitions. I suggest that you use the word Professional only for Equipment and use the word Commercial only for different Markets (that professional equipment typically are sold to), se examples below. How to categorize I would like to underline that relevant market/customer categories should preferably be clearly defined here, for re-use in the following tasks. Capacity, such as max load weight or drum volume or similar, is not a relevant way of categorizing professional wash equipment. Different market areas have unique requirements that are fulfilled with help of tailored solutions, such as options, changeable programmes etc. Electrolux Laundry Systems normally mention the following markets that also could be used for categorizing: ▪ Commercial Laundries ▪ They require superior performing equipment with high throughput and minimal faults. ▪ Dry Cleaners ▪ LagoonTM is a wet cleaning process that also satisfies these unique customer needs, i.e delicate garments. ▪ Surface Cleaning ▪ Efficient floor cleaning calls for proper mop washer extractors with controlled rest moisture. ▪ Health Care ▪ In hospitals and similar health care establishments, there are very high hygiene demands. Cross-contamination must be avoided. ▪ Hotels ▪ Typically linen and towels in hotels are only slightly dirty. The guests shall feel the cleanliness of the linen and the towels. ▪ Minimum of wear is essential. ▪ Restaurants ▪ In professional kitchens with greasily laundry you have high hygiene demands. ▪ Self-Service Laundries	tion in the report.

Feedback		Comment
	▪ Such as Apartment House Laundries, Launderettes (coin operated), ▪ Camping Laundries (coin operated) and Leisure/Sports Laundries, where the users are not the same as the owners and therefore safety and easy to use are the most important issues. ▪ Work wear ▪ Tailored solutions developed to guarantee the functions of specific types of work clothing, rather it be the extreme safety requirements ▪ in a fireman's heat suit, or "only" the need to look crisp and neat in a uniform. The professional wash equipment are requested to have ▪ High capacity, meaning; ▪ Clean laundry kg/hour & footprint with - good enough clearness - minimum wear and tear ▪ Reliability, meaning: ▪ Long lifetime and minimum of maintenance - 10-15 years and 30 000 cycles ▪ Cost effective, meaning: ▪ Quick processes (typical wash cycle 30 minutes) ▪ Low energy consumption (thanks to quick process) ▪ Low water consumption ▪ Low detergent consumption ▪ Low maintenance cost ▪ Programmable machines ▪ Very much in cooperation with detergent suppliers. Chapter 1.3 Delimitation of professional washing machines and dryers Already here the scope becomes unclear if not the above mentioned definitions are made. Table 2, second column, page 10 Is 'Washer extractors' really a Commercial Dryer? Second paragraph (framed) page 14 1. Also add a definition of dryers 2. Last line. Replace 'non-professional purpose' with 'professional purpose'	

Feedback		Comment
	Chapter 2 Test standards on Professional washing machines and dryers WRAS missing The following WRAS std could also be worth mention due to very high local demands in England to follow it. BS 6920-2.1:2000+A3:2008 Suitability of non-metallic products for use in contact with water intended for human consumption with regards to their effect on the quality of the water. Chapter 3.1 European Directives Gas Directive missing Gas Directive 90/396/EEC is valid for gas heated tumble dryers and combined gas-heated washer-dryers and must be fulfilled	
JRC IPTS		
Draft Revised Task 1 Professional Washing Machines and Dryers Report	The Revised Draft Task 1 report makes a better impression than its first version. Previous comments of ours have been taken into account and additional information has been supplied. Nevertheless, important issues on the scope of the study need further elaboration. Especially we would like to draw the attention to the exclusion from the scope of the Professional dry-cleaning machines. This does not seem to be well justified at this stage. In particular, we would like to draw attention to the following: In the revised Task 1: 1. There is still no definition for professional dryers. 2. The scope is restricted to professional laundry processes. This restriction needs to be substantiated. 3. Professional dry-cleaning is excluded from the scope of this study. This does not seem to be well justified at this stage. On the contrary we consider that there are reasons for including dry-cleaning products in the scope of the study (please see below in section specific comments).	Noted and added in Section 1.5

Letters from VDMA

VDMA

Garment and Leather
Technology Association

Extended VDMA comment on Preparatory Studies for Eco-Design Requirements of Energy-using Products
Lot 24: Professional washing machines, dryers and dishwashers (Tender No. TREN/D3/91-2007)
Draft Version Task 1 Report, washing machines and dryers

An in-depth discussion among the representatives of the companies Jensen, Veit, Seibt + Kapp and Kannegiesser present at the VDMA meeting on 16th June 2010 in Frankfurt/Main led to the conclusion that the field of application of machines falling within the category of "Professional washing machines" and "Professional dryers" is in the industrial sector and that, thus, these machines should be excluded from Lot 24.

Reason:
The use of the machines in the industrial sector is characterized by a very broad application spectrum and very diverse techniques. Furthermore, many machines are customized to meet the individual customers' needs.

A **significant** characteristic of the "industrial" machines is the fact that the **process parameters** in the treatment process can be **freely chosen and set** by the user. Since the process parameters have considerable causal influence on the (energy) consumption of a machine, it is the opinion of the authors that no consistent specifications or requirements regarding any limit values are possible.

The consumption values result mainly from the techniques which vary considerably from product group to product group. Additionally, it is particularly the washing procedures which are partly subject to country-specific regulations such as hygiene regulations.

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Examples of the range of articles:

- hospital laundry
- hotel laundry
- professional clothing
- outerwear for nursing homes
- cleaning articles (mop covers, dirt mats)
- etc.

Resulting influences on the different treatment procedures:

- washing temperatures (40–90) °C
- treatment durations
- washing mechanics
- water consumption
- chemicals consumption
- drying temperatures and durations

This variety of the described influential factors and their possible combinations have led to the conclusion, already mentioned above, that it is not possible to specify universally applicable and mandatory limit values for machines and plants for industrial use.

In the following you will find an overview regarding the distinction between household use, on the one hand, and industrial use, on the other hand, as well as a comparison between the main distinctive features which have an influence on the validability of the measurement quantities. You will also find examples for dependencies of parameterizations within the framework of an industrial treatment process.

1. Comparison: Household/Trade — Industry/Professional

	Household/Trade	Industry/Professional
Field of application	machines used in private households or household-oriented fields	machines used in industry or industry-oriented fields
Fields	private household; coin-operated laundries;	commercial laundries; industrial laundries;

- 2 -

	restaurants and diners/snack bars; pensions and small hotel businesses	larger hotel businesses
Laundry load	< 4 tons/week	> 4 tons/week

2. Distinctive features

	Household/Trade	Industry/Professional
Influentiability of consumption	consumption is defined by a hard-coded parameterization of the treatment programmes	consumption is defined by the freely parameterizable treatment programmes
Free parameterization (set) of the treatment programmes	not possible; limited selection, e.g., temperature and programme	possible settings: • time • type of treatment and process sequence • temperature • amount of water (litres/kg) • detergent dosage • dosing of different finishing chemicals for different programme steps • treatment duration • residual moisture
Supply of media (e.g. steam)	individual machine	centralized supply of media (e.g. centralized steam generator)
Treatment process	usually completed following the end of the process inside the machine (e.g. complete drying = subsequent manual folding)	usually part of a continuous treatment process (e.g. complete drying = subsequent mechanical folding, sorting, packaging)
Requirements for operation	no special requirements; can be operated by laypersons	can only be operated by people with special training and additional schooling by manufacturers and detergent engineers
Number of items on the market/year	> 200 000	< 10 000

3. Examples for the process-related dependencies in the industrial/professional sector

a) Finishing process in the tunnel finisher as a function of the washing and dewatering process

Process chain: Treatment of articles made of blended fabrics

	Washing process	Dewatering	Finishing process
Influential factors	• no cool-down process • warm rinsing	• high pressing power • warm dewatering	in order to meet the demands for quality, considerably more sprayed steam is required to remove the intense creases in the fabric
Result	+ reduced water consumption	+ high dewatering performance + little residual moisture – intense creasing	– high energy consumption due to higher steam consumption

Summary: Negative example for increased energy consumption within one process chain despite reductions having been obtained with individual machines.

b) Finishing process in the ironer line as a function of the drying process

Process chain: Treatment of flatwork, cotton fabric

	Washing process	Dewatering	Ironing process
Influential factors	• no cool-down process • warm rinsing	• high pressing power • warm dewatering	• low amount of water to be evaporated • high throughput speed
Result	+ reduced water consumption	+ high dewatering performance + little residual moisture	+ lower energy consumption because of lower amount of water to be evaporated from the fabric + high ironing performance + no quality loss

Summary: Positive example for lower energy consumption over the whole process chain due to improved dewatering.

Munich, 25th June 2010

VDMA

Garment and Leather
Technology Association

VDMA comment on Preparatory Studies for Eco-Design Requirements of Energy-using Products
Lot 24: Professional washing machines, dryers and dishwashers (Tender No. TREN/D3/91-2007)

According to our opinion, the industrial sector should be excluded from implementation measure Lot 24.
In our view, the industrial sector includes the following product groups stated in the Öko-Institut's study report as of January 2011:

- professional washer extractors (WM 3 and WM 4) whose capacity exceeds 25 kg
- professional air tumble dryers (D 6) whose capacity exceeds 25 kg
- washing tunnel machines (WM 7)
- pass-through (transfer) tumble dryers (D 7)
- professional barrier washers (WM 6)

As far as the professional washer extractors (WM 3 and WM 4) and the professional air tumble dryers (D 6) are concerned, we think that the study performer has drawn an artificial line which does not represent reality. So far, the Öko-Institut has not provided any justification either as to why this 40 kg limit has been chosen.

We think that, in order to represent reality, the line should be drawn at 25 kg. Practical experience gained by the users themselves has shown that this a logical limit value. Machines with nominal loads exceeding 25 kg are primarily used in industrial laundries since here large amounts of laundry are treated. Furthermore, the general number of these larger machines is low and lies far below the guideline value given in the Eco-Design Directive.

An industrial washing range is usually composed of a washing tunnel (WM 7) or a professional barrier washer (WM 6), respectively, and the pass-through (transfer) tumble dryer (D 7) and is used exclusively in the industrial sector. We believe that these products should be excluded from Lot 24 as industrial washing ranges are:

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- used exclusively in the industrial sector;
- constructed in an order-related way and according to the customers' requirements, resulting in the fact that each machine or plant, respectively, has its unique characteristics. Thus, no standard limit values regarding the consumption can be specified since the consumption-related values result mainly from the process technologies, washing procedures, country-specific regulations and hygiene-related provisions which all exhibit considerable variations;
- sold in low annual numbers which lie considerably below the guideline value given in the Eco-Design Directive.

There are further reasons speaking in favour of completely excluding the industrial sector from implementation measure Lot 24:

- According to Mr. Almstrom of CENELEC is also of the opinion that the industrial sector should be excluded from implementation measure Lot 24.
- In the sector of industrial laundry machines and plants, far less than 10 000 units are produced per year. Thus, the annual production of these machines and plants is far below the guideline value of 200,000 units per year given in the Eco-Design Directive (see Directive 2009/125/EC, Article 15 (2 a)).
- As a result of the order-related construction of industrial laundry machines and plants we do not see a basis for developing homogenous and relevant test methods which could be used to specify standardized values.
- In general it has to be said that, as far as highly automated industrial laundries are concerned, the energy savings potential needs absolutely to be taken into consideration in order to be able to meet today's and tomorrow's high market demands. For this reason, there is an inevitable demand for machines which are ever more energy and environmentally efficient. In order to be able to achieve positive saving results, however, these machines have always to be considered within the overall context of the treatment process rather than on an individual basis (see extended VDMA comment of 25th June 2010).

We do not see any benefits in standardized provisions — combined with labelling — with regard to environmental and energy efficiency.

7th February 2011

Reflections and concerns of CENELEC/TC59X/SWG 1.12 regarding the outcome of performance standards for commercial laundry machines, from 2010-11-11

Introduction

CENELEC TC 59X "Performance of household and similar electrical appliances" is the body responsible for providing harmonized standards in support of European legislation. TC59X settled a Sub Working Group 1:12 (CLC/TC59X/SWG1.12) with the scope to develop Performance standards for laundry machines for commercial use. Since this SWG was created in 2009 it already has started the development of such standards.

Target

The standards under development shall be developed in such a way that they will be the harmonized standards for performance tests for commercial laundry machines if regulations based on recommendations within the Lot 24 work and measures taken by the Commission will come to force.

Reflections and concerns

After the initial meetings held within the SWG 1.12 we want to communicate to the Commission and to the Lot 24 consultant the reflections made during these SWG meetings being held to date. SWG1.12 is confident that it can develop performance standards for commercial washing machines and commercial tumble dryers based on current and coming versions of household standards EN60456 and EN 61121. It is evident that the content from EN 60456 and EN 61121 must be revised and in some cases totally changed in order to fulfill the demand for the new commercial standards.

Limitations of the standards

SWG1.12 also realize that it is not possible to create performance standards for washing machines and tumble dryers within the commercial area covering all kind of technical solutions, sizes or heating alternatives. SWG 1.12 can foresee that following equipment and variants can not be covered by the developed standards:

- Continuous batch washers and transfer dryers due to their size and completely different design.
- Equipment that is imbedded in larger production lines and where the total energy efficiency shall be measured and not the single components
- Gas heated washing machines and heat fluid heated washing machines due to the low number of machines produced.
- Washing machines and tumble dryers intended for use in applications where other requirements than energy have a priority. Such applications include:

  - Hygienic processes where disinfection/sanitation levels must be achieved such as hospital processes and mop cleaning processes.
  - Processes including safety issues as cleaning of fireman dresses.
  - Technical processes where special features are essential like clean room washing machines and dryers.
- It is also doubtful if performance standards for steam heated washing machines and gas and steam heated tumble dryers can be developed as test methods including steam and gas do not exist in present performance standards. The development of such test methods will take considerable time and a reliable time frame for such standards can not be given. Furthermore to our knowledge no independent laboratory and no test laboratory at any manufacturer can perform such tests within the controlled conditions needed for such a standard. Installing the measurement instruments needed in the laboratories will create investments not justified in relation to the number of such washing/drying equipment being produced.

Customized energy saving solutions

In the commercial sector there also exist many energy saving solutions that are a mix of single laundry equipment and central customized saving solutions. Often these solutions are more energy efficient than the single equipment of best technology. One example: In a launderette (coin store) a number of tumble dryers can be connected to a central heat recovery unit or there can be heat recovery units on each dryer. A central unit can be more energy efficient. If as a result of the Lot 24 studies a measure will be implemented giving a penalty or a score regarding the energy efficiency of the dryers, the units connected to the central unit must not have such a penalty compared with the dryers with internal recovery systems even if they as single units are less energy efficient.

Uncertainty

SWG1.12 must clearly state that data generated from any performance standard will include an uncertainty interval that can not be ignored.

Standard EN 60456 has reduced the allowable tolerances as far as it is possible within practical limits but still the uncertainty of the result is as wide as or wider than one performance class. In the new commercial standards the equipment under test will have a greater variety in design and/or a wider size span and will also generate data with an uncertainty. The test conditions in the commercial standards can not be more stringent than in EN 60456 or EN 61121 and will more likely need to have larger test tolerances for some parameters. This will generate uncertainty levels as high as or higher than the existing performance standards.

If the LOT 24 recommends and the Commission implements measures including performance the uncertainty levels must be taken into consideration.

7.3 Further laundry appliances being out of scope from Lot 24

The following laundry appliances have been excluded from the scope of Lot 24 (cf. Section 5). For completeness, however, they are shortly described in the following sections.

7.3.1 Dry-Cleaning – description of the process and equipment

The contractors of EuP Lot 24 – Professional washing machines, dryers and dishwashers (TREN/D3/91-2007-Lot 24-SI2.521728) Öko-Institut e.V. and Bio Intelligence Service were asked by the European Commission (DG TREN) to present a short working paper on dry-cleaning machines in order to help decide whether these machines can be excluded from the scope of this Lot. In this section, the process and equipment of dry-cleaning are described; a detailed market analysis for dry-cleaning machinery is annexed to Task 2 report. The conclusions with regard to the scope are listed in Section 2.2.2.

In the draft Commission Regulation with regard to eco-design requirements for household washing machines,[91] such machines are defined as a "machine which cleans and rinses textiles using water […]". This means that washing machines remove stains from laundry with water, detergents, thermal and mechanical energy.

Water can be chemically classified as a polar solvent. In contrast, dry-cleaning uses non-aqueous non-polar, mostly organic solvents like perchlorethylene (perchlor), hydrocarbon, cyclosiloxane, or CO_2 instead of water.

The most important reason for dry-cleaning instead of washing textiles is that some materials, especially wool, are very sensitive to water; their fibres swell and get deformed by water in combination with heat (felting or shrinkage). Dry-cleaning provides shape permanence: Folds and pleats are not damaged; flatwork like linen or tablecloth keeps its stiffness. Furthermore, the risk of discolouration is normally negligible. Another reason for using different processes is that wet- and dry-cleaning each remove different types of stains. While dry-cleaning is better for removing grease, ink, oil, or paint, water-based stains are best removed in a washing process.

Dry-cleaning typically works as follows:[92]

- Workers in dry-cleaning facilities usually treat spots by hand before placing garments in the machines.
- Liquid solvents, detergents, and sometimes a small amount of water are added to the machines.

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91 http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Working_Documents/Lot_14/v2_WM-Ecodesign_Regulation_02-03-10.doc

92 http://www.epa.gov/dfe/pubs/garment/ctsa/factsheet/ctsafaq.htm#2

- The machines then agitate clothes in a manner similar to a washing machine to remove dirt, oil and stains.
- Once clean, the clothes are dried either in the same machine or transferred manually to a separate dryer, then pressed and shaped.
- Used solvent is distilled so it can be purified. Distillation separates the solvent from waste residues such as detergents, dye, dirt and oil, so the solvent can be reused. In addition to distillation, most machines also use filters to clean the used solvent.
- After the purification process, filters which contain the solvent in very small amounts and certain solvent residues must be managed and disposed of as hazardous waste. They have to be sent to special facilities for recycling or incineration.

The dry-cleaning process described above demonstrates that – besides the different cleaning agent (water versus non-aqueous non-polar solvents) – there are also significant differences in the machine technology in comparison to wet-cleaning.

Generally, there are two basic types of dry cleaning machines: transfer and dry-to-dry.

Transfer machines accomplish washing and drying in separate machines. The laundry is transferred by a worker from the washer/extractor unit to the dryer unit. Dry-to-dry machines are single units that wash, extract and dry the articles in the same cylinder in a single machine. The articles enter and exit the machine dry.

The following two figures describe the simplified process flows for a transfer- and a dry-to-dry machine in order to show some of the major equipment components.[93]

[93] Source: US EPA (Ed.): Cleaner Technologies Substitutes Assessment: Professional Fabricare Processes. EPA 744-B-98-001. Washington, 1998, p.5

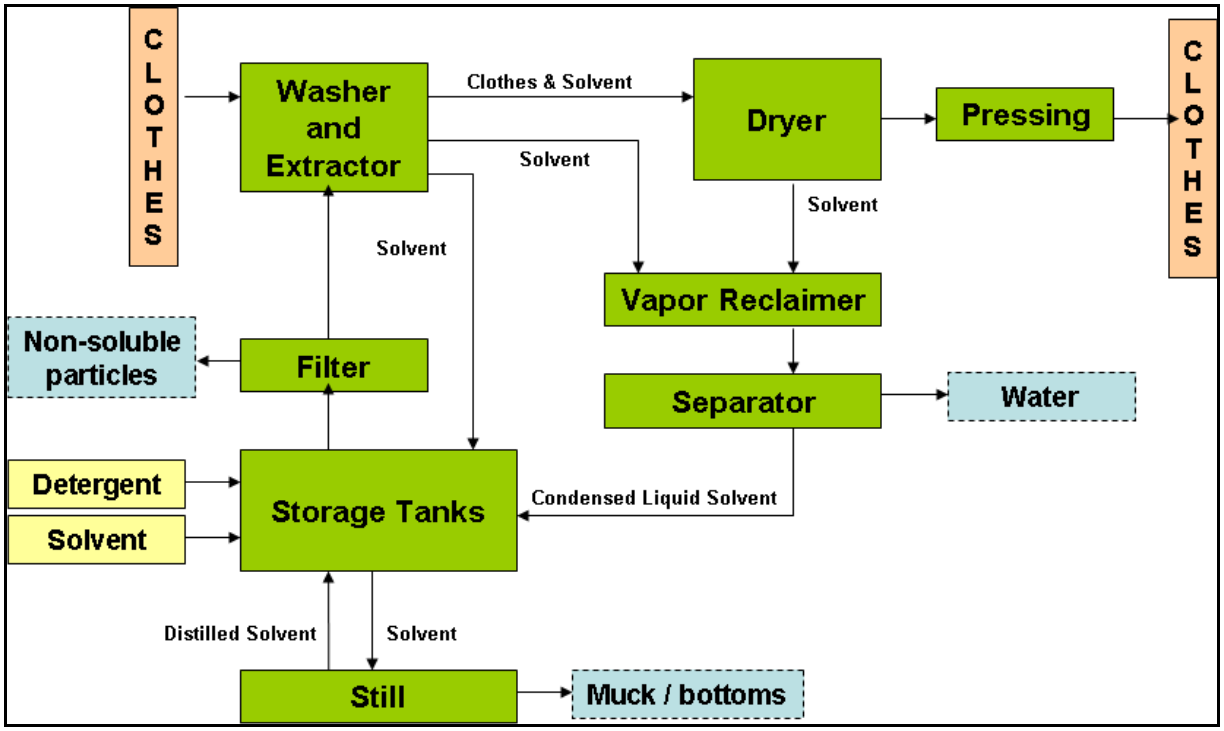


Figure 2 Simplified Process Flow Diagram for Transfer Machinery

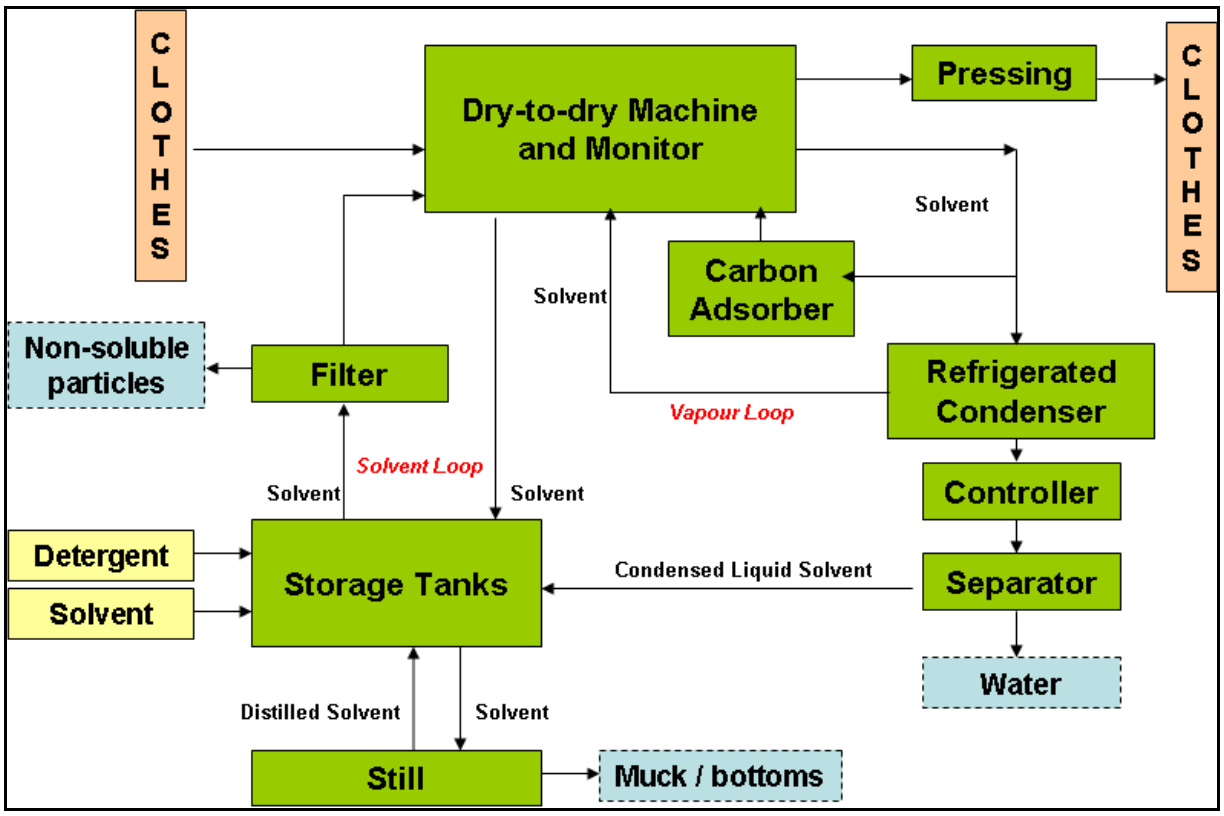


Figure 3 Simplified Process Flow Diagram for Dry-to-dry Machinery

In contrast to washing machines, dry-cleaning machines operate with a completely closed circuit regarding the solvent. Furthermore, the following equipment components considerably differentiate dry-cleaning machines from washing machines:

- Storage tanks for the solvent.
- Vacuum distillation unit ('still'): Most dry-cleaners use distillation to keep the solvent clean enough to avoid odours and the darkening of articles. Without distillation, oils, soils, dyes, detergents and other solvent-soluble impurities would build up in the solvent.
- Different kinds of filters: Filtration of non-soluble particles out of the solvent while in use. Some sorts of filters can be regenerated after each load of clothes; other filters have to be removed from the facility after usage as hazardous waste.
- Carbon adsorber / refrigerated condenser / separator: The carbon adsorber adsorbs the solvent from the aeration stream. Once it reaches its adsorbing capacity, the solvent is usually removed (desorbed) from the adsorber by passing steam through the device. Steam containing solvent exits from the adsorber and is routed to a condenser, which liquefies the solvent and water vapours. The liquid solvent and water mixture from the condenser is routed to the water separator. The solvent is recovered and recycled back through the machine.

Finally, in comparison to washing machines different legislation applies to dry-cleaning machines: The European Solvent Emissions Directive 1999/13/EC regulates emissions of volatile organic compounds (VOCs) due to the use of organic solvents in certain activities and installations. Dry cleaning falls within the scope of the Directive, i.e. any industrial or commercial activity using VOCs in an installation to clean garments, furnishing and similar consumer goods with the exception of the manual removal of stains and spots in the textile and clothing industry.

7.3.2 Dryers with direct heat transfer (drying as secondary function)

7.3.2.1 Finisher

Steam air finisher

Garments like shirts, trousers, jackets, coats etc. have to be de-wrinkled and re-shaped. This process is called conditioning and is performed with different types of steam air finishers. Variants:

- Form finisher / multi finisher: The machine supports the garment by the shoulders, and pulls it over a nylon bag (a human dummy figure made of a material designed to retain heated air). The clamped hem is "tensioned" by mechanical devices. At the same time, vertical tension is applied to the fabric. By this process of both hem and vertical ten-

sioning, the garments regain their original dimension and appearance. Finally, very hot air inflates the bag which presses the garment from the inside and dries it at the same time.

- Shirt Finisher: Shirt finishing equipment is designed especially for laundries with a high turnover of shirts. The machines can either be electric or steam-heated. In principle, the functionality is comparable to that of a form finisher.
- Trouser finisher: This machine expands the waistband and clamps the hems of the garment. Steam is injected to soften the fabric. Then, very hot air inflates the garment which gives it a pressed appearance while also drying the fabric, only leaving creases to be pressed.
- Rotor cabinet: Rotor or rotary finishing cabinets provide the combined possibility to condition jackets *and* trousers. They are fitted with a rotary door. On the one side is a "shoulder device", along with a bag that works in the same way as the form finisher's. On the other side of the door, a "trouser device" supports the waist of the trousers. Manual clamps are fitted to the hems, and treatment is much the same as for the trouser finisher.

Tunnel finisher

According to ISO 10472-4: Machine for the drying and finishing of shaped garments within which damp garments arranged on hangers are loaded onto an overhead conveyor for transport through the machine in an atmosphere of high humidity followed by an atmosphere of hot dry air produced by the tunnel finisher. A conveyor system transports the garments (e.g. blouses, shirts, dresses, coats, trousers etc.) through different chambers of the tunnel finisher. In the first modules, the materials are softened with a measured and well-directed amount of sprayed steam to remove tensions. In the next step, the garments are gently stretched. Influencing factors hereby are a combination of air and steam, as well as their temperature and speed passing along the goods from top to bottom. Final drying happens in the last module, as the air that is drawn in is largely unsaturated. It cools down the outgoing articles. At the same time, the incoming cool air is heated up by the heated garments. The last chamber therefore operates effectively like a heat exchanger.

7.3.3 Dryers with indirect heat transfer (drying as secondary function)

7.3.3.1 Flatwork ironers

According to ISO 10472-5: Machine for the ironing of flatwork. Flatwork is a textile article (e.g. a bed sheet) which can be satisfactorily dried and smoothed by being passed through a flatwork ironing machine.

Ironing in the professional context fulfils the same purpose as a domestic hand iron. The heat of heavy steam-heated rollers removes residual water (drying the fabric), and the pressure removes creases. Textiles that are ironed are mostly flat, and are therefore called flatwork. This applies to “wet work” items, such as bed sheets, pillow cases, serviettes, or tablecloths. Professional ironers can be designed with either through- or return-feed. Through-feeding means that the linen is fed into the ironer on one side, and out on the other. The return-feed model saves space as the linen is fed both into and out of the ironer on the same side. Further, multi-function machines combine feeding, ironing and folding in one unit.

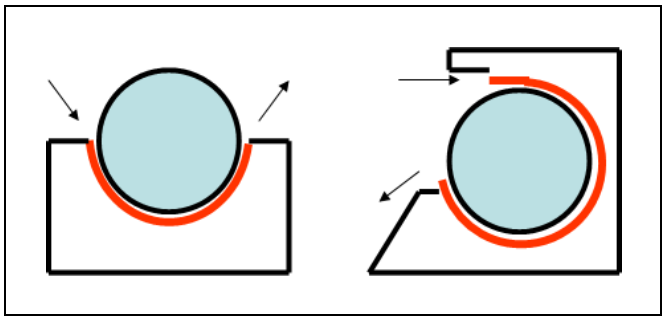


Figure 4 Functionality of a through-feed and a return-feed ironer

Types of flatwork ironers:

Bed ironers (chest ironers)

- Small bed ironers, also called chest ironers, are used in small installations and are generally designed with return-feed. The types of linen to be chest ironed are typically table clothes, serviettes, and pillowcases. The textiles are placed on a feeding table. By means of a rotating padded roll, the linen is moderately pressed against a heated fixed chest. The moisture in the linen is heated and turned into steam which “de-tensions” the fibres of the textile so that they are reshaped. The textiles are processed, and fed out to a collection table in front of the ironer. Small bed ironers can be operated manually by three or four operators who feed and fold the sheets by hand. In this case, the capacity achieved is 15-20 metres/min.
- Large bed ironers are suitable for laundries with high capacity requirements; they generally are of the through-fed type. This type of ironer is available with more than one roller, and the diameter of the roller varies. The capacity is increased by adding rollers, the efficiency by using special feeders, folders and stackers. The sheet is clamped to a feeding machine by one or more operators. The feeder automatically stretches and positions the sheet which is then fed through the rollers at quite a high speed. The capacity ranges up to 20-40 metres/min, depending on the size of the rollers and the degree of automation in the feeding and folding process. When the sheet has passed through, it is folded length- and crosswise. Finally, it is stacked in an automatic stacker unit.

Cylinder ironers

Cylinder ironers, also called roll heated flatwork ironers, are used to iron linen such as bed textiles and large tablecloths. The textiles are placed on a feeding belt. The continuously running belts feed the textiles into a heated rotating cylinder where the linen is ironed and dried. The finished textiles are fed out on a discharge belt behind the ironer or on a collection tray in the front.

7.3.3.2 Ironing and fusing presses

According to ISO 10472-6, the following definitions apply:

- *Ironing press*: Machine for the smoothing or shaping of fabric items by pressing them between two components, at least one of which is heated and, if required, equipped with a steaming device.
- *Fusing press*: Machine for the fusing of two textile layers by pressing them between two components, at least one of which is heated to a temperature such that the coating of one layer becomes adhesive.

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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

May 2011

Final Report,
Part: Washing Machines and Dryers

Task 2: Economic and Market Analysis

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For reasons of better readability, two Task 2 reports were prepared.

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

The Task 2 report on *professional dishwashers*
is published separately.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective of Task 2

The purpose of this task is to present the economic and market analysis related to professional washing machines and dryers. The aim is, firstly, to place this product group within the overall context of the European Union (EU) industrial and trade policy. Secondly, it provides market and cost inputs for the EU-wide environmental impacts of the product group. Thirdly, it aims to provide insights into the latest market trends. This will be an input for subsequent tasks such as improvement potential. Finally, practical data on consumer prices and rates is provided to be used later in the Life cycle Cost (LCC) calculations.

Note that the report at hand only covers professional laundry machines and dryers. The Task 2 report on professional dishwashers is published separately.

This document also includes a preliminary market analysis of dry-cleaning equipment, whose exclusion from the scope of the study was decided in Task 1 (see Annex, Section 7.1).

2 General economic data

2.1 Production

This section provides a brief description of the market situation of professional washing machines and dryers in the EU. The PRODCOM[1] database is useful for an initial analysis as it is transparent and publicly available data on manufacturing and production within the EU, as provided by Member States (MS). Of the PRODCOM categories presented in Task 1, only the following are included in the scope of the study and were analysed:

- **Code 28.94.22.30**: Household or laundry-type washing machines of a dry linen capacity > 10 kg (including machines that both wash and dry);
- **Code 28.94.22.70**: Drying machines, of a dry linen capacity > 10 kg.

The following PRODCOM product categories were not analysed in this section (cf. Task 1):

- **Code 28.94.21.30**: Ironing machines and presses, because fusing presses and dryers using indirect methods of heat transfer were proposed to be excluded from the scope in Task 1;
- **Code 28.94.21.50**: Washing, bleaching or dyeing machines (excluding household or laundry-type washing machines), because not relevant;

[1] PRODucts of the European COMmunity.

- **Code 28.94.21.70**: Machines for reeling, unreeling, folding, cutting or pinking textile fabrics, because not relevant;
- **Code 28.94.21.80**: Machines used in the manufacture of linoleum or other floor coverings for applying the paste to the base fabric or other support and machines for dressing, finishing, wringing, drying, coating or impregnating textile yarns, fabrics or made up textile articles, because not relevant.
- **Code 28.94.23.00**: Centrifugal clothes-dryers, because separate hydro-extractor or pressing appliances were excluded from the scope in Task 1.

2.1.1 Unit volume

In 2009, 31 871 washing machines and 26 127 dryers were produced in EU-27 according to PRODCOM figures for the Codes 28.94.22.30 and 28.94.22.70 (see above).[2] Table 1 and Table 2 show the number of units for 2005-2009, giving an indication of where large manufacturing centres of professional washing machines and dryers are located.

Table 1 Number of household or laundry-type washing machines of a dry linen capacity superior to 10 kg (including washer-dryers)[3] produced, 2005-2009

Member State	2005	2006	2007	2008	2009
Austria	0	0	0	0	0
Belgium	n.a.	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.	n.a.
Cyprus	0	0	0	0	0
Czech Republic	n.a.	n.a.	n.a.	0	0
Denmark	0	0	0	0	0
Estonia	0	0	0	0	0
Finland	42	47	0	0	0
France	n.a.	n.a.	n.a.	n.a.	1 480
Germany	3 060	2 943	3 221	3 388	3 264
Greece	n.a.	n.a.	n.a.	n.a.	n.a.
Hungary	n.a.	0	0	0	0
Ireland	0	0	0	0	0
Italy	1 803	2 066	n.a.	n.a.	n.a.
Latvia	0	0	0	0	0
Lithuania	25	14	0	0	0
Luxemburg	0	0	0	0	0
Malta	0	0	0	0	0

[2] Please note that these categories might also include large household washing machines or dryers > 10 kg.
[3] PRODCOM Code 28.94.22.30

Member State	2005	2006	2007	2008	2009
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	n.a.	n.a.	n.a.	185	112
Portugal	0	0	0	0	0
Romania	n.a.	n.a.	0	0	0
Slovakia	0	0	0	0	0
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.
Spain	6 029	7 822	9 843	9 841	6 128
Sweden	n.a.	n.a.	n.a.	n.a.	n.a.
UK	0	n.a.	n.a.	0	0
EU-27	**39 999**	**44 045**	**41 640**	**37 366**	**31 871**

The PRODCOM data suggests that Spain, Germany, Italy (figures available only in 2005 and 2006) and France are the largest centres of manufacturing of professional washing machines. While this is not an exhaustive or comprehensive analysis, it gives an overview of the professional laundry market and indicates in which Member States (MS) the analysis can be usefully pursued. As for MS for which data were confidential or missing, 20 887 units are unaccounted for in 2009, which is most of the total production (66%) and shows the limits of the PRODCOM database for the categories considered here: only 34% of total 2009 reported production in the EU is reported and non-confidential data. Stakeholders have commented that Sweden, Belgium and Czech Republic contribute a significant number of units to the market, and are thought to account for most of the unaccounted units but this information is not available in PRODCOM.

The available data shows that:

- Spain produced 19% of total EU units in 2009;
- Germany produced 10% of total EU units in 2009;
- Italy produced 5% of total EU units in 2006;
- France produced 5% of total EU units in 2009.

This can be contrasted with the value of these produced units, presented in Section 2.1.2.

Table 2 Number of drying machines of a dry linen capacity superior to 10 kg[4] produced, 2005-2009

Member State	2005	2006	2007	2008	2009
Austria	n.a.	n.a.	n.a.	n.a.	n.a.
Belgium	n.a.	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.	n.a.
Cyprus	0	0	0	0	0
Czech Republic	n.a.	n.a.	n.a.	n.a.	n.a.
Denmark	n.a.	n.a.	0	0	0
Estonia	0	0	0	0	0
Finland	93	106	3	0	0
France	n.a.	n.a.	n.a.	n.a.	n.a.
Germany	n.a.	2 747	2 864	n.a.	n.a.
Greece	n.a.	n.a.	n.a.	n.a.	n.a.
Hungary	0	0	0	0	0
Ireland	0	0	0	0	0
Italy	n.a.	n.a.	n.a.	n.a.	n.a.
Latvia	0	0	0	0	0
Lithuania	0	0	0	0	0
Luxemburg	0	0	0	0	0
Malta	0	0	0	0	0
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	n.a.	n.a.	n.a.	n.a.	42
Portugal	n.a.	n.a.	6	n.a.	n.a.
Romania	n.a.	n.a.	n.a.	n.a.	n.a.
Slovakia	n.a.	n.a.	n.a.	n.a.	n.a.
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.
Spain	1 128	1 954	1 915	1 984	2 120
Sweden	n.a.	n.a.	n.a.	n.a.	n.a.
UK	n.a.	n.a.	n.a.	n.a.	n.a.
EU-27	**36 923**	**44 799**	**30 000**	**29 055**	**26 127**

Concerning dryers, the PRODCOM data available is even scarcer. The total number of dryers produced is 26 127 units in 2009. Based on the information in Table 2, only 8.3% of total 2009 reported production in the EU is non-confidential reported data (15.9% in 2007). The available data shows that:

- Spain represents 8.1% of the units produced in the EU in 2009;
- Germany represents 9.6% of the units produced in the EU in 2007.

Of the MS where information is not available, Belgium, Italy and Sweden are expected to represent significant shares of total EU-27 production.

[4] PRODCOM Code 28.94.22.70

2.1.2 Sales value

Figure 1 shows the value of professional washing machines and dryers produced according to PRODCOM. The production value of professional washing machines and dryers produced in the EU amounted to **309 million Euros** in 2009 (compared to 468 million Euros in 2005), split into 201 million Euros for washing machines and 108 million Euros for dryers. The average annual decrease in sales over the period is 8.5%. This will be elaborated further in the market trend section (Section 4.1).

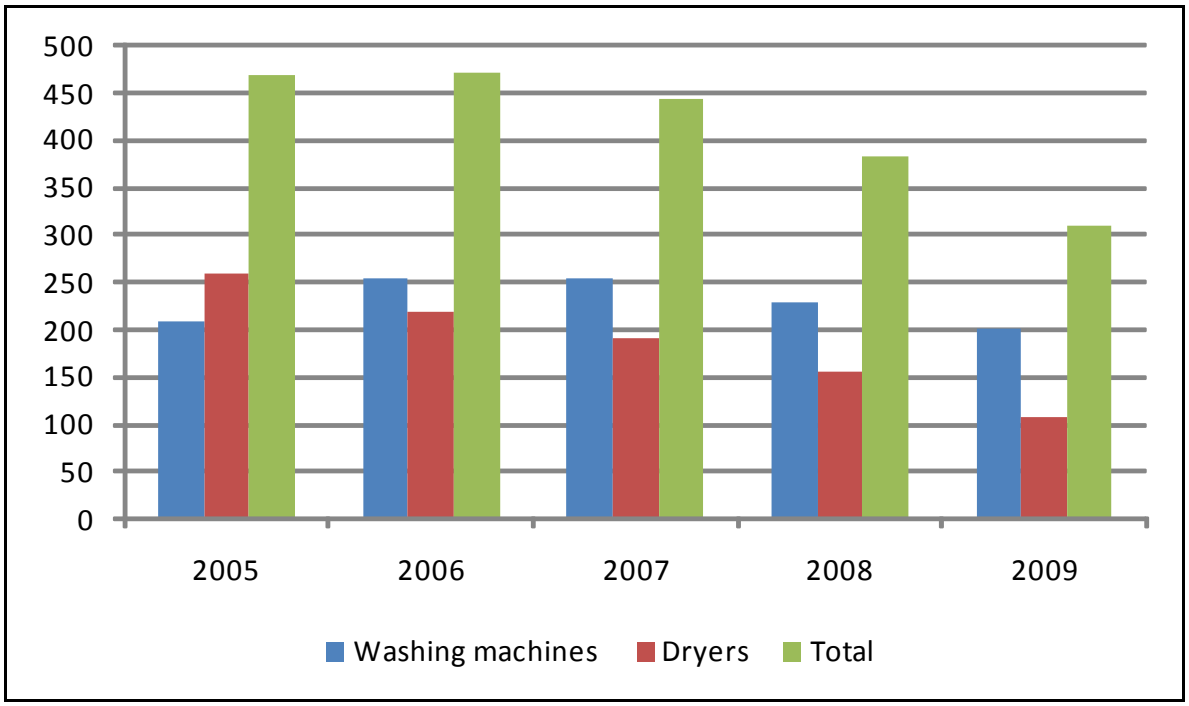


Figure 1 Value of professional washing machines and dryers produced in EU-27 (million Euros), 2005-2009[5]

MS sales data shows a key difference between the volume of units produced and the value of the sales for Germany and Spain. Table 3 shows that Germany has the highest production value of washing machines in the EU (40% of the total value), more than twice of Spain, which – shown in Table 1 – produces almost twice as many machines. This can be explained by the difference in unit values reported by PRODCOM (see Section 2.1.3). Germany and Spain have the largest market values for washing machines, with Italy (based on 2005 and 2006 data) and France playing smaller roles in manufacturing.

[5] PRODCOM statistics based on NACE 2 Rev. accessed at: http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database, 28 September 2010.

Table 3 Value of household or laundry-type washing machines of a dry linen capacity superior to 10 kg (including washer-dryers)[6] produced in EU-27 by Member State (in thousand Euros)[5]

Member State	2005	2006	2007	2008	2009
Austria	0	0	0	0	0
Belgium	n.a.	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.	n.a.
Cyprus	0	0	0	0	0
Czech Republic	n.a.	n.a.	n.a.	0	0
Denmark	0	0	0	0	0
Estonia	0	0	0	0	0
Finland	72.5	79.4	0	0	0
France	n.a.	n.a.	n.a.	n.a.	11 919.0
Germany	61 373.9	72 852.7	77 591.5	82 070.1	79 703.2
Greece	n.a.	n.a.	n.a.	n.a.	n.a.
Hungary	n.a.	0	0	0	0
Ireland	0	0	0	0	0
Italy	9 014.0	10 278.0	n.a.	n.a.	n.a.
Latvia	0	0	0	0	0
Lithuania	65.2	42.9	0	0	0
Luxemburg	0	0	0	0	0
Malta	0	0	0	0	0
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	n.a.	n.a.	n.a.	629.3	1 069.6
Portugal	0	0	0	0	0
Romania	n.a.	n.a.	0	0	0
Slovakia	0	0	0	0	0
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.
Spain	40 514.9	45 231.6	54 181.6	49 414.3	35 258.9
Sweden	n.a.	n.a.	n.a.	n.a.	n.a.
UK	0	n.a.	n.a.	0	0
EU-27	**209 238.8**	**253 181.3**	**253 479.7**	**229 295.4**	**201 016.9**

The German market is also the largest for professional dryers, with around 73% of the total value in 2008. Spain, with around 12% of the total value, plays a secondary role and data on the remainder of the market is not available. Again, the difference in shares between the sales numbers and the sales values can be explained by the difference in unit values reported by PRODCOM.

6 PRODCOM Code 28.94.22.30

Table 4 Value of drying machines of a dry linen capacity superior to 10 kg[7] produced in EU-27 by Member State (in thousand Euros)[8]

Member State	2005	2006	2007	2008	2009
Austria	n.a.	n.a.	n.a.	n.a.	n.a.
Belgium	n.a.	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.	n.a.
Cyprus	0	0	0	0	0
Czech Republic	n.a.	n.a.	n.a.	n.a.	n.a.
Denmark	n.a.	n.a.	0	0	0
Estonia	0	0	0	0	0
Finland	135.7	160.6	12.8	0	0
France	n.a.	n.a.	n.a.	n.a.	n.a.
Germany	196 696.7	143 673.5	135 394.4	113 412.2	n.a.
Greece	n.a.	n.a.	n.a.	n.a.	n.a.
Hungary	0	0	0	0	0
Ireland	0	0	0	0	0
Italy	n.a.	n.a.	n.a.	n.a.	n.a.
Latvia	0	0	0	0	0
Lithuania	0	0	0	0	0
Luxemburg	0	0	0	0	0
Malta	0	0	0	0	0
Netherlands	0	n.a.	n.a.	0	0
Poland	n.a.	n.a.	n.a.	n.a.	82.1
Portugal	n.a.	n.a.	372.6	n.a.	n.a.
Romania	n.a.	0	0	0	0
Slovakia	0	0	0	0	0
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.
Spain	5 569.3	10 830.3	8 803.9	10 315.9	12 638.7
Sweden	n.a.	n.a.	n.a.	n.a.	n.a.
UK	0	0	0	n.a.	n.a.
EU-27	**258 940.4**	**219 437.3**	**191 652.0**	**154 922.8**	**107 734.7**

2.1.3 Unit value

Professional washing machines and dryers have a unit value which is highly dependent on the specific MS market. Table 5 shows the range of unit values for non-domestic washing machines and dryers as reported by PRODCOM for MS where information is available.

[7] PRODCOM Code 28.94.22.70

[8] PRODCOM statistics based on NACE 2 Rev. accessed at: http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database, 28 September 2010.

Table 5 Average unit value of non-domestic washing machines and dryers by MS reporting, 2008[9]

Member State	Unit value of washing machines[10] (Euros)	Unit value of dryers[11] (Euros)
Germany	24 223	47 274[12]
Spain	5 021	4 498
Italy	4 974[13]	-
Lithuania	3 061[13]	-
Poland	3 401	-
Finland	1 689[13]	4 255[12]
EU-27	**6 136**	**5 286**

The average unit value of non-domestic washing machines in the EU-27 is **6 136 Euros** while that of dryers is **5 286 Euros**. Given the low number of MS with data available, these numbers should be considered with caution.

The unit values of washing machines and dryers are much more important in Germany than in the other MS (Spain, Italy, and Finland) where information is available, which explains the large differences between the production shares and the sales value shares. It can thus be assumed that Germany manufactures larger and more expensive appliances than the other MS.

Overall, PRODCOM statistics are not complete for each product (especially for dryers) and MS, so they can only provide a rough overview of the market situation. Further detail specifically for the professional washing machine and dryer market is provided in the following section.

2.2 Trade

2.2.1 PRODCOM imports and exports

Table 6 and Table 7 show the overall imports and exports (both intra and extra EU) of professional washing machines and dryers by MS for the year 2009.[14] In terms of quantity, Belgium, Czech Republic, Spain and Sweden appear as the most important exporters of washing machines whereas the largest importers are the United Kingdom and Italy. Figures

9 Unless specified, data refers to 2008

10 PRODCOM Code 28.94.22.30

11 PRODCOM Code 28.94.22.70

12 Latest data available: 2007

13 Latest data available: 2006

14 PRODCOM statistics based on NACE 2 Rev. accessed at: http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database, 28 September 2010

for dryers are somehow different: Germany, Italy and Sweden are the most important exporters, while France and UK are net importers.

Table 6 Volume and value of exports and imports of professional washing machines 2009

Household or laundry-type washing machines of a dry linen capacity superior to 10 kg (including washer-dryers)[15]				
	Exports		Imports	
Member State	Quantity	Value (Euros)	Quantity	Value (Euros)
Austria	74	837 880	486	3 189 480
Belgium	9 574	34 821 290	1 927	9 031 210
Bulgaria	2	2 900	90	466 470
Cyprus	0	0	251	240 560
Czech Republic	14 910	22 396 620	121	829 880
Denmark	1 756	643 900	743	1 983 110
Estonia	6	41 260	11	47 380
Finland	92	641 420	300	1 931 760
France	703	5 913 740	4 800	12 127 920
Germany	2 336	43 350 940	1 010	3 204 860
Greece	122	111 710	1 025	1 389 770
Hungary	n.a.	n.a.	n.a.	n.a.
Ireland	208	59 880	236	560 360
Italy	7 908	8 947 940	8 424	16 935 380
Latvia	6	27 520	9	35 580
Lithuania	51	235 970	46	261 190
Luxemburg	40	1 011 640	409	1 570 870
Malta	0	0	450	90 990
Netherlands	122	742 280	543	2 673 090
Poland	8	28 290	385	1 768 880
Portugal	299	681 960	1 495	2 786 170
Romania	23	177 800	1 789	741 710
Slovakia	41	1 500	54	312 520
Slovenia	298	3 222 940	114	554 560
Spain	4 300	22 001 810	2 121	3 335 450
Sweden	11 061	36 985 600	303	4 119 870
UK	5 679	743 940	25 206	8 387 140

[15] PRODCOM Code 28.94.22.30

Table 7 Volume and value of exports and imports of professional dryers 2009

Drying machines of a dry linen capacity superior to 10 kg[16]				
	Exports		Imports	
Member State	Quantity	Value (Euros)	Quantity	Value (Euros)
Austria	n.a.	4 456 550	n.a.	2 264 880
Belgium	n.a.	7 248 080	n.a.	6 487 600
Bulgaria	n.a.	3 500	n.a.	451 450
Cyprus	n.a.	0	n.a.	187 390
Czech Republic	n.a.	4 664 660	n.a.	4 082 290
Denmark	n.a.	61 260	n.a.	1 511 010
Estonia	n.a.	10 780	n.a.	9 570
Finland	n.a.	210 860	n.a.	753 810
France	n.a.	2 321 820	n.a.	14 956 420
Germany	n.a.	60 188 860	n.a.	1 225 210
Greece	n.a.	151 520	n.a.	713 230
Hungary	n.a.	n.a.	n.a.	n.a.
Ireland	n.a.	0	n.a.	432 840
Italy	n.a.	20 542 130	n.a.	9 108 780
Latvia	n.a.	52 610	n.a.	56 670
Lithuania	n.a.	87 240	n.a.	15 140
Luxemburg	n.a.	36 310	n.a.	208 060
Malta	n.a.	0	n.a.	8 270
Netherlands	n.a.	1 172 170	n.a.	2 678 820
Poland	n.a.	684 260	n.a.	599 940
Portugal	n.a.	252 950	n.a.	1 048 830
Romania	n.a.	110 210	n.a.	351 440
Slovakia	n.a.	12 570	n.a.	211 850
Slovenia	n.a.	247 710	n.a.	1 285 510
Spain	n.a.	7 357 010	n.a.	3 422 480
Sweden	n.a.	10 632 370	n.a.	3 903 940
UK	n.a.	1 494 920	n.a.	15 156 740

2.2.2 INTRA

The Eurostat trade databases INTRA and EXTRA also contain import and export data albeit using the CN8 codification (Combined Nomenclature, which was established to meet the requirements both of the Common Customs Tariff and of the external trade statistics of the European Union), using 8-digit codes. The quantity and value of products traded by Member States with other Member States (INTRA) in 2009 are presented below.

[16] PRODCOM Code 28.94.22.70

Table 8 Volume and value of exports and imports of professional washing machines and dryers to and from EU Member States, 2009[17]

Member State	Exports		Imports	
	Quantity	Value (Euros)	Quantity	Value (Euros)
CN8 84501190 Fully-automatic household or laundry-type washing machines, of a dry linen capacity >6 kg but <=10 kg				
EU-27	3 430 686	807 844 843	2 633 286	710 720 965
Germany	576 941	213 818 305	711 290	180 254 165
Italy	1 032 697	223 743 547	155 485	37 248 268
Spain	151 158	31 542 646	99 032	30 562 149
CN8 84502000: Laundry-type washing machines, of a dry linen capacity >10 kg				
EU-27	18 802	87 159 696	36 434	67 286 390
Germany	1 485	27 264 610	434	1 728 899
Italy	1 162	3 493 072	2 739	14 188 362
Spain	1 106	4 849 783	770	2 744 434
CN8 84512900: Drying machines for textile yarns, fabrics or made-up textile articles (excl. machines of a dry linen capacity <=10 kg and centrifugal driers)				
EU-27	n.a.	50 592 304	n.a.	42 879 518
Germany	n.a.	18 949 504	n.a.	751 236
Italy	n.a.	7 231 098	n.a.	6 791 342
Spain	n.a.	1 392 878	n.a.	1 351 826
CN8 84501200: Household or laundry-type washing machines, with built-in centrifugal drier (excluding fully-automatic machines)				
EU-27	19 715	3 444 264	60 636	17 471 016
Germany	115	48 930	380	203 339
Italy	106	186 482	206	213 418
Spain	135	53 877	1 088	383 325
CN8 84512190: Drying machines of a dry linen capacity >6 kg but <=10 kg (excluding centrifugal driers)				
EU-27	8 320	85 577 165	47 485	77 452 329
Germany	n.a.	24 078 511	n.a.	29 066 406
Italy	n.a.	1 697 696	n.a.	2 034 500
Spain	n.a.	427 101	n.a.	1 275 828

2.2.3 EXTRA

The quantity and value of products traded by Member States with non-Member States (EXTRA) in 2009 are presented in Table 9.

[17] Source: Eurostat trade database INTRA

Table 9 Volume and value of exports and imports of professional washing machines and dryers to and from non-Member States, 2009[18]

Member State	Exports		Imports	
	Quantity	Value (Euros)	Quantity	Value (Euros)
CN8 84501190 Fully-automatic household or laundry-type washing machines, of a dry linen capacity >6 kg but <=10 kg				
EU-27	1 201 232	471 962 517	1 268 862	235 790 593
Germany	902 090	396 407 921	76 138	15 564 701
Italy	117 547	26 689 832	101 958	18 598 394
Spain	36 174	9 484 190	190 255	32 515 547
CN8 84502000: Laundry-type washing machines, of a dry linen capacity >10 kg				
EU-27	40 831	96 481 114	15 914	11 140 938
Germany	851	16 086 083	576	1 475 911
Italy	6 746	5 454 614	5 685	2 746 934
Spain	3 194	17 151 892	1 351	590 990
CN8 84512900: Drying machines for textile yarns, fabrics or made-up textile articles (excl. machines of a dry linen capacity <=10 kg and centrifugal driers)				
EU-27	n.a.	71 400 043	3	28 239 124
Germany	n.a.	41 239 199	n.a.	473 898
Italy	n.a.	13 310 832	n.a.	2 317 362
Spain	n.a.	5 963 974	n.a.	2 070 583
CN8 84501200: Household or laundry-type washing machines, with built-in centrifugal drier (excluding fully-automatic machines)				
EU-27	88 265	3 492 768	156 038	20 331 893
Germany	393	387 482	33	8 584
Italy	258	197 224	5	35 359
Spain	368	138 424	1 787	407 137
CN8 84512190: Drying machines of a dry linen capacity >6 kg but <=10 kg (excluding centrifugal driers)				
EU-27	n.a.	30 345 808	3 773	21 414 956
Germany	n.a.	12 616 856	n.a.	2 446 718
Italy	n.a.	390 264	n.a.	604 290
Spain	n.a.	103 330	n.a.	1 328 899

2.3 Apparent EU consumption

Apparent consumption as shown in Table 10 and Table 11 provides information on the total quantity sold by manufacturers in the EU. It is calculated as follows:

Apparent consumption = Imports – Exports + Production

Apparent consumption can be calculated in currency (Euro) or in physical units. In order to have consistent categories, PRODCOM trade data is used. Note that for several countries, import and export data is reported in PRODCOM but production is reported as zero. These

[18] Source: Eurostat trade database EXTRA

figures should thus be considered with caution (some figures in the table are negative which is in theory impossible).

Table 10 Apparent consumption of household or laundry-type washing machines of a dry linen capacity superior to 10 kg (including washer-dryers) at EU level, 2005-2008[19]

Member State	2005		2006		2007		2008	
	Value (million Euros)	Quantity (units)	Value (million Euros)	Quantity (units)	Value (million Euros)	Quantity (units)	Value (million Euros)	Quantity (units)
Austria	4.72	1 035	4.95	1 045	4.59	357	3.14	266
Belgium	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cyprus	0.22	71	1.28	155	0.40	80	0.50	140
Czech Republic	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-30.06	-11 215
Denmark	3.16	-447	2.64	-828	2.15	-2 610	2.44	-937
Estonia	0.50	102	0.27	42	0.69	-26	0.47	4
Finland	1.69	739	0.83	467	2.86	459	0.53	298
France	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Germany	10.27	1 103	12.73	2 561	19.39	7 263	26.49	4 160
Greece	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Hungary	n.a.	n.a.	0.56	431	0.65	57	0.56	98
Ireland	1.48	461	0.14	-727	0.62	64	0.29	202
Italy	12.77	1 761	12.81	3 292	n.a.	n.a.	n.a.	n.a.
Latvia	0.07	17	0.36	49	0.19	88	0.16	14
Lithuania	0.07	-31	0.11	28	0.40	92	0.46	9
Luxemburg	1.44	209	0.80	191	0.71	47	1.63	201
Malta	0.37	616	0.27	1 139	0.19	545	0.18	252
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.86	469
Portugal	2.34	480	1.46	376	2.54	328	2.03	-35
Romania	n.a.	n.a.	n.a.	n.a.	2.77	540	2.05	1 947
Slovakia	0.25	81	0.36	53	1.15	39	0.60	29
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Spain	26.84	3 773	26.56	4 328	25.38	1 750	25.00	5 254
Sweden	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
UK	12.50	10 274	n.a.	n.a.	n.a.	n.a.	9.17	12 524
EU-27	**114.59**	**25 849**	**137.21**	**32 618**	**127.09**	**16 424**	**104.74**	**12 691**

[19] Source: Eurostat PRODCOM, Code 28.94.22.30

Table 11 Apparent consumption of drying machines of a dry linen capacity superior to 10 kg at EU level, 2005-2008[20]

Member State	2005	2006	2007	2008
	Value (million Euros)			
Austria	n.a.	n.a.	n.a.	n.a.
Belgium	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.
Cyprus	0.17	0.18	0.19	0.31
Czech Republic	n.a.	n.a.	n.a.	n.a.
Denmark	n.a.	n.a.	2.00	1.79
Estonia	0.11	0.10	0.04	-0.11
Finland	1.63	1.53	0.88	1.04
France	n.a.	n.a.	n.a.	n.a.
Germany	109.05	40.68	29.16	2.43
Greece	n.a.	n.a.	n.a.	n.a.
Hungary	0.23	0.36	0.14	0.24
Ireland	3.13	2.69	2.87	2.35
Italy	n.a.	n.a.	n.a.	n.a.
Latvia	0.23	0.51	0.03	0.04
Lithuania	0.72	0.12	0.19	-0.04
Luxemburg	0.15	-0.17	0.01	0.20
Malta	0.07	-0.24	-0.06	0.07
Netherlands	2.01	n.a.	n.a.	0.91
Poland	n.a.	n.a.	n.a.	n.a.
Portugal	n.a.	n.a.	1.04	n.a.
Romania	n.a.	1.93	1.92	1.19
Slovakia	0.11	1.10	0.23	0.55
Slovenia	n.a.	n.a.	n.a.	n.a.
Spain	1.11	6.12	8.64	5.77
Sweden	n.a.	n.a.	n.a.	n.a.
UK	1.06	8.78	8.43	n.a.
EU-27	**151.59**	**120.28**	**110.29**	**55.18**

The apparent unit consumption of dryers is not available in PRODCOM (exports and imports data are missing). For washing machines, it is not substantial (around 20 000–30 000 washing machines on average). In terms of value, the apparent consumption of washing machines is almost twice that of dryers in 2008 but they are similar for the period 2005-2007 (around 100–150 million Euros).

[20] Source: Eurostat PRODCOM, Code 28.94.22.70

When dividing the number of inhabitants by the apparent consumption of washing machine in 2008 by MS (see Table 12), it appears that the values are not consistent at all between MS: some are negative (because of "impossible" negative apparent consumption); the positive ones range from 1 628 (Malta) to 374 040 (Lithuania). Although slight differences can be expected across MS depending on the laundry habits, such discrepancies clearly stresses a problem of availability and consistency of the PRODCOM data, for the codes considered.

Table 12 Number of inhabitants per household or laundry-type washing machines of a dry linen capacity superior to 10 kg (including washer-dryers) by Member State, 2008[21]

Member State	2008	
	Population (inhabitants)	Number of inhabitants per washing machine (apparent consumption)
Austria	8 318 592	31 273
Belgium	10 666 866	n.a.
Bulgaria	7 640 238	n.a.
Cyprus	789 269	5 638
Czech Republic	10 381 130	-926
Denmark	5 475 791	-5 844
Estonia	1 340 935	335 234
Finland	5 300 484	17 787
France	64 004 333	n.a.
Germany	82 217 837	19 764
Greece	11 213 785	n.a.
Hungary	10 045 401	102 504
Ireland	4 401 335	21 789
Italy	59 619 290	n.a.
Latvia	2 270 894	162 207
Lithuania	3 366 357	374 040
Luxemburg	483 799	2 407
Malta	410 290	1 628
Netherlands	16 405 399	n.a.
Poland	38 115 641	81 270
Portugal	10 617 575	-303 359
Romania	21 528 627	11 057
Slovakia	5 400 998	186 241
Slovenia	2 010 269	n.a.
Spain	45 283 259	8 619
Sweden	9 182 927	n.a.
UK	61 191 951	4 886
EU-27	**497 683 272**	**39 215**

[21] Source: Eurostat PRODCOM, Code 28.94.22.30

The Eurostat PRODCOM database has the advantage of being an official EU source that is used and referenced in other EU policy documents regarding trade and economic policy. However, it is not complete or of high enough quality to serve as a useful market data source for this study and it was necessary to investigate other sources of sales and stock data. Additional information that was gathered through questionnaires sent to stakeholders (cf. Annex, Section 7.2), mainly manufacturers, is therefore presented in the next section.

3 Market and stock data

Based on the product definition in Task 1, seven categories have been defined for professional washing machines and seven categories for professional dryers, which can be used here for market and stock data definition. Based on the market data collected, further refinement will allow the key representative products (or product features) to be identified and analysed in the later stages of the study, while others may be put aside.

Questionnaires were sent to the complete mailing list of stakeholders registered on the preparatory study website, and were followed up by contacting nine key manufacturers and associations directly. Responses were received from five manufacturers[22] and cross-checked for consistency.

3.1 Market structure

The professional laundry market is above all a business-to-business (B2B) market and therefore can be characterised by some key points.

3.1.1 Sales and distribution

- The majority of smaller manufacturers typically sell and distribute their products to laundry equipment dealers who can stock and sell one or several brands of washing machine, dryer and usually other types of laundry equipment (pressing and ironing appliances, etc.). This is particularly applicable for the smallest capacity professional washer extractors and washing machines. Manufacturers of small capacity appliances sold through intermediate dealers/retailers generally do not track where many of their products end up.
- Many professional laundry appliances are also directly sold by the manufacturer to the customer, especially larger capacity machines (heavy duty appliances) which are usually tuned to customer-specific specifications or requirements upon purchase. In particular, manufacturers can assist the customers in the definition of suitable washing or drying programmes for semi-professional (partly programmable) and professional

[22] Electrolux, Miele, Kannegiesser, VDMA, Fagor.

(fully programmable) equipment, depending on the use patterns (see Task 3 for more details).

- Equipment dealers often service and maintain products and can also be dedicated (affiliate) to one or a few brands.
- The proportion of appliances sold directly or through dealers varies depending on the manufacturer, the type of appliance and the MS considered. Manufacturers estimate that around 20% of the sales are made directly between the manufacturer and the customer and the remaining share occurs through intermediate dealers.

3.1.2 International trade

- Professional washing machine and dryer imports from outside EU are not a major market presence in the EU market. Foreign brands (Alliance Laundry Systems, Whirlpool Commercial, etc.) are predominantly American and some have subsidiary manufacturing plants within the EU. Other non-EU manufacturing countries include China and Thailand. Few sales of professional washing machines and dryers are expected to be direct imports from the United States or other non-EU countries. Stakeholders have commented that total EU imports represent a low share of the EU market. Nevertheless, according to the PRODCOM and EXTRA databases, the value of imports from non-EU countries in 2009 represented 6% of the production value for professional washing machines[23] and 26% for professional dryers[24]. These figures have to be considered with caution given the uncertainty related to the different categorisation.
- Exports to countries outside the EU are estimated to represent a small share according to stakeholders. While the main EU manufacturing Member States export their products, it is expected that the majority of this trade is done on an intra-EU level. Russia, Japan, South East Asia and the Middle East are the largest extra-EU professional washing machine and dryer export markets, according to stakeholders. According to the PRODCOM and EXTRA databases, the situation seems different as exports to non-EU countries in 2009 represented around 48% of the production value for professional washing machines[23] and 66% for professional dryers[24]. Again, these figures which are surprisingly high have to be considered with caution given the uncertainty related to the different categorisation used in PRODCOM and EXTRA.

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[23] Comparing categories CN8 84502000 (Laundry-type washing machines, of a dry linen capacity >10 kg) in EXTRA and PRODCOM Code 28.94.22.30 (household or laundry-type washing machines of a dry linen capacity superior to 10 kg, including washer-dryers).

[24] Comparing categories CN8 84512900 (Drying machines for textile yarns, fabrics or made-up textile articles (excl. machines of a dry linen capacity <=10 kg and centrifugal driers)) and PRODCOM Code 29.94.22.70 (Drying machines of a dry linen capacity superior to 10 kg).

3.2 Manufacturers

The B2B nature of the professional washing machine and dryer market makes it much less visible than the domestic market. This poses difficulties when attempting to characterise the market in terms of sales, stock and prices. Besides, there are few manufacturing companies so that the market data is highly sensitive for competitiveness reasons. It is considered relevant to list the manufacturers for the sake of characterising the market. The following manufacturers have been identified in the professional washing machine and dryer market in the EU (see Table 13).

Table 13 Non-exhaustive list of professional washing machine and dryer manufacturers relevant to EU market

Manufacturer	Country (alphabetic order)	Manufacturer	Country (alphabetic order)
IPSO (part of Alliance Laundry Systems)	Belgium	PODAB	Sweden
Primus	Belgium (Czech Republic)	Schulthess	Switzerland
Jensen	Denmark (Sweden, Germany, Italy, Switzerland)	Broadbent	UK
Danube	France	Warwick	UK
Kannegiesser	Germany	Alliance Laundry Systems	United States
Miele Professional	Germany (Austria)	ASKO	United States
Stahl	Germany	American Dryer Corporation	United States
IMESA	Italy	Whirlpool Commercial	United States
Girbau	Spain (France)	Staber	United States
Fagor Industrial	Spain	Milnor	United States
Electrolux Professional	Sweden (France, Thailand)		

(Brackets for country signify presence of production sites)

The above list is not intended to be exhaustive but it should include a majority of the manufacturers relevant to the European market with a vast majority of the market share covered. It can be seen by the number of manufacturers operating in each MS that Belgium, Germany, Sweden, Spain, Czech Republic and Italy are major manufacturing countries in the EU. These countries account for a dominant share of the manufacturing market in Europe.

There are no EU-wide professional washing machine and dryer manufacturer associations which partly explains the limited market data available on professional laundry appliances. There are, however, textile services associations at MS level and at EU level (e.g. European Textile Services Association ETSA).

3.3 Sales

The aim of this section is to assess the sales volume (number of units sold) for different types of semi-professional and professional laundry equipment. Based on the previous market structure data, Table 14 summarises approximate laundry machine manufacturing capacity in the EU.

Table 14 Estimated production of professional laundry machines by Member State, 2009[25]

Member State	Share of laundry machines produced per year	Comparison with PRODCOM[26]
Belgium	17.5%	n.a.
Czech Republic	17.5%	n.a.
France	0.5%	5% (2009, washing machines only)
Germany	14.0%	8.5% (2007)
Italy	6.0%	5% (2006, washing machines only)
Slovenia	0.5%	n.a.
Spain	21.0%	14.2% (2009)
Sweden	23.5%	n.a.
EU Total	**100.0%**	**100.0%**

Despite differences in the percentages and loopholes in the PRODCOM data, the results are in line with the available PRODCOM data, which showed that Spain, Germany and Italy were the major manufacturers in the EU, representing around 35-40% of EU production capacity. Other major manufacturing MS are Belgium, Czech Republic and Sweden.

Stakeholder estimations[27] suggest that 82 000 washing machines and 41 000 dryers are produced annually in the EU, i.e. a total of 123 000 professional laundry appliances. This figure is significantly higher than the figure given by PRODCOM (66 000 professional laundry appliances produced in 2008, of which 37 000 washing machines and 29 000 dryers). This might partly come from the fact that the PRODCOM categories take into account only machines with a capacity superior to 10 kg, whereas semi-professional and professional appliances with capacity in the range 6-10 kg represent an important market segment. Although PRODCOM is an official source, the disadvantage is that the data is less timely and often less complete compared to unofficial sources. We assume that the estimation of

[25] Based on stakeholder communications

[26] Sources: Table 1 and Table 2

[27] Questionnaires responses received from: Electrolux, Kannegiesser, VDMA, Miele, Fagor

123 000 professional appliances produced annually in the EU is more accurate than the PRODCOM inputs but **the uncertainty in this figure remains high**.

Manufacturers feedback indicates that 85% of the appliances are sold for use within the EU, meaning that 15%, i.e. 18 500 appliances, are exported to non-EU countries. Including a proportion of professional laundry machines imports from outside the EU of 10% according to manufacturers estimates (which is in line with PRODCOM estimates in Section 3.1.2), professional laundry appliance sales in the EU are estimated at **117 000 units per year**. Table 15 summarises this data.

Table 15 EU professional laundry machines sales, 2009 (estimate)

	Professional laundry machines per year
EU manufacturing estimate	123 000
minus units exported (15% of EU manufacturing estimate)	-18 500
plus units imported (10% of EU manufacturing estimate)	+12 300
Total EU sales	**116 800**

If we assume that the market export and import percentages are the same for washing machines and dryers, approximately **78 000 professional washing machines and 39 000 dryers were sold annually in the EU in 2009.**

The distribution of these sales is estimated to be roughly proportional to each Member State's market size but is also expected to vary with the different cultural habits of the MS. The average laundry washing needs per customer in each MS are not expected to vary much from one region of Europe to another, however the types of establishments (e.g. apartment machines vs. launderettes), their number of customers, and thus the type of machine which is most appropriate for the average laundry establishment is expected to vary from region to region in Europe. For instance, in Nordic countries, Switzerland and Austria, it is common practice to have professional laundry equipment in buildings that can be used by the inhabitants of the building whereas launderette options will be preferred in other countries.

The range of products according to the definition of the scope in Task 1 is included in this estimate.

3.3.1 Sales by product type

As stated earlier, very few market data on EU professional laundry machines manufacturing and trade exist. This poses several challenges for an eco-design preparatory study such as this one, as a lack of information can prevent clear and informed policy recommendations from being made. At the international level, even fewer data sources are available.

According to a summary of a report on the United States commercial laundry sector[28], washers and extractors account for 40% of the laundry equipment sales (pressing machines and dry cleaning equipment included) while professional dryers represent 16% of the sales, but no further breakdown is available.

While this information is not directly relevant to the European market, it is useful for approximating how many machines of each type are sold as a proportion of the total which would be similar to European sales. Thus, washing machine sales should be around 2.5 times dryer sales if these proportions were to be respected. Our sales estimations show that this ratio is 2:1 in the EU.

The following analysis is divided by the type of laundry equipment, as segregated in Task 1 for professional washing machines and dryers. As no public information was available, the breakdown of annual sales by product type was calculated from aggregated manufacturers' responses to the questionnaire. All the estimated sales are summarised in Table 16.

3.3.1.1 Professional washing machine categories

Categories WM1-4: Semi-professional and professional washer extractors

These categories of washing machines account for by far the largest number of laundry equipments sold. They are very flexible regarding capacity (from 6 to 120 kg), are expected to be the least expensive (the price strongly depends on capacity) and are suitable for many applications. The customers of these products are most diverse and have a variety of needs.

- Category WM1: Sales of semi-professional washer extractors are estimated to be **25 000 units per year**,
- Category WM2: Sales of professional washer extractors less than 15 kg capacity are estimated to be **45 500 units per year**,
- Category WM3: Sales of professional washer extractors between 15 and 40 kg capacity are expected to be **6 200 units per year** and
- Category WM4: Sales of professional washer extractors over 40 kg are expected to be **210 units per year**.

Category WM5: Professional washer dryers

Washer dryers are specific products which combine the washing and drying processes into one single appliance. Manufacturers estimate that this market is currently very limited but that it may grow in the coming years. The market for this type of appliance is particularly

[28] See http://business.highbeam.com/industry-reports/equipment/commercial-laundry-drycleaning-pressing-machines

increasing in Japan, where space is precious, and also in the United States. EU sales are estimated at **200 units per year**.

Category WM6: Professional barrier washers

Barrier washers are not as common as washer extractors as they are usually bought by customers with specific hygienic requirements (e.g. hospitals). Indeed, they enable to achieve specific sanitary targets thanks to their unique design: the inlet and outlet are separated to isolate clean linen from soiled linen. Cross contamination (germs, bacteria, dirt) is thus avoided. The market is estimated to have high potential and EU sales were estimated at **850 units** in 2009.

Category WM7: Washing tunnel machines

Every heavy duty machine design is customer specific and industrial laundry equipment is mostly integrated in a comprehensive system of different laundry processes.

Sales are estimated by manufacturers at **250 tunnel washing machines per year** in the EU.

3.3.1.2 Professional dryer categories

Categories D1-2, D4-6: Semi-professional dryers and professional tumble dryers

These categories of dryers account for the most important share of dryer equipment sold. Like washer extractors, they are very flexible regarding capacity, and are suitable for many applications.

- Semi-professional dryer, condenser (D1) and air vented (D2): Sales of semi-professional dryers are estimated to be **7 500 units per year**,
- Professional tumble dryers, <15 kg (D4): Sales of professional tumble dryers less than 15 kg capacity are estimated to be **16 000 units per year**,
- Professional tumble dryers, 15-40 kg (D5) and >40 kg (D6): Sales of professional tumble dryers over 15 kg are estimated to be **3 800 units per year**.

Category D3: Professional cabinet dryers

Sales in this product category are estimated at **10 700 units per year**.

Category D7: Pass-through (transfer) tumble dryer

Heavy duty dryers are customer specific and sold to limited customer segments, which explains their low sales. Approximately **1 200 transfer dryers** are sold annually.

Table 16 summarises the estimated numbers of sold units per product category. Given the lack of available public market data and the limited number of responses from manufacturers

(also due to the fact that the market is dominated by a few large companies), these figures are to be considered with caution.

Table 16 Estimated EU sales of professional laundry machines by product type, 2009

Product type	Estimated number of units sold
Washing machines	
WM1: Semi-professional washer extractor	25 000
WM2: Professional washer extractor, <15 kg	45 500
WM3: Professional washer extractor, 15-40 kg	6 200
WM4: Professional washer extractor, >40 kg	210
WM5: Professional washer dryer	200
WM6: Professional barrier washer	850
WM7: Washing tunnel machine	250
Total washing machines	**78 710**
Dryers	
D1: Semi-professional dryer, condenser	3 200
D2: Semi-professional dryer, air vented	4 300
D3: Professional cabinet dryer	10 700
D4: Professional tumble dryer, <15 kg	16 000
D5: Professional tumble dryer, 15-40 kg	3 500
D6: Professional tumble dryer, >40 kg	300
D7: Pass-through (transfer) tumble dryer	1 200
Total dryers	**39 200**
Total laundry appliances	**Approx. 118 000**

3.3.2 Sales by customer

In the US in the late 1990s, the consumers of professional laundry equipment with the largest market share were hotels, hospitals and contract laundry services that serve commercial and institutional customers.[29] Government institutions, including the armed services, prisons, schools, and hospitals, bought about 11% of the production. It seems reasonable to assume that these shares have not substantially changed since, and EU estimations should therefore be close to these. Professional laundry equipment is produced for the following main customer segments (cf. Task 1 report):

- **Coin & Card Laundry (CCL)**: laundrette, camping, student dorms, real estate etc. and **Apartment Household Laundry (AHL)**: household, real estate, old people's homes etc; the users are not the owners and therefore safety and easy handling are the most important issues.

[29] http://business.highbeam.com/industry-reports/equipment/commercial-laundry-drycleaning-pressing-machines

- **Hospitality Laundry (HPL)**: hotels, restaurants, quick service restaurants etc.
- **Healthcare Laundry (HCL)**:
  - **Healthcare Hospital (HH)** with very high hygiene demands
  - **Healthcare Nursing Home (HN)** with hygiene demands
- **Commercial Industrial Laundry (CIL)**: service providers, textile rent cleaning, small or heavy duty laundries etc.
- **Speciality Laundry (SP)** including high-tech industries (mops, functional garments like fire and rescue service or offshore, pharmaceutical and electronic factories).

It will be quite difficult and not well targeted to estimate the different market shares and all the associated parameters (lifetimes, user behaviours, etc.) for each product group in each market segment. To focus the analysis, the most dominant customer segment for each category has been evaluated (see Table 17 and

Table 18). The presentation of the market shares for each type of appliance is based on global market research and stakeholders' feedback.

Table 17 Target customer segments of professional washing machines by product category

Product type	Market share of customer segments	Dominant customer segment
WM1: Semi-professional washer extractor	**CCL+AHL: 60%** HPL: 25% HH: 10% HN: 5% CIL: ~0% SP: ~0%	**Coin & Card Laundry + Apartment Household Laundry**
WM2: Professional washer extractor, <15 kg	**CCL+AHL: 50%** HPL: 25% HH: 10% HN: 5% CIL: 5% SP: 5%	**Coin & Card Laundry + Apartment Household Laundry**
WM3: Professional washer extractor, 15-40 kg	CCL+AHL: 0% **HPL: 65%** HH: 10% HN: 15% CIL: 5% SP: 5%	**Hospitality Laundry**
WM4: Professional washer extractor, >40 kg	CCL+AHL: 0% HPL: 35% HH: 5% HN: 5% **CIL: 50%** SP: 5%	**Commercial Industrial Laundry**
WM5: Professional washer dryer	CCL+AHL: 35% **HPL: 65%** HH: 0% HN: 0% CIL: 0% SP: 0%	**Hospitality Laundry**

Product type	Market share of customer segments	Dominant customer segment
WM6: Professional barrier washer	CCL+AHL: 0% HPL: 0% **HH: 50%** HN: 40% CIL: 0% SP: 10%	**Healthcare Hospital Laundry**
WM7: Washing tunnel machine	CCL+AHL: 0% HPL: 0% HH: 5% HN: 0% **CIL: 90%** SP: 5%	**Commercial Industrial Laundry**

Table 18 Target customer segments of professional dryers by product category

Product type	Market share of customer segments	Dominant customer segment
D1: Semi-professional dryer, condenser	**CCL+AHL: 60%** HPL: 25% HH: 10% HN: 5% CIL: 0% SP: 0%	**Coin & Card Laundry + Apartment Household Laundry**
D2: Semi-professional dryer, air vented	**CCL+AHL: 60%** HPL: 25% HH: 10% HN: 5% CIL: 0% SP: 0%	**Coin & Card Laundry + Apartment Household Laundry**
D3: Professional cabinet dryer	**CCL+AHL: 70%** HPL: 10% HH: 10% HN: 10% CIL: 0% SP: 0%	**Coin & Card Laundry + Apartment Household Laundry**
D4: Professional tumble dryer, <15 kg	**CCL+AHL: 50%** HPL: 25% HH: 10% HN: 5% CIL: 5% SP: 5%	**Coin & Card Laundry + Apartment Household Laundry**
D5: Professional tumble dryer, 15-40 kg	CCL+AHL: 0% **HPL: 65%** HH: 10% HN: 15% CIL: 5% SP: 5%	**Hospitality Laundry**
D6: Professional tumble dryer, >40 kg	CCL+AHL: 0% HPL: 35% HH: 5% HN: 5% **CIL: 50%** SP: 5%	**Commercial Industrial Laundry**

Product type	Market share of customer segments	Dominant customer segment
D7: Pass-through (transfer) tumble dryer	CCL+AHL: 0% HPL: 0% HH: 5% HN: 0% **CIL: 90%** SP: 5%	**Commercial Industrial Laundry**

The tables show that industrial users (CIL) are purchasers of heavy duty appliances (professional washer extractors >40 kg, washing tunnel machines, professional tumble dryers >40 kg, pass-through tumble dryers) while users in hospitality and coin & card/apartment household laundry are purchasers of smaller washer extractors and dryers. The health care sector purchases both small and large appliances, and is the main market segment for professional barrier washers.

It is expected that the variation between MS on the type of professional laundry equipment purchased varies very little, but the type of purchasers can be slightly different for cultural reasons. As already stated before, in Nordic countries, Switzerland and Austria semi-professional or professional laundry equipment is provided in every building to be used by the inhabitants while launderettes are more common in other MS. The type of equipment and the use patterns in these two end markets are similar even if these machines are not used in the same environment. Thus, the average laundry needs and purchases are estimated to be similar in the different MS, despite possible structural differences of the market segments.

3.4 Average product life

The lifetime of the appliances is of interest as being a key parameter in assessing the LCCs of the appliances as well as the environmental impacts in the later stages of the study (Tasks 5 and 7). Lifetime can also be used to estimate the stock data based on sales. In the context of this study, the focus is on 'active lifetime', meaning the time in service.

Professional appliances are expected to be used more frequently than washing machines and dryers for household use, but should also be designed more robustly so that the order of magnitude of the lifetime should be similar.[30]

With regard to the customer segments (see Section 3.3.2), the typical average product lifetime of professional washing machine and dryer categories depends on the respective use patterns (number of cycles per day): for instance, the number of cycles per day may

[30] According to: BIO Intelligence Service / Giraffe / Intertek (2009); "Reducing the environmental impacts of clothes cleaning", for DEFRA; household washing machines' lifetime are estimated to be 12 years and household tumble dryers' lifetime to be 13 years. In preparatory study Lot 14 on household washing machines (ISIS, 2007, for DG TREN), the lifetime used is 15 years.

differ between a professional washing machine either used in launderettes or in hospitality laundry.

Based on responses to the working document,[31] the design lifetimes in cycles of the product categories in this study are estimated in Table 19. The design lifetime in years were derived from the lifetimes in cycles and the user behaviour parameters based on the respective main customer segment for each product category presented in Task 3 (see Task 3 for calculations details).

While semi-professional appliances (categories WM1 and D1-2) only have a lifetime of 8 years (considering the main customer segment defined within the study), professional machines (categories WM2 to WM6; D3 to D6) have an average lifetime of 11 to 15 years. For heavy duty appliances (categories WM6-7 and D6), the lifetime is similar and estimated to be 13-14 years.

Table 19 Estimated lifetimes of products in this study based on stakeholder responses

Type of appliance	Design lifetime in cycles	Design lifetime in years[32]
Laundry machines		
WM1: Semi-professional washer extractor	15 000 cycles	8
WM2: Professional washer extractor, <15 kg	30 000 cycles	13
WM3: Professional washer extractor, 15-40 kg	30 000 cycles	14
WM4 : Professional washer extractor, >40 kg	40 000 cycles	15
WM5 : Professional washer dryer	20 000 cycles	11
WM6 : Professional barrier washer	30 000 cycles	14
WM7 : Washing tunnel machine	40 000 hours	13
Dryers		
D1: Semi-professional dryer, condenser	15 000 cycles	8
D2: Semi-professional dryer, air vented	15 000 cycles	8
D3: Professional cabinet dryer	20 000 cycles	15
D4: Professional tumble dryer, <15 kg	30 000 cycles	13
D5: Professional tumble dryer, 15-40 kg	30 000 cycles	14
D6: Professional tumble dryer, >40 kg	40 000 cycles	13
D7: Pass-through (transfer) tumble dryer	40 000 hours	13

[31] Questionnaires responses received from: Electrolux, VDMA, Miele, Fagor, Kannegiesser.

[32] Taking into account the use rate in the main customer segment associated.

3.5 Stock

The aim of this section is to assess the total stock of professional laundry appliances in use today for different types of commercial use. No information has been obtained from market studies. Estimates given here are based on the sales estimation for 2009, the past trends deducted from PRODCOM data and stakeholders' feedback, as well as the lifetime of the equipments.

3.5.1 Assumptions

According to stakeholders' comments on the working document, the annual growth rate of the professional laundry equipment market for the period 2000–2009 was approximately 1%, except for barrier washers for which it was 2%. The growth rate of 1% is estimated to be an average between the products categories and may slightly differ but this effect will not be taken into account in the calculations of the stock.

PRODCOM data suggests results in line with this growth rate concerning professional washing machines (see Figure 2, growth rate estimation of 0.7%) but shows the professional dryers market decreasing over the past five years (see Figure 3), growth rate estimated at -1.7%. However, the important variations of the figures make this trend not fully reliable.

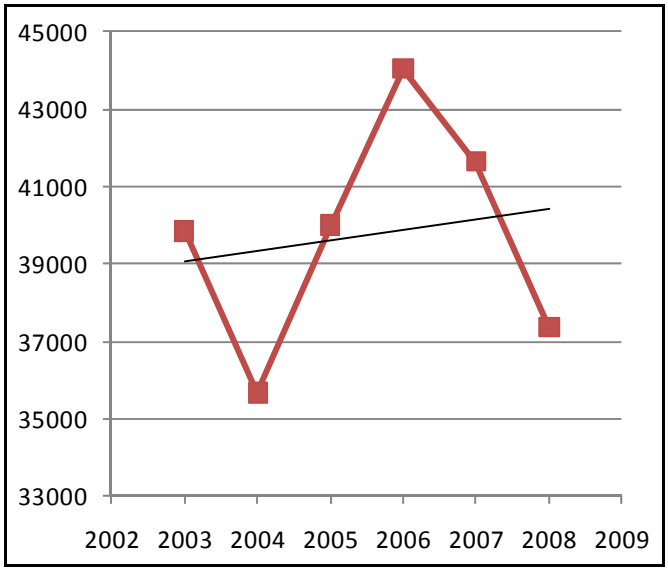


Figure 2 Production figures of professional washing machines in the EU-27 between 2003 and 2008[33]

[33] PRODCOM statistics based on NACE 2 Rev. accessed at: http://epp.Eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database, June 3 2010

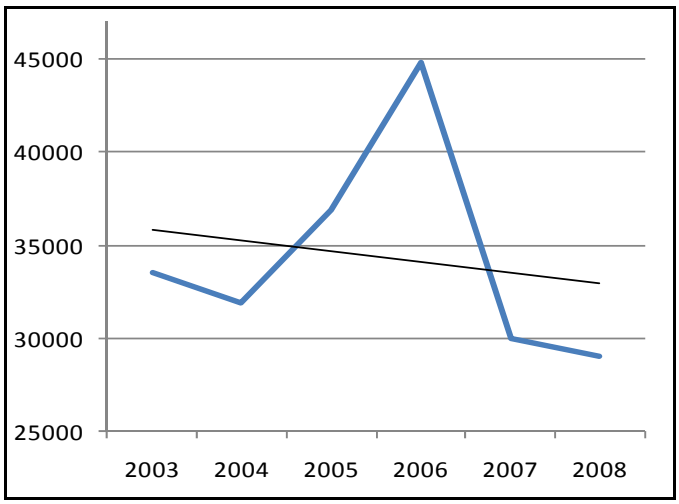


Figure 3 Production figures of professional dryers in the EU-27 between 2003 and 2008[33]

To calculate the stock of professional laundry appliances in use in 2009, we will thus assume a constant growth rate of 1% over the past twenty years for all product categories, except category WM6 for which 2% will be applied.

The lifetime determines the average duration of a unit within the stock. Therefore, the current number of units will correspond to the accumulated number of units sold during the lifetime. Appliance lifetimes ranges related to the main market segment identified for each product category were presented in Table 19.

3.5.2 Results

Considering the sales estimations given in the previous section for 2009, the total stock of professional laundry machines in the EU for the year 2009 is shown in Table 20. Cells in grey indicate the sales contributing to the stock in 2009.

The total stock of professional laundry equipment is estimated at around 1 300 000 machines in the EU-27.

Table 20 Total stock of professional laundry equipment calculated from sales as per Table 16, 2009

Year	WM1	WM2	WM3	WM4	WM5	WM6	WM7	D1	D2	D3	D4	D5	D6	D7	Total
Sales 1994	21 501	39 133	5 332	172	172	628	215	2 752	3 698	9 203	13 761	3 010	258	1 032	100 867
Sales 1995	21 719	39 528	5 386	174	174	641	217	2 780	3 736	9 296	13 900	3 041	261	1 042	101 895
Sales 1996	21 938	39 927	5 441	176	176	654	219	2 808	3 773	9 389	14 040	3 071	263	1 053	102 928
Sales 1997	22 160	40 331	5 496	177	177	667	222	2 836	3 811	9 484	14 182	3 102	266	1 064	103 975
Sales 1998	22 383	40 738	5 551	179	179	681	224	2 865	3 850	9 580	14 325	3 134	269	1 074	105 032
Sales 1999	22 610	41 149	5 607	181	181	695	226	2 894	3 889	9 677	14 470	3 165	271	1 085	106 100
Sales 2000	22 838	41 565	5 664	183	183	709	228	2 923	3 928	9 775	14 616	3 197	274	1 096	107 179
Sales 2001	23 069	41 985	5 721	185	185	723	231	2 953	3 968	9 873	14 764	3 230	277	1 107	108 271
Sales 2002	23 302	42 409	5 779	186	186	738	233	2 983	4 008	9 973	14 913	3 262	280	1 118	109 370
Sales 2003	23 537	42 837	5 837	188	188	753	235	3 013	4 048	10 074	15 064	3 295	282	1 130	110 481
Sales 2004	23 775	43 270	5 896	190	190	768	238	3 043	4 089	10 176	15 216	3 328	285	1 141	111 605
Sales 2005	24 015	43 707	5 956	192	192	784	240	3 074	4 131	10 278	15 370	3 362	288	1 153	112 742
Sales 2006	24 257	44 149	6 016	194	194	800	243	3 105	4 172	10 382	15 525	3 396	291	1 164	113 888
Sales 2007	24 503	44 595	6 077	196	196	816	245	3 136	4 214	10 487	15 682	3 430	294	1 176	115 047
Sales 2008	24 750	45 045	6 138	198	198	833	248	3 168	4 257	10 593	15 840	3 465	297	1 188	116 218
Sales 2009	25 000	45 500	6 200	200	200	850	250	3 200	4 300	10 700	16 000	3 500	300	1 200	117 400
Stock 2009	**193 139**	**557 280**	**81 379**	**2 799**	**2 093**	**10 471**	**3 063**	**24 722**	**33 219**	**149 737**	**195 967**	**45 937**	**3 674**	**14 697**	**1 318 175**

3.6 Summary of market data

Table 21 summarises the market data presented in the previous sections. This data will be useful in later tasks (Task 5-7-8) for estimating life cycle properties of these products and build scenarios at the EU level.

Table 21 Market data summary, by product type

Product type	Estimated number of units sold per year (2009)	Estimated stock (2009)	Average product lifetime (years)
Laundry machines			
WM1: Semi-professional washer extractor	25 000	193 139	8
WM2: Professional washer extractor, <15 kg	45 500	557 280	13
WM3: Professional washer extractor, 15-40 kg	6 200	81 379	14
WM4: Professional washer extractor, >40 kg	200	2 799	15
WM5: Professional washer dryer	200	2 093	11
WM6: Professional barrier washer	850	10 471	14
WM7: Washing tunnel machine	250	3 063	13
Dryers			
D1: Semi-professional dryer, condenser	3 200	24 722	8
D2: Semi-professional dryer, air vented	4 300	33 219	8
D3: Professional cabinet dryer	10 700	149 737	15
D4: Professional tumble dryer, <15 kg	16 000	195 967	13
D5: Professional tumble dryer, 15-40 kg	3 500	45 939	14
D6: Professional tumble dryer, >40 kg	300	3 674	13
D7: Pass-through (transfer) tumble dryer	1 200	14 697	13

4 Market trends

4.1 General market trends

This subtask aims to provide market trends indicating market structures and relevant trends in product design. According to the information provided by stakeholders, the main markets for professional laundry appliances are apartment, launderettes and hospitality (around 80% of the market of the washer extractors and tumble dryers which are the most sold appliances).

It is logical to expect that the evolution of the markets of these machines is closely related to the evolution of these sectors. Furthermore, environmental policy constraints that apply to this sector have a great impact on the type of machine sold. Several companies have already

started to produce appliances with energy and water efficiency features: the market is changing as environmental awareness increases.

An estimation of the future market for laundry equipment must consider the following aspects:

- growth of the launderettes and apartment sector;
- growth of the hospitality segment;
- evolution of sales for large capacity equipments.

No public information has been found on the market growth of the launderette or apartment sector. It will be assumed that the trends of this section will be mainly based on the evolution of the hospitality sector.

The current trend in the hotel industry is to outsource tasks in order to simplify internal processes[34], e.g. cleaning and administrative tasks. Thus, on-premise laundries (OPLs) are increasingly being replaced by large off-premise laundries that will deal with a large number of customers[35]. Regarding the market competition for hotels, in the same study it is mentioned that regardless of the size of the company, in order to keep their market share, new technologies must be adopted, including environmentally-friendly products and IT systems.

In hotel (and catering) industry, actions to improve the environmental performance of the whole sector including its equipment are mostly expected to come from policies and regulations.[34] To a lower degree, concern for the environment is also producing a change in the technology of machines used within the hotel and catering sector – less energy-consuming machines are increasing their share of the market[36]. Based on the feedback of stakeholders, the market share for more energy and water efficient appliances has been increasing during the past years.

In a study conducted by Oxford Research,[37] the growth tendency of the hotel and catering sector was estimated to be 1% per year at EU level for the combination of different scenarios.

Since no studies presenting the actual size of laundry equipment sector have been identified, the trend for hospitality and health care laundries is going to be assumed to reflect the behaviour of professional laundry machines and dryers sales for the coming years. Stake-holders' comments on the working document are in line with these estimations of 1-2%

[34] European Foundation for the Improvement of Living and Working Conditions (2005); Visions of the future. What future? The hotels and catering sector

[35] Freedonia (2008); Freedonia Focus on Commercial & Industrial Laundry Machinery

[36] European Foundation for the Improvement of Living and Working Conditions (2005) Policies, issues and the future. The hotels and catering sector

[37] Oxford Research (2009); Comprehensive sectoral analysis of emerging competencies and economic activities in the European Union Lot 12: Hotels and restaurants

annual growth in the last 10 years, except for the barrier washers, which are growing quicker (2–3% per year).

Thus the future trends appear similar to the past trends. In order to estimate sales in 2015 and 2020, a growth rate of 1% will be applied to categories WM1 to WM5 and D1 to D6 and a growth rate of 2% will be applied to WM6. Regarding heavy duty appliances, stakeholders indicated that the market is expected to follow the growth of the linen volume, assessed between 2 and 5% per year. For categories WM7 and D7, a growth rate of 3% will be used for the calculations. These rates are mainly driven by the replacement of old laundry equipment and by the population growth.

The total sales of professional washing machines and dryers estimated for 2009 are 117 000 units (Table 16). The estimation of sales for 2015, 2020 and 2025 is represented in Table 22.

Table 22 Projected market for different types of washing machines and dryers 2009-2025

Type of appliance	Sales 2009	Estimated sales 2015	Estimated sales 2020	Estimated sales 2025
Laundry machines				
WM1: Semi-professional washer extractor	25 000	26 550	27 900	29 300
WM2: Professional washer extractor, <15 kg	45 500	48 300	50 750	53 350
WM3: Professional washer extractor, 15-40 kg	6 200	6 600	6 900	7 300
WM4: Professional washer extractor, >40 kg	200	210	220	235
WM5: Professional washer dryer	200	210	220	235
WM6: Professional barrier washer	850	960	1 060	1 170
WM7: Washing tunnel machine	250	300	350	400
Dryers				
D1: Semi-professional dryer, condenser	3 200	3 400	3 550	3 750
D2: Semi-professional dryer, air vented	4 300	4 550	4 800	5 050
D3: Professional cabinet dryer	10 700	11 350	11 950	12 550
D4: Professional tumble dryer, <15 kg	16 000	17 000	17 850	18 750
D5: Professional tumble dryer, 15-40 kg	3 500	3 700	3 900	4 100
D6: Professional tumble dryer, >40 kg	300	320	335	350
D7: Pass-through (transfer) tumble dryer	1 200	1 450	1 650	1 950

4.2 Employment figures

Stakeholders' feedback on employment in EU manufacturing companies (direct production) of professional laundry appliances indicates that approximately 6 000 persons are currently employed in these companies.

4.3 Redesign cycle

According to information provided by stakeholders, the redesign cycle varies with the category of equipment and the objective of the process. Designing equipment “from scratch” with completely new characteristics can take between 10 to 12 years for heavy duty appliances and from 6 to 10 years for smaller washing machines and dryers.

Redesigning a single part of the appliance can take between 6 and 36 months depending on its complexity: the required time is very specific to the design changes so that it is not realistic to indicate an average or typical timing. Normally these redesign processes are intended to improve the water or energy efficiency.

4.4 Product specific trends – development of professional laundry machinery, 2000-2020

Manufacturer brochures and websites were analysed to identify important product specific developments and trends of professional laundry equipment. Furthermore a questionnaire was sent to stakeholders to confirm the identified market trends and developments and also to receive some quantitative data (see Annex, Section 7.2).

4.4.1 Energy and water consumption

Professional washing machines

In general, the market has changed towards professional washing machines with reduced energy and water use in recent years. As Table 21 shows, the average energy consumption of professional washing machines sold in the EU has decreased by approximately 25 to 40% within the past 10 years (difference between new products sold and average products still in use today). Similar figures apply to the average water consumption. Table 23 shows that the average water consumption of professional washing machines has decreased by approximately 7 to 50% over the last ten years. It is assumed that due to a constant dosage of detergents and laundry aid, their respective savings correspond to the water savings. Note: The figures are based on estimations by stakeholders as currently no commonly applied European measurement standard for professional washing machines and dryers exists (see also Task 1).

Table 23 Development of energy consumption of washing machines in the past 10 years

Washing machine category	Consumption of a ten year old washing machine kWh/kg laundry	Consumption of an average new washing machine kWh/kg laundry	Improvement between ten year old and new product
WM1: Semi-professional washer extractor	0.20	0.15	25%
WM2: Professional washer extractor, <15 kg	0.24	0.17	29%
WM3: Professional washer extractor, 15-40 kg	0.30	0.21	30%
WM4: Professional washer extractor, >40 kg	0.50–0.55	0.35	30%–42%
WM5: Professional washer dryer	n.a.	0.80 (Wash and Dry)	n.a.
WM6: Professional barrier washer	n.a.	0.39	n.a.
WM7: Washing tunnel machine	n.a.	0.35	n.a.

Table 24 Development of water consumption of washing machines in the past 10 years

Washing machine category	Consumption of a ten year old washing machine l/kg laundry	Consumption of an average new washing machine l/kg laundry	Improvement between ten year old and new product
WM1: Semi-professional washer extractor	12.5	9	28%
WM2: Professional washer extractor, <15 kg	15–18	12	20%–33%
WM3: Professional washer extractor, 15-40 kg	15–18	13	13%–28%
WM4: Professional washer extractor, >40 kg	15–18	14	7%–22%
WM5: Professional washer dryer	n.a.	10	n.a.
WM6: Professional barrier washer	18-20	16	11%–20%
WM7: Washing tunnel machine	8-12	6	25%–50%

Data from A.I.S.E.[38] comparing the water and energy consumption of washer extractors and tunnel washers in the 1970s with the 1990s back these developments (the consumption figures refer to litres of fresh water per kg of dry linen or kg of steam per kg of dry linen).

[38] A.I.S.E.: “Industrial & Institutional Sector – Environmental dossier on Professional laundry”; (2000).

Table 25 Water and energy consumption of washer extractors and tunnel washers in the 1970s and 1990s (Source: A.I.S.E)

	Washer Extractor	Tunnel washers
Steam		
1970s	1.1 kg/kg	0.7-0.8 kg/kg
1990s	0.6-0.8 kg/kg	0.4-0.5 kg/kg
Fresh water		
1970s	30 l/kg	10-15 l/kg
1990s	15-20 l/kg	8-12 l/kg

Key factors to these reductions have been new products and processes for low temperature washing and for re-use of rinse water.

Regarding the next ten years, the reduction of energy and water consumption of professional washing machines is assumed to continue. According to three stakeholder responses to our questionnaire, the average energy consumption of the future sold (and thus manufactured) washing machines (over all product categories in EU in comparison to the average product) is expected to further decline between 2010 and 2020 by approximately 10 to 40%. Over the same period, the average water consumption (accordingly the consumption of detergents and laundry aid) is expected to decrease by approximately 10 to 20%. These rough estimations will be counterchecked by further calculations within Task 7 (improvement potentials compared to current base cases).

Professional dryers

As the following table shows, the average energy consumption of dryers sold in the EU has decreased by approximately 18 to 26% within the past 10 years (representing the difference between new products sold and average products still in use today). The figures are based on estimations by stakeholders that are not measured according to a common standard as such a standard does not yet exist at EU level (see also Task 1).

Table 26 Development of energy consumption of dryers in the past 10 years

Dryer category	Consumption of a ten year old dryer kWh/kg laundry[39]	Consumption of an average new dryer kWh/kg laundry[39]	Improvement between ten year old and new product
D1 Semi-professional dryer, condenser	0.73	0.60	18%
D2 Semi-professional dryer, air vented	0.70	0.56	20%
D3 Professional cabinet dryer	n.a.	0.75	n.a.

[39] Numbers in brackets: Energy consumption kWh/cycle

Dryer category	Consumption of a ten year old dryer kWh/kg laundry[39]	Consumption of an average new dryer kWh/kg laundry[39]	Improvement between ten year old and new product
D4 Professional tumble dryer, <15 kg	n.a.	0.55	n.a.
D5 Professional tumble dryer, 15-40 kg	0.85	0.65	23%
D6 Professional tumble dryer, > 40 kg	1.15	0.85	26%
D7 Professional pass-through (transfer) tumble dryer	n.a.	0.80	n.a.

n.a. no information available

Regarding the development over the next ten years, the reduction of energy consumption is assumed to continue. According to three stakeholder responses to our questionnaire, the average energy consumption of the future sold dryers (over all product categories in EU in comparison to the average product) is expected to further decrease between 2010 and 2020 by approximately 15 to 20%. These rough estimations will be counterchecked by further calculations within Task 7 (improvement potentials compared to current base cases).

4.4.2 Detergent consumption

Companies in the industrial and institutional (I&I) market provide a variety of detergent products and services that make their business fundamentally different from the household products market. The products and services that are offered cater for specialised cleaning and hygiene needs.

According to A.I.S.E.[40], the institutional laundry detergent segment has developed towards a higher acceptance of concentrated detergents, both for granular and liquid detergents. This development has moved forward faster in the last few years and is expected to continue.

The industrial laundry market uses mostly concentrated granular detergents and liquids. 'Paste-type' products or anhydrous liquids can also be found The use of concentrates reduces the amount of packaging and transport (because of a smaller volume) and chemicals and therefore might have a reduced total environmental impact[41]. Further, there

[40] International Association for Soaps, Detergents and Maintenance Products. Its memberships currently totals 37 National Associations in 42 countries, comprising more than 900 companies – ranging from small- and medium sized enterprises (SMEs) to multinationals, primarily in Europe.

[41] So called volume concentrates have a higher bulk density (0.6-0.9 g/cm^3) compared to regular detergents (0.5-0.6 g/cm^3). However, the ingredients do not differ considerably besides the almost total absence of the bulking agent sodium sulphate. Thus, with volume concentrates not the entry of chemicals into the waste water is reduced but the packaging, as the same amount is realised with a smaller volume. A further development is provided by the so called super concentrates. Besides a higher bulk density and the absence of bulking agents, the composition is changed resulting in less pollution of the waste water – optimum dosage

are trends towards more environmentally friendly types of packaging, like e.g. bag-in-box or reusable packs.

There is a growing market for multi component systems[42] which depend on the country, water conditions and the type of soil in order to use the correct chemicals at optimum concentrations.

According to A.I.S.E., customers generally tend to look more for:

- Automatic and controlled dosing systems.
- Easy and simple systems to use.
- Multi component systems, convenience, ergonomics.
- Hygiene claims.
- Powders and liquids.
- Lower temperatures (40–60°C).
- Sustainable solutions – i.e. energy and water savings; also (or mainly) for cost savings.
- Hand dosed products (as opposed to automatic dispensing).

4.4.3 Changes on the demand side

The demand for professional laundry machines has changed significantly over the past 10 years. The following arguments apply to all market segments:

- According to stakeholders' feedback, today consumers pay more attention to a low energy consumption compared to ten years ago. The reasons however have to be seen rather in cost aspects than in pure environmental aspects.
- Today, energy and partly water consumption are important purchase arguments for many customers. Water consumption does not play such an important role as energy consumption (the water rates differ within the EU).
- Today, life cycle costs play a more important role compared to 10 years ago. Life cycle costs have become a stronger criterion in the sales talk, especially for high value products. The changing awareness of the customers has partly led to the willingness to pay more for energy-saving features if the investment pays back within a certain time span (usually two to five years). The importance of life cycle considerations to commercial and public customers obviously depends on the financial situation of both the economy in general and the customers.

provided.
(Source: http://www.oekoplus.sepeur-media.de/fp/archiv/RUBsonstiges/Waschmittelkonzentrate.php)

[42] A multi-component system is a detergent systems based on components used to build up a complete detergent, a stock solution or a laundering programme for automatic dosing. This system may incorporate a number of products such as pre-wash agents, basic detergents, washing strengtheners, bleaching agents, rinsing agents and special detergents for laundering delicates. (Source: www.nordic-ecolabel.org)

- Due to budget cuts, life cycle costs play a lower role in governmental installations compared to private companies, although governmental institutions are obliged to consider not only investment cost but the whole life cycle cost. This relation has not changed within the last ten years.
- The investment (including the payback period) and the process parameters (functionality, hygiene) remain of highest importance.

4.4.4 Marketing of professional laundry machinery and technological features

In relation to influencing customer attitudes, important aspects of manufacturers' communications regarding professional laundry machinery are:

- functionality,
- economic and environmental aspects of the use phase (i.e. costs of energy and water consumption),
- comfort / ergonomics,
- hygiene / sanitation.

When analysing the most recent brochures, it was observed that functional aspects in combination with their energy and water consumption, and resulting economic saving potential, are used to advertise the latest generation of washing machines and dryers. Some examples of technological features in high-end appliances:

- load control,
- heat exchanger,
- heat recovery systems for waste-water or exhaust heat,
- heat pump,
- residual moisture control.

New design options are generally first implemented in household equipment before possibly being included in professional equipment as well. The reason for this phenomenon is that reliability and lifetime play a more important role for professional equipment compared to household machines; increasing the complexity of a machine by applying new and more sophisticated technological options may increase the risk of breakdown.

It is assumed that these features will become more widespread in dryers within the next ten years. The detailed descriptions, further best available technologies and their market shares are provided in Task 6.

5 Consumer expenditure base data

Based on the defined product categories for professional washing machines and dryers, average consumer prices, including VAT (in Euro), as well as applicable rates for running costs (e.g. electricity, repair and maintenance, disposal) and other financial parameters (e.g. inflation rates) will be determined.

The total lifetime cost of a laundry machine can be divided into five relevant categories:

- Purchase price: the cost incurred to purchase the machine (including labour costs, costs due to raw material, etc.);
- Installation cost: the cost required to install a professional laundry machine;
- Running costs: the costs incurred to operate the machine throughout a typical lifetime. They may include electricity costs and costs of consumables (detergents, water, filters, etc.);
- Maintenance and repair costs: the costs incurred by the owner of the professional laundry machine throughout the lifetime of the machine to ensure its proper and effective operation;
- Disposal costs: the quantifiable costs (or benefits) borne by the owner of the machine at the end of life of professional machine.

5.1 Purchase price

In the context of this study, average appliance consumer prices are of interest as they are required as an input for the LCC calculations of the base cases that will be performed in Task 5.

Prices within an appliance category can vary widely on the different markets of the EU. Parameters that are the most critical for fixing the price are the capacity, followed by the technical features and functional options available and chosen by the client. Because professional laundry equipment is a business to business sector, prices of appliances are not easily available (at least, prices from EU manufacturers). Therefore, the assessment of average product prices relies entirely on aggregated stakeholders' data. They were estimated as an average of the responses received to the questionnaires sent to manufacturers (5 replies received).

Professional washing machines

Semi-professional washer extractors (WM 1) tend to start at 1 000 Euros and can cost up to 5 500 Euros. The price range of professional washer extractors up to 40 kg (WM 2-3) is comprised between 5 000 and 35 000 Euros. These appliances tend to occupy the lower

cost portion of the market, while appliances designed for heavier garment load (WM 4-7) tend to occupy the more expensive portion of the market, with purchase prices up to 500 000 Euros. Their price range is much larger than other types and therefore they are more difficult to characterise on a broad European level. Washing capacity and digital programmes tend to be the differentiating factors between purchasing prices of products in this study. Barrier washers (WM6) tend to be more expensive than washer extractors as they have specific features and accessories, ensuring their specific objectives related to hygiene are met. These products typically have been found to start at 15 000 Euros and can cost up to 120 000 Euros.

Professional dryers

The same structure of the market applies to professional dryers. Smaller tumble dryers and cabinet dryers (D1 to D6) cost between 800 and 35 000 Euros, while heavy duty appliances (D7) belong to the range of 40 000 to 110 000 Euros. The costs for pass-through (transfer) tumble dryers are influenced not only by the capacity, but by the different features (e.g. heat recovery), components and stages presented by the appliance. The most expensive models include for example one pre-treatment module, four steam modules, four air circulation modules, one exit module.

The average prices for the machines within the classifications are shown in Table 27.

Table 27 European average price by machine category

Type of appliance	Typical price range (Euros)	Average price (Euros)
Laundry machines		
WM1: Semi-professional washer extractor	1 000–5 500	2 670
WM2: Professional washer extractor, <15 kg	5 000–35 000	5 000
WM3: Professional washer extractor, 15-40 kg	5 000–35 000	15 250
WM4: Professional washer extractor, >40 kg	50 000–170 000	58 750
WM5: Professional washer dryer	n.a.	8 000
WM6: Professional barrier washer	15 000–120 000	38 250
WM7: Washing tunnel machine	280 000–500 000	390 000
Dryers		
D1: Semi-professional dryer, condenser	800–3 500	1 970
D2: Semi-professional dryer, air vented	800–3 500	1 680
D3: Professional cabinet dryer	3 500–20 000	3 500
D4: Professional tumble dryer, <15 kg	3 500–20 000	4 000
D5: Professional tumble dryer, 15-40 kg	3 500–20 000	7 125
D6: Professional tumble dryer, >40 kg	18 000–35 000	21 500
D7: Pass-through (transfer) tumble dryer	40 000–110 000	62 500

5.2 Installation costs

Delivery and installation costs can be included in the product price as the manufacturers deal with this task requiring skilled personnel but it is not always the case (e.g. if the appliance is sold through a intermediate dealer). Depending of the product considered there is a high variation of these costs. They are not negligible compared to other expenses due to laundry appliances (purchase price or operating expenses). Stakeholders have estimated that delivery and installation costs represent around 4% of the purchase price of the smallest appliances and around 9% for the heavy duty machines (WM7 and D7).

However, no information was available by product category so that this rate will be used for all appliances.

5.3 Running costs

Running costs, understood as costs generated by the use of the appliance, can be split into energy (electricity, gas), water and consumable costs (detergent, rinse, etc.).

Energy costs are a significant running cost of professional laundry equipment. They are mainly due to the mechanical action required (e.g. tumblers) as well as to the heating of the water in laundry machines and of the air in dryers. According to stakeholders, the equivalent of 1 kWh of heat per kg is used to heat water.

In industrial applications, the consumption is variable: manufacturers usually only deliver the appliances or systems and the specifications of the washing process (i.e. the “recipe” of the process, including programme time, temperature, dosage of chemicals, water/laundry ratio) are defined individually by the customer himself or the detergent provider. The energy, water and detergent (and other chemicals) consumption depends on the definition of the recipe (see Task 3).

The latest electricity and gas rates for industrial customers in MS are presented below, according to the different consumption classes. The EU average will be used in LCC calculations at a later stage of the study (Task 5 and Task 7).

5.3.1 Energy costs

Electricity rate

The electricity rate in EU depends on the consumption and therefore will vary depending on the customer types (which can be attributed to certain product types too). Three consumption bands for the electricity rate at industrial rates (IA – < 20 MWh, IB – 20-500 MWh, and IC – 500-2 000 MWh) are presented in Table 28.

Table 28 Electricity rates for industrial customers in EU-27,[43] average 2007-2009 (taxes excluded)

Member State	Consumption Band Rate (Euros/kWh)		
	Industrial – IA < 20 MWh	Industrial – IB 20 MWh – 500 MWh	Industrial – IC 500 MWh – 2 000 MWh
Belgium	0.141	0.120	0.097
Bulgaria	0.073	0.069	0.061
Czech Republic	0.161	0.129	0.106
Denmark	0.102	0.086	0.079
Germany	0.156	0.112	0.093
Estonia	0.071	0.059	0.055
Ireland	0.165	0.144	0.127
Greece	0.136	0.108	0.087
Spain	0.148	0.119	0.100
France	0.099	0.075	0.059
Italy	:	:	:
Cyprus	0.160	0.160	0.144
Latvia	0.110	0.086	0.077
Lithuania	0.107	0.094	0.083
Luxembourg	0.162	0.116	0.100
Hungary	0.128	0.125	0.116
Malta	0.151	0.148	0.137
Netherlands	0.161	0.103	0.088
Austria	0.111	0.104	0.086
Poland	0.136	0.101	0.085
Portugal	0.121	0.093	0.083
Romania	0.109	0.102	0.088
Slovenia	0.145	0.122	0.094
Slovakia	0.185	0.150	0.126
Finland	0.077	0.071	0.062
Sweden	0.108	0.078	0.068
United Kingdom	0.134	0.112	0.102
EU-27	**0.138**	**0.105**	**0.090**

Small hotels/restaurants are estimated to use less electricity, while large institutional facilities would use much more. Thus, an electricity price was allocated to each of the main market segments previously described:

- Coin & Card Laundry, Apartment Household Laundry: 0.138 Euros/kWh (band rate IA);
- Hospitality Laundry: 0.105 Euros/kWh (band rate IB);

[43] Eurostat (2009); Environment and Energy, Data in focus, 48/2009; extracteD12/08/2010

- Healthcare Laundry: 0.105 Euros/kWh (band rate IB);
- Commercial Industrial / Specialty Laundry: 0.090 Euros/kWh (band rate IC).

Taking into account the dominating market segments for each different product category presented in Table 28, the average electricity rates for LCC calculations are given in Table 29.

Table 29 Electricity rates for professional laundry appliances in the EU based on market segment shares

Type of appliance	Electricity rate (Euros/kWh)
Laundry machines	
WM1: Semi-professional washer extractor	0.138
WM2: Professional washer extractor, <15 kg	0.138
WM3: Professional washer extractor, 15-40 kg	0.105
WM4: Professional washer extractor, >40 kg	0.090
WM5: Professional washer dryer	0.105
WM6: Professional barrier washer	0.105
WM7: Washing tunnel machine	0.090
Dryers	
D1: Semi-professional dryer, condenser	0.138
D2: Semi-professional dryer, air vented	0.138
D3: Professional cabinet dryer	0.138
D4: Professional tumble dryer, <15 kg	0.138
D5: Professional tumble dryer, 15-40 kg	0.105
D6: Professional tumble dryer, >40 kg	0.090
D7: Pass-through (transfer) tumble dryer	0.090

The results are in line with the fact that smaller machines tend to be used in smaller establishments and hence have a higher electricity rate as shown in the table. Larger laundry machines would be used in facilities with higher electricity consumption and thus lower electricity rates.

Natural gas rates

Natural gas rates have to be taken into account for dryers which use natural gas fuel for heating. There are also few laundry machines using gas as a direct energy source (but indirectly, steam used to heat up the water may come from gas heating) but this option is more common for dryers. The evolution of natural gas rates between 2007 and 2009 as well as rates that vary depending on the customers' consumption as reported by Eurostat are presented in Table 30.

Table 30 Natural gas rates for consumers in EU-27,[44] average between 2007 and 2009 (taxes excluded)

Member States	Consumption band rate [Euros/GJ]		
	Industrial – I1 < 1 000 GJ	Industrial – I2 1 000 GJ – 10 000 GJ	Industrial – I3 10 000 GJ – 100 000 GJ
Belgium	12.4820	10.6260	8.7920
Bulgaria	7.2216	7.0365	6.5722
Czech Republic	10.4181	9.1017	8.4341
Denmark	13.7775	13.0929	7.0364
Germany	12.2960	11.5920	10.6360
Estonia	7.7399	7.2829	6.6899
Ireland	13.4760	10.8900	9.6740
Spain	10.6561	8.7573	7.9959
France	11.7276	10.2872	9.2532
Italy	11.0010	10.6386	9.0520
Latvia	10.2443	9.7811	9.0292
Lithuania	9.3861	9.1367	8.7945
Luxembourg	11.8760	10.5800	10.2420
Hungary	11.4618	10.7835	9.3420
Netherlands	11.8480	10.3720	8.7142
Austria	10.6300	10.4400	:
Poland	10.1192	9.2683	8.2000
Portugal	13.8253	10.7658	8.6272
Romania	5.5257	5.5080	5.6072
Slovenia	13.3580	12.6800	9.8840
Slovakia	11.7883	10.5191	9.9378
Finland	:	:	7.5800
Sweden	14.7633	13.1448	11.2499
United Kingdom	10.8420	8.4012	7.1704
EU-27	**11.2115**	**10.0097**	**8.7921**

Again, the three first consumption bands available for natural gas have been used here to determine the natural gas rates as they are assumed to be the applicable bands for professional laundry appliances customers (as was the case for electricity consumption bands), however, no specific data for natural gas consumption has been given:

- Coin & Card Laundry, Apartment Household Laundry: 11.2115 Euros/GJ (band rate I1);
- Hospitality Laundry: 10.0097 Euros/GJ (band rate I2);
- Healthcare Laundry: 10.0097 Euros/GJ (band rate I2);
- Industrial / High-Tech Laundry: 8.7921 Euros/GJ (band rate I2).

[44] Eurostat (2009); "Environment and Energy, Data in focus, 49/2009"; extracteD12/08/2010

Based on the market segments given in Table 17, the rates presented in Table 31 will be used for LCC calculations.

Table 31 Summary of the rates used for gas for professional laundry equipment

Type of appliance	Gas rate (Euros/GJ)
Laundry machines	
WM1: Semi-professional washer extractor	11.22
WM2: Professional washer extractor, <15 kg	11.22
WM3: Professional washer extractor, 15-40 kg	10.01
WM4: Professional washer extractor, >40 kg	8.79
WM5: Professional washer dryer	10.01
WM6: Professional barrier washer	10.01
WM7: Washing tunnel machine	8.79
Dryers	
D1: Semi-professional dryer, condenser	11.22
D2: Semi-professional dryer, air vented	11.22
D3: Professional cabinet dryer	11.22
D4: Professional tumble dryer, <15 kg	11.22
D5: Professional tumble dryer, 15-40 kg	10.01
D6: Professional tumble dryer, >40 kg	8.79
D7: Pass-through (transfer) tumble dryer	8.79

Preliminary information shows that gas may not be relevant for smaller laundry appliances. However this will be elaborated in later tasks (Task 3).

5.3.2 Water costs

The cost of water to consumers can be difficult to evaluate as it is either based on a variable rate which corresponds to consumption or a fixed rate which is set by local utilities.

An indication of water prices in France is shown in Figure 4, where a breakdown in the cost of water to consumers is given over 15 years.

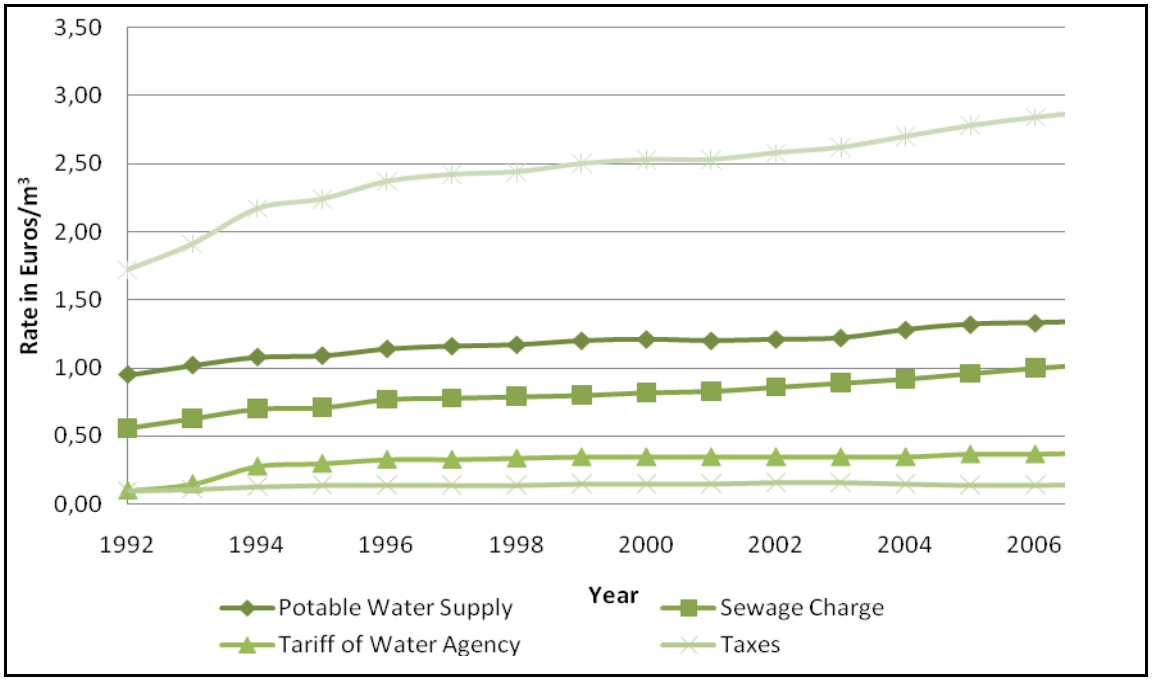


Figure 4 Water cost break down in Rhone region of France for 15 years

A final water tariff to the consumer can be observed at 2.90 Euros/m^3 with an average increase of 0.064 Euros/m^3 per year, suggesting a current water tariff in this region of France of 3.08 Euros/m^3. Furthermore, a study by the company BIPE analysed the water rate for eight major European cities in 2006. The relevant information is presented in Table 32.

Table 32 Water consumption and effective rate for eight European cities[45]

City	Water Consumption (m^3/capita/y)	Average persons per household	Average water bill per household (Euros)	Effective water rate (Euros/m^3)
Amsterdam	57	2.3	506	3.86
Athens	61	2.7	171	1.04
Berlin	43	1.8	360	4.65
London	54	2.4	312	2.41
Madrid	61	2.9	207	1.17
Paris	52	1.9	229	2.32
Rome	104	2.6	229	0.85
Stockholm	77	2.0	303	1.96

[45] Consumption, persons per household and average water bill per household taken from: BIPE, Analysis of Drinking Water and Wastewater Services in Eight European Capitals: the Sustainable Development Perspective, 2006

Based on the population of the above cities, the weighted average water rate for the eight cities cited by BIPE is 2.38 Euros/m^3.

Based on the above sources, a water rate extrapolated from the weighted average of the eight largest cities in the EU to the year 2010 based on the evolution of water price experienced in France over 15 years gives a water price of **2.64 Euros/m^3** for the EU-27.

This figure will be used to calculate the LCCs of laundry equipment in Task 5 of this study and may impact the LCCs of these appliances when considered on the scale of the entire European laundry machines market. As water consumption is arguably a central theme to efficiency, this figure will be used in a sensitivity analysis to determine how variations in this price affect the LCC of professional laundry equipment. This will also help to evaluate the high variability in water prices found in the above analysis.

Starting from 2010, the Water Framework Directive[46] requires MS to improve their water management strategy through setting pricing and policy incentives to preserve the natural water systems of MS. It can be expected that in years to come, the price of water will become an increasingly large concern for professional laundry equipment manufacturers and likewise, professional laundry equipment users, as MS gradually increase the cost of water to reflect environmental and resource use costs more adequately, as defined in the Directive.

5.3.3 Detergent costs

There is a wide variety of detergents available. For household laundry equipment, the sales proportions of the UK detergent market, expected to be representative of the EU market in the absence of authoritative EU-level data, are the following: 40% powders, 20% tablets, 16% super concentrated liquids, 15% liquid tablets, 5% gels and 4% concentrated liquids.[47] Regarding the commercial sector, the situation is slightly different as customers often choose their suitable detergent formula in order to adapt their washing process to the type of garment and soiling they deal with: there is more customer-specific demand. Thus the range of chemicals used in the washing process is even broader: on-premise laundry detergents; fully formulated detergents; powder/liquid detergents; pre-wash additives; boosters; pH-adjustment; water hardness regulators; bleach additives; disinfectant detergents/additives for hygienic laundry (hospital, food industry); fabric softeners; starch finishing; ironing aid; fragrance rinse; etc (cf. Task 1). The industrial and institutional sector of laundry detergents (including the products previously quoted) in 2008 represented 0.66 billion Euros and 10% of the global Industrial & Institutional (I&I) products sector (see Figure 5).

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[46] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Available at: http://europa.eu/legislation_summaries/agriculture/environment/l28002b_en.htm; accessed 01 Feb 2010

[47] BIO Intelligence Service / Giraffe / Intertek (2009); “Reducing the environmental impacts of clothes cleaning”; for DEFRA

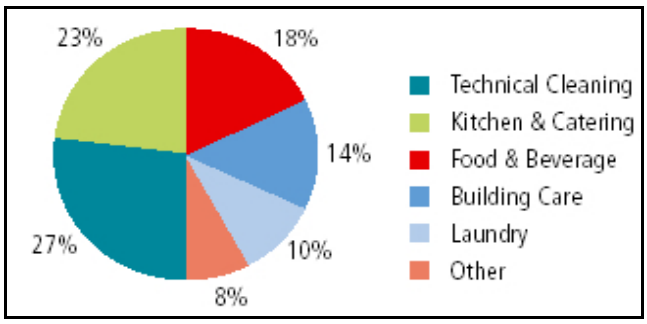


Figure 5 Value of industrial and institutional products by category in EU-27+NO+CH, 2008[48]

It would not be realistic to try and assess prices and quantities used of each of these products for each product category. The simplified tool that is used for the environmental and economic assessment in Task 5 (called EcoReport) only has one type of detergent in its database. Thus one single price for detergent will be determined and used within the whole study. A sensitivity analysis is carried out in Task 8, taking into account the possible variations of the detergent rate.

The types of detergents used in professional laundry equipment might also change in future as laundry sustainability programmes have been launched by A.I.S.E since 2006 in order to promote the use of compacted powders, which are more environmentally-friendly than non-compacted detergents.[49]

Prices for commercial laundry detergents are not publicly available but we can assume that there is wide variation in the prices of detergents found in Europe. Also, commercial laundry prices can be expected to be slightly cheaper than household laundry detergents, as customers buy in bulk. For the purposes of this study, the cost of detergent is assumed to be **2 Euros/kg**, which is based on an internet search; stakeholders including manufacturers and professional detergent associations were unable to provide data. This price will be translated into a direct cost for the consumer for each wash cycle in later tasks when the amount of water, concentration of detergent and frequency of use is characterised (Tasks 3 and 4).

The total annual volume of fabric washing detergents used in commercial laundries is estimated to be about 10% of the volume used by consumers in the household market[50].

[48] A.I.S.E, Annual review 2008. Available at: http://www.aise.eu/downloads/AISE_AR2008FINAL.pdf

[49] http://www.aise.eu/downloads/AISE%20SR-AR2009-2010.pdf

[50] Association Internationale de la Savonnerie, de la Détergence et des Produits d'Entretien (2000), Professional laundry and the environment.

5.3.4 Interest and inflation rates

Table 33 shows the latest reliable national inflation and interest rates for the EU-27 as published by Eurostat and the European Central Bank (ECB). Figures from 2007 have been given as more recent data is unavailable for 2008 and 2009.

Table 33 Interest and inflation rates for EU-27

Member State	Inflation rate [%][51]	Interest rate [%][52]
Austria	2.9	4.29
Belgium	2.8	4.33
Bulgaria	10.9	4.54
Cyprus	3.4	4.48
Czech Republic	5.1	4.28
Denmark	2.3	4.29
Estonia	9.3	5.69
Finland	2.5	4.29
France	2.5	4.30
Germany	2.7	4.22
Greece	3.7	4.50
Hungary	7.2	6.74
Ireland	3.1	4.31
Italy	2.7	4.49
Latvia	13.8	5.28
Lithuania	8.6	4.55
Luxembourg	3.5	4.56
Malta	2.3	4.72
Poland	3.6	5.48
Portugal	2.6	4.42
Romania	6.7	7.15
Slovakia	2.6	4.49
Slovenia	5.3	4.52
Spain	3.7	4.31
Sweden	2.4	4.17
Netherlands	1.7	4.29
UK	n.a.	5.06
EU-27 Average	**3.0**	**4.58**

[51] 12 month average rates May 08-07 / May 07-06; source: Eurostat; http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/08/85&format=HTML&aged=0&language=EN&guiLanguage=en

[52] European Central Bank long-term interest rates; 10-year government bond yields, secondary market. Annual average (%), 2007; http://epp.Eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-30-08-410/EN/KS-30-08-410-EN.PDF

The above information regarding the economy in general has changed significantly since it was published, effectively rendering it obsolete: it will not be used in this study. The European Commission has provided a general discount rate for this project to be assumed at **4.0%**.

5.4 Maintenance and service costs

Stakeholders have commented that service contracts are usually included as part of the purchase of professional laundry equipment. The exact nature of the contracts can vary and depends on the type of equipment, complexity and capital cost. Normally more sophisticated and expensive equipment have more elaborate and comprehensive service contracts to help ensure a long product lifetime and payback period on capital investments. For smaller appliances dealers or wholesalers may provide warranty services to clients on behalf of the manufacturer, or they may also provide the warranty services at their own expense as part of the dealer arrangement between the manufacturers. For heavy duty appliances, the manufacturer typically services the product as these products are also typically sold directly from the manufacturer themselves. The amount of money represented by the maintenance and repair costs is not negligible in the assessment of the life cycle costs of professional laundry appliances. Stakeholders have estimated that maintenance and repair costs represent approximately:

- 3% of the purchase price of the product over the whole lifetime for categories WM1-2-3-5 and D 1-2-3-4-5;
- 25% of the purchase price over the whole lifetime for categories WM 4-6-7;
- 18% of the purchase price over the whole lifetime for categories D6-7.

These values will be used to estimate the life cycle costs of the appliances later in the study.

A recent study[53] in the US also assessed the annual repair and maintenance costs of professional washer equipment. The ratios of the repair and maintenance costs (over the lifetime) on the purchase price of three product categories are presented in Table 34.

Table 34 Repair and maintenance costs over lifetime of professional laundry equipment[53]

Category	Purchase price	Repair and maintenance costs over lifetime	Ratio
Single-load	$1 090	$274	25%
Washer extractor	$190 000	$112 500	59%
Tunnel washer	$1 100 000	$209 000	19%

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

Despite slight differences in the product category definitions between the two studies, single-load machines are similar to WM1 while washer extractors correspond to WM2-3 and tunnel washers to WM7. The amount of money spent for repair and maintenance over the lifetime of the appliances is much larger according to this table, than the 3% indicated by stakeholders but is similar for tunnel washers (19%). This is most likely due to differences in definition and differences between the US and EU markets, for example in terms of service contracts. The feedback from the manufacturers was therefore used as estimations of the maintenance and repair costs.

Stakeholders have commented that the most common items for maintenance on professional laundry equipment are control panels, doors, drive belts, and heating elements. All these components in professional laundry machines and dryers are easily replaceable and generally justify maintenance rather than replacing the entire machine. The most common cause for professional laundry machine breaking is operator misuse or abuse.

5.5 Disposal costs

In general, most commercial laundry service establishments need a working laundry appliance for daily operation. As a result, for all replacement sales, the old laundry unit is removed at the same time as the new unit is provided.

Many professional laundry machines can be refurbished and resold as second hand products by dealers. These products generally are given some new elements (drive belts, doors...) as was described as the most common items to fail in the maintenance section.

Professional laundry equipment that is not refurbished is almost always recycled for scrap parts. A large majority of the materials is valuable metallic parts (stainless steel) and the value for scraps is high. As a result, most dealers or manufacturers will offer to remove the old appliances on purchase and delivery for new units, and may even provide the customer with a discount for the salvaged product.

As a result, this study will assume the **disposal cost for professional laundry equipment is 0 Euro per product.**

5.6 Summary of end-user expenditure

Table 35 summarises the consumer expenditure data presented in the previous sections. This data will be useful in later tasks (especially Task 5) for estimating life cycle properties of these products.

Table 35 User expenditure base data

Category	Cost items	Units	Value
Purchase	Purchase price	Euros/product	800–500 000
Purchase	Delivery and installation	% of product price	4 (9 for heavy duty)
Use	Electricity rate	Euros/kWh	0.090–0.138
Use	Gas	Euros/GJ	8.79–11.21
Use	Water rates	Euros/m^3	2.64
Use	Detergent	Euros/kg	2
Use	Interest-inflation rate	%	4
Maintenance	Servicing and repair	% of product price	3–25
Disposal	Removal and disposal / recycling	Euros/product	0

6 Conclusion

In conclusion, Task 2 presents the professional laundry appliances market sector with generic economic data extracted from the Eurostat database, completed by information obtained directly from the main manufacturers.

The main manufacturing Member States identified are Germany, Spain and Sweden. The smallest professional appliances (professional washer extractor, <15 kg, professional tumble dryer, <15 kg) are the most sold product types, followed by semi-professional machines. Largest products (professional barrier washer, washing tunnel machine, pass-through tumble dryer) have low sales as these machines are reserved for heavy duty installations. Their environmental impacts should not be neglected, however, due to the intensity of use and the large capacities of these machines.

The task also contains the consumer expenditure data that will serve as a basis for the economic analysis of the base cases (Task 5) and the improvement options (Task 7). Purchase prices of professional laundry appliances are comprised between 800 and 500 000 Euros. As a general remark, customers show an interest in more energy-efficient products, provided that these products result in cost savings in the long term.

7 Annex

7.1 Dry-cleaning equipment

The following shall provide a brief description of the market situation of professional dry-cleaning machines in Europe. Please note that during the course of the study, dry-cleaning equipment has been excluded from the scope of Lot 24.

PRODCOM analysis

The PRODCOM database is useful for an initial analysis as it contains transparent and publicly available data provided by Member States of the EU on manufacturing and production information within the EU.

The dry-cleaning machines are labelled by the PRODCOM code 28942250. The production quantities between 2005 and 2009 are presented in Table 36.

Table 36 Number of dry-cleaning machines produced, 2005-2009[54]

Country	2005	2006	2007	2008	2009
Austria	0	0	0	0	0
Belgium	0	0	0	0	0
Bulgaria	0	0	0	-	0
Cyprus	0	0	0	0	0
Czech Republic	0	0	0	0	0
Denmark	0	0	0	0	0
Estonia	0	0	0	0	0
Finland	0	0	0	0	0
France	0	0	0	0	0
Germany	-	-	-	-	-
Greece	-	-	-	-	-
Hungary	0	0	0	0	0
Ireland	0	0	0	0	0
Italy	4 088	5 917	10 414	8 996	6 959
Latvia	0	0	0	0	0
Lithuania	15	10	5	7	5
Luxembourg	0	0	0	0	0
Malta	0	0	0	0	0
Netherlands	0	0	-	0	0
Poland	0	0	0	0	0

[54] PRODCOM statistics based on NACE 2 Rev. accessed on 31.08.2010 at: http://epp.Eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database

Country	2005	2006	2007	2008	2009
Portugal	0	0	0	0	0
Romania	0	0	0	0	0
Slovakia	0	0	0	0	0
Slovenia	0	0	0	0	0
Spain	-	-	-	-	-
Sweden	0	0	0	0	0
United Kingdom	0	0	0	0	0
EU 27	4 603	6 874	14 000	15 000	10 400

'-' signifies that the information is unavailable. Source: PRODCOM

The PRODCOM data suggests that Italy is a very important manufacturer of dry-cleaning machines (64% of the EU 27 production in 2008 and 67% in 2009). However, in 2007, 2008 and 2009, a large share of the EU 27 total is missing. As no information is available for Germany, Spain and Greece, these countries may be important producers as well. Stakeholders' information confirmed that the main producing Member States are Italy and Germany.

In terms of production values, Italy represented 94% of the EU 27 total in 2009 (see Table 37). The figures are again missing for Germany, Spain and Greece which might explain the gaps between the EU 27 total and the sum of the available Member States figures.

Table 37 Value of dry-cleaning machines by Member State (thousand Euros) produced in EU 27, 2005-2009[55]

Country	2005	2006	2007	2008	2009
Austria	0	0	0	0	0
Belgium	0	0	0	0	0
Bulgaria	0	0	0	-	0
Cyprus	0	0	0	0	0
Czech Republic	0	0	0	0	0
Denmark	0	0	0	0	0
Estonia	0	0	0	0	0
Finland	0	0	0	0	0
France	0	0	0	0	0
Germany	13 520	-	-	-	-
Greece	-	-	-	-	-
Hungary	0	0	0	0	0
Ireland	0	0	0	0	0
Italy	87 627	132 417	199 152	174 765	120 662

[55] PRODCOM statistics based on NACE 2 Rev. accessed on 31.08.2010 at: http://epp.Eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database

Country	2005	2006	2007	2008	2009
Latvia	0	0	0	0	0
Lithuania	40	28	19	20	14
Luxembourg	0	0	0	0	0
Malta	0	0	0	0	0
Netherlands	0	0	-	0	0
Poland	0	0	0	0	0
Portugal	0	0	0	0	0
Romania	0	0	0	0	0
Slovakia	0	0	0	0	0
Slovenia	0	0	0	0	0
Spain	-	-	-	-	-
Sweden	0	0	0	0	0
United Kingdom	0	0	0	0	0
EU 27	101 200	140 000	215 738	188 069	128 324

'-' signifies that the information is unavailable. Source: PRODCOM

Dry-cleaning is considered a business-to-business market. Small companies account for 60% of sales, while 40% are distributed among big industrial companies. Small-and medium-sized machines are mainly sold in Europe and the Middle East, while the principal market for bigger equipment is located in the United States. Domestic consumption accounts for 70% of European sales according to PRODCOM figures.

Main manufacturers

The following enterprises have been identified as manufacturers of dry-cleaning machines in Europe. Brackets refer to the country where the headquarters are located.

- Techno-dry (Italy)
- Real Star (Italy)
- ILSA (Italy)
- Firbimatic (Italy)
- Ama Universal (Italy)
- Bergparma (Italy)
- Lindus (Italy)
- Maestrelli (Italy)
- Union Spa (Italy)
- Italclean (Italy)
- Renzacci (Italy)
- MIPA (Italy)
- Suprema (Italy)
- EazyClean Technologies (Germany)
- Böwe (Germany)
- Satec (Germany)

Sales estimation

According to PRODCOM[56] values, the average value of dry-cleaning units in Europe was around 12 340 Euros per unit in 2009.

Table 38 Apparent sales of dry-cleaning equipment in EU-27, according to PRODCOM values for 2009

	Quantity (EU-27) (units)	Total value EU-27 (Euros)	Value/unit[b]
Production (P)	10 400[a]	128 324 502[a]	12 340
Import (I)	190[b]	2 348 380[a]	12 340
Export (E)	2 675[b]	33 008 180[a]	12 340
Apparent sales (P+I-E)	**7 915[b]**	**97 664 702[b]**	**12 340**

[a] *Figure from PRODCOM Eurostat*
[b] *Calculated figure*

In Table 38, sales of dry-cleaning machines are estimated at around **7 915 units** per year in 2009 within EU-27, according to PRODCOM figures. No differentiation by technology (per-chlorethylene, hydrocarbon, cyclosiloxane) was found. Italy, Germany, France, Spain and the United Kingdom are the main European markets of these appliances. According to a stake-holder's market analysis, the sales in these countries in 2009 are estimated at 250 appliances in Italy, 70 units in Germany, 100 units in France, 150 units in Spain and 75 units in the UK. Given that these countries represent the majority of EU sales, these estimations result in a much lower sales figure than the one estimated through PRODCOM as EU sales would then represent around **1 000 units** in 2009. At first sight, the PRODCOM-based estimation seems less reliable than the direct evaluation from stakeholders, because of the data gaps and unusual trends between 2005 and 2009.

Purchasers of these machines are mainly small businesses offering retail services and big industrial service providers. Figures from the United States suggest that the ratio of retail to industrial companies is 20:1. In both cases, the service can be related to clothing, rugs and leather items, among others. The estimated useful life of the machines is up to 20 years, considering major maintenance actions have to be taken at 10 years.[57]

Estimation of the stock

A study directed by First Research Industry Profile estimated that the total amount of companies providing dry-cleaning services in the United States (2005) was about 20 000 for

[56] http://epp.Eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database

[57] Source: www.dentoncad.com/index.php?option=com_docman&task=doc_download&gid=394&Itemid=37, Stakeholders questionnaire answers

retail service and 1 000 at industrial level.[58] For Europe, the estimate is up to 60 000 considering differences in behaviour, total gross domestic product (GDP) and total population. According to stakeholder inputs, the total number of dry-cleaning stores in 2003 in the EU was 54 600, with the following breakdown: 43 700 stores with one single machine, 8 050 stores with two to four machines and 2 850 stores with more than four machines. A rough estimation of the stock thus gives 76 400 appliances in the EU in 2003.[59]

The figures for dry-cleaning stores in 2010 show that the dry-cleaning market has been shrinking since 2003 in France, Germany and Italy, which are the countries with the biggest markets.

Table 39 Number of dry-cleaning stores[60]

Dry-cleaning stores	2003	2010	Average annual decrease
France	5 800	4 500	3.7%
Germany	3 900	3 500	1.6%
Italy	22 000	14 800	5.8%
EU	54 600	-	-

The PRODCOM data already presented is much more variable and despite a decrease between 2007 and 2009 in the production figures (see Table 36), the number of units produced in 2009 is twice the production in 2005, a trend which does not seem very likely. The PRODCOM data should thus be considered with caution.

The stock in 2010 can be estimated by assuming that the share of France, Germany and Italy in the total number of dry-cleaning stores in the EU has remained constant between 2003 and 2010. The number of dry-cleaning stores in these three countries represented 58% of the total number of stores in the EU in 2003. The number of dry-cleaning stores in the EU is then estimated at 39 300 in 2010. Assuming that the stores have the same number of machines on average in 2003 and in 2010, **55 000 dry-cleaning machines** should be in use in the EU in 2010. This figure is consistent with estimations that stakeholders made for stocks at national level: 3 500 appliances in Germany, 5 000 in France and 6 000 in Spain.

Given the lifetime estimated at 20 years and the stock of 55 000 appliances, it looks surprising to have a sales number of only 1 000 products per year. A sales estimation of 2 500-3 000 appliances would be more in line with the stock. Several factors might explain this phenomenon: the error on the sales estimation (PRODCOM, estimated less relevant,

[58] Source: First Research Industry Profile; Dry Cleaning and Laundry Facilities, 2005.

[59] Assuming an average of three machines for stores with two to four machines and five machines for stores with more than four machines.

[60] Source: Stakeholder inputs. Data for other Member States was incomplete or not available.

however shows much higher sales figures than stakeholder input); the recent decrease of the dry-cleaning sector, lowering the sales number at a given time in comparison with the number of appliances used during a period of 20 years; and the fact that a large number of dry-cleaning shops are closing down every year, introducing a lot of second-hand machines to the market, especially in Italy.

The market share of small machine sales is expected to remain roughly constant or decrease for two main reasons: new fabric technologies have widened the spectrum of washable clothes and new household products capable of "dry cleaning" with similar results.[61]

The total cost of dry-cleaning machines can be divided into five categories:

- Purchase and installation costs

  The purchase price of dry cleaning machines depends on the country in which the machine is meant to be used. Industry sources indicate that French and German regulations are the most demanding in this regard. Therefore, the machinery should include specific characteristics that increase the price. The list price of an appliance of 15 kg capacity that complies with French standards is estimated to be between 30 000 and 35 000 Euros. Installation costs are estimated to reach up to 15% of the purchasing cost.
- Running costs – running costs are the costs incurred to operate the dry-cleaning machine throughout a typical lifetime. They may include electricity costs and costs of consumables (detergents, water, filters, etc.).
  - Energy cost: this is expected to be significant over the life cycle of dry-cleaning machines. The latest costs for industrial customers are presented below, according to the different consumption classes.
    - *Electricity rate:* three consumption bands are presented in Section 5.3.1 for the electricity rate at industrial rates (IA – < 20 MWh, IB – 20-500 MWh, and IC – 500-2 000 MWh) in the table below (source: Eurostat). Retail service providers are assumed to be in the IB range, while industrial service providers are assumed to be in the IC rate band.
    - *Natural gas rates*: natural gas rates have to be taken into account for dry-cleaning machines which use natural gas fuel for heating. The rates vary depending on consumption as reported by Eurostat and presented in the Section 5.3.1. Machines using gas as an energy source are likely to be used for industrial purposes. Therefore, the IC rate band is expected. The percentage of dry-cleaning machines using gas remains unknown.

[61] Recent wet-cleaning appliances have been approved to clean garments labeled as P (dryclean only).

- Water rate: A small portion of water is used in the process. Water rates are presented in Section 5.3.2.
- Consumables:
  - *Detergents*: dry cleaning consumables are represented by the solvent used in the process and the required detergent. According to some studies and websites selling the products, the type of solvent influences the price: on average, perchloroethylene (Perc) costs around 1.7 Euros per litre, and it requires the purchasing of special detergents (4.4 litres of detergent/litre of Perc) at an approximate cost of 5.5 Euros/litre. Hydrocarbon dry-cleaning reduces the price of the solvent (1.2 Euros/litre) but increases the consumption. A business using two machines to process about 75 000 kg of clothing per year can use around 2 300 litres of Perc per year or 2 500 litres of hydrocarbon over the same period (using two hydrocarbons machines). From these figures, the estimated consumption of solvent is 0.031 litres of Perc/kg of laundry and, 0.033 litres of hydrocarbons/kg of laundry[62].

- Maintenance costs – the costs incurred by the owner of the dry-cleaning machines throughout the lifetime of the machines to ensure their proper and effective operation. According to a study from the United States, the maintenance cost can reach up to 12 Euros/hour, and is required around 620 hours per year. This translates to 7 440 Euros per year of maintenance. Hydrocarbon equipment maintenance is almost 100% more expensive than for Perc appliances, including the cost of special maintenance equipment.
- Disposal costs – in the market there are several providers of refurbished machines. This leads to the conclusion that most machines are re-used at the end of their useful life, either by refurbishing or recycling valuable metallic parts.
- Labour costs are neglected as they are assumed not to be relevant for the study at hand.

7.2 Questionnaires “Task 2” for stakeholders

These papers are provided separately:

- EuP_Lot24_Wash_T2_Annex_Questionnaire.pdf
- EuP_Lot24_Wash_T2_Annex_Additional_Questionnaire.pdf
- EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

[62] Source: M. Morris & K. Wolf.; Hydrocarbon Technology Alternatives to Perchloroethylene for Dry Cleaning. 2005

7.3 Stakeholder feedback to draft versions of Task 2

Please note that the feedback refers to prior versions of draft Task 2 report; thus the indicated numerations of chapters, tables, figures or pages might have been changed.

Feedback		Comment
JRC-IPTS		
	A section referring to the intra-community trade market of the products based on Eurostat and/or on real market data is missing.	PRODCOM provides import and export data for the products by Member State. A breakdown by destination is not available, precluding a distinction between intra-community and extra-community trade. The available PRODCOM data have been provided, as well as data from the Eurostat INTRA database.
	With respect to the previous point a section referring to the extra-community trade market of the covered products is missing.	PRODCOM provides import and export data for the products by Member State. A breakdown by destination is not available, precluding a distinction between intra-community and extra-community trade. The available PRODCOM data have been provided, as well as data from the Eurostat EXTRA database.
	A calculation of the apparent consumption of the product group based on Eurostat data is missing.	Will be included in the next task version.
	The apparent consumption is calculated by a developed model in which a number of assumptions are made. This model is mainly based on numerous proportion values which where estimated based on stakeholder input. No cross-check has been made. Eurostat data (see attached spreadsheets) indicate strongly differing values (please see below in detailed comments section). These differences should be presented, analysed and explained.	The project team is aware that the market data is highly dependent on stakeholder inputs but the data presented in Eurostat does not seem highly reliable. Also, the stakeholder collaboration depends on their willingness to co-operate, and companies have limited resources for data gathering. Differences with Eurostat data have been stated and will be more thoroughly analysed.

Feedback		Comment
	The calculation of the product stock data values is not sufficient. Data gaps of sales in several years are filled in with reverse calculations based on estimated apparent consumption values for one year. A more robust determination of these values is needed. In the current version of the stock sales values, all calculations rely on one estimated aggregated value of one year and several additional. The environmental performance of the product as computed in the MEEUP methodology is strongly based on the stock data values. Thus, these rates strongly affect the final outcome and therefore need to be developed in a more reliable way.	We agree that the data limitations make the stock estimation quite uncertain. We have used the available sales data and a simple, transparent extrapolation to calculate stock. Also, please be aware that although the stock numbers will affect the total EU estimations, they have no influence on the relative difference between the base case and the improved products when expressed in percentage terms (for the environmental and economic analyses and also in the scenario analysis of Task 8).
	Various values presented in Section 2.3.2 on product-specific trends are not substantiated. There is no reference, and therefore lacks transparency and traceability of them. References and complementary sources should be presented and in case of stakeholder input, the metadata on the stakeholder information panel is considered necessary.	References and complementary sources will be added in the revised version.
	Similar, to draft Task 2 report on professional dishwashers, part of Lot 24, stakeholder input is the main used source. For sake of transparency metadata information on the survey basis and the response of the stakeholders is necessary.	To be included, to the extent possible (confidentiality issues).
	Starting from Section 2.4.3 and up to Section 2.4.5, several paragraphs have been copied and pasted from the draft Task 2 report on professional dishwashers. This information, to the extent that it is relevant, should be properly referenced and presented in a different form.	The study was split into two sections, “dishwashers” and “washing machines and dryers”, by the project team but these two parts belong to the same study, Lot 24. Some information is common to both parts so it does not seem appropriate for one part to reference the other. As professional dishwashers and laundry appliances have some similar aspects (regarding their end users, recycling behaviour, etc.), it is natural that some information would be relevant to both product groups. Another consistency check will nonetheless be carried out.

Feedback		Comment
VDMA – Garment and Leather Technology		
Draft Version Task 2 Report	On the occasion of Interim Stakeholder Meeting for the laundry part on 1st October 2010 in Paris we would like to issue comment to Draft Version Task 2 on the topic "sales by product type for the categories WM 6-7: Heavy duty washers" as follows: From our point of view, 400-450 tunnel washing machines are sold per year. You can calculate one press or centrifugal extractor (65% presses and 35% centrifugal extractors) and 4-5 transfer dryers per tunnel washer worldwide. The verified total amount of heavy duty washer extractors and professional tumble dryers is unknown to us.	Noted
	Due to our experience we assume that 65% to 70% of the machines are delivered into the EU. Therefore we think it is possible to calculate with approximately 280–315 tunnels, approximately 280–315 presses or extractors and approximately 1120–1575 transfer dryers in the EU.	Noted
	From our point of view the described lifetime (Table 2-11) of the heavy duty tunnel washers and the transfer dryers is more than 20 000 h.	Noted and amended in the next task
	We support the statement "Exclusion of heavy duty appliances". Furthermore we suggest also the exclusion of WM5 and D5 due to the minor amount of heavy duty units in the industrial market segment.	Noted

Further Feedback from VDMA

VDMA

Garment and Leather
Technology Association

VDMA comment on Preparatory Studies for Eco-Design Requirements of Energy-using Products
Lot 24: Professional washing machines, dryers and dishwashers (Tender No. TREN/D3/91-2007)
Draft Version Task 2 Report Professional laundry machines and dryers

On the occasion of Interim Stakeholder Meeting for the laundry part on 1st October 2010 in Paris we would like to issue comment to Draft Version Task 2 on the topic "*sales by product type for the categories WM 6-7: Heavy duty washers"* as follows:

From our point of view, 400-450 tunnel washing machines are sold per year. You can calculate one press or centrifugal extractor (65% presses and 35% centrifugal extractors) and 4-5 transfer dryers per tunnel washer worldwide. The verified total amount of heavy duty washer extractors and professional tumble dryers is unknown to us.

Due to our experience we assume that 65% to 70% of the machines are delivered into the EU. Therefore we think it is possible to calculate with approximately 280 – 315 tunnels, approximately 280 – 315 presses or extractors and approximately 1120 – 1575 transfer dryers in the EU.

From our point of view the described lifetime (Table 2-11) of the heavy duty tunnel washers and the transfer dryers is more than 20,000 h.

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We support the statement “Exclusion of heavy duty appliances”. Furthermore we suggest also the exclusion of WM5 and D5 due to the minor amount of heavy duty units in the industrial market segment.

Munich, 29th September 2010

- 2 -

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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

May 2011

Final Report,
Part: Washing Machines and Dryers

Task 3: Consumer Behaviour and Local Infrastructure

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For reasons of better readability, two Task 3 reports were prepared.

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

The Task 3 report on *professional dishwashers*
is published separately.

For the benefit of the environment, this document has been optimised for **double-sided printing**.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective

Consumer behaviour can – in part – be influenced by product-design but overall it is a very relevant input for the assessment of the environmental impact and the Life Cycle Costs of a product. One aim of this task is to quantify relevant user-parameters that influence the environmental impact of products during product-life. A second aim is to identify barriers and restrictions to possible eco-design measures, due to e.g. infra-structural factors. As currently no applicable performance measurement standard for professional washing machines and dryers exists (cf. Task 1),[1] the data might be the basis for the development of new standard test conditions. These data serve for calculations of life cycle environmental impacts and costs in later tasks.

The choice of the appropriate washing machine or dryer type depends, amongst other criteria, on the amount of laundry to be cleaned or dried in the establishment. Thus, Section 2 provides a first overview of the main application areas and capacity ranges of the different product categories. Combined with the typical use intensity for each washing machine and dryer category, the total amount of cleaned and dried laundry per year for each product category is calculated.

In Section 3, ideal user behaviour is described in general, which is intended to correlate to the specific consumptions values (i.e. per kilogram laundry) given by manufacturers. By multiplying the typical weight of laundry cleaned or dried per year with the specific consumption values, the energy, water and detergent consumption per year under ideal conditions are calculated for each product category.

In Section 4 aspects of real life operating conditions are described and their influence on the consumption of the appliances is quantified (if possible). Section 5 identifies and describes barriers and opportunities relating to the local infrastructure. Finally, Section 6 gives information about the end-of-life behaviour, i.e. repair-, maintenance and disposal practice.

[1] The ISO 9398 standards for industrial laundry machines define the measurement method for the energy and water consumption but do not include the performance. Furthermore, the standard does not describe the common used process in the different laundry market areas. For this reason, most manufacturers (according to Electrolux professional, Kannegiesser, and Miele professional) do not use these standards. Instead, they use internal test procedures under “ideal” use conditions which allow direct comparison between models of similar performance characteristics.

1.2 Methodology and assessment of data quality

In order to derive information on user behaviour and its influence on resource consumption a stepwise approach was taken. All information provided in Task 3 has been collected through a self-administrated survey amongst the stakeholders (see Annex, Sections 7.1 and 7.2). For this purpose, a draft version including preliminary assumptions was prepared on the basis of discussions with stakeholders and literature. The working paper was then circulated to stakeholders (manufacturers, industry associations, user associations). The feedback was used to adjust the preliminary assumptions.

In order to identify the knowledge of manufacturers about their consumers' behaviour and their strategy in terms of eco-design and environmental communication, several manufacturers representing a large share of the European Market[2] were asked for input in the working paper. Five stakeholders replied to the self-administrated working paper by December 2010. Following the discussions at the final stakeholder meeting in Brussels, 12 January 2011, an additional questionnaire regarding the most relevant parameters (e.g. consumption values and local infrastructure) has been sent out. The objective of this questionnaire was to complement/confirm/consolidate the preliminary assumptions. Feedback from four manufacturers (Miele (D), Girbau (ES), Electrolux (SE), and Primus (CZ)) and from the German Engineering Federation VDMA has been received with regard to the additional questionnaire.

The answering manufacturers represent a major market share: According to PRODCOM data in Task 2, Germany and Spain together represent 29% in terms of units produced and 50% (washing machines) to 85% (dryers) in terms of the sales value. Further, analysis in Task 2 shows that also Sweden, Belgium and Czech Republic are major manufacturing countries in the EU; however, their production and sales data are not published in PRODCOM. According to manufacturers' feedback in Task 2, the manufacturers including VMDA members responding to our survey cover approximately 70% to 80% of the market (see Task 2, Table 14). This also includes the Eastern European market as the responding manufacturers also sell and represent the major market share in these countries.

Further, VDMA manufacturers and Miele, Electrolux and Primus principally focus on different washing machine and dryers categories (however, with some machines sizes overlapping): VDMA members tend to produce rather large appliances, whereas the other manufacturers tend to produce smaller applianes. Girbau even offers the whole range of product categories. Thus, the respondents to our questionnaire also represent the laundry market with regard to the machine categories being in the scope of Lot 24.

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[2] Many of the professional laundry manufactures are not organised in associations. Moreover, there is no European association for professional manufacturing, except for some manufactures of industrial machines (for the plant engineering and construction) being members of VDMA (German Engineering Federation) – working group "Garment and Leather Technology".

Unfortunately, the user side of professional washing machines (WM) and dryers (D) or their associations have not participated in the survey. However, as around 20 percent of professional washing machines and dryers are usually sold directly from manufacturers to users and tuned to customer specific requirements upon purchase (cf. Task 2) manufacturers have at least in this market segment quite good knowledge on the user behaviour. This is especially true for the larger washing machines and dryers, but also partly for the other professional and semi-professional washing machines and dryers. For the semi-professional and smaller machines the information by manufacturers were additionally counterchecked with previous preparatory studies on household appliances (Lot 14 and Lot 16).Thus, manufacturers' estimations on the typical user behaviour can be judged as viable.

Due to the lack of an applied European measurement standard it is difficult to assess and compare the compiled consumption data for the energy, water, detergent of professional washing machines and dryers. In addition, the information coming from the manufacturers on consumption values is usually given under "ideal" use conditions, i.e. for example, standby times or partial loading of washing machines or dryers are neglected. Additionally, as the exact measuring conditions may vary between different manufacturers, the information on specific consumption values (e.g. kWh per kg) has to be handled with care. This applies particularly because the information is often used for promotional purposes and tends to understate the consumption.

1.3 Sinner's Circle principle ("Sinner'scher Kreis")

To achieve a certain degree of washing performance with professional washing machines, four interdependent factors[3] interact and have to be optimally adjusted (so called "Sinner's Circle", see also Figure 1).[4]

- Temperature (thermal energy consumption);
- Mechanics (mechanical energy consumption);
- Chemistry (type and concentration of detergent and laundry aid);
- Time.

[3] These factors are similar in each washing or cleaning process, i.e. also for household dishwashing or in case of laundry treatment.

[4] See e.g. aid Infodienst (2005) and DIN 10510.

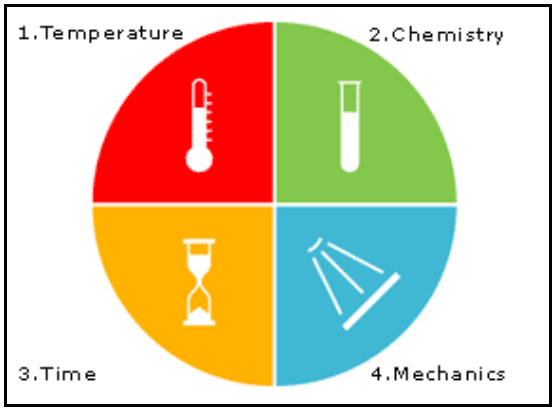


Figure 1 Factors influencing the washing process: Sinner's Circle ("Sinner'scher Kreis")[5]

As most of these factors might also be influenced by consumer behaviour, the Sinner's Circle principle should be taken as theoretical background for Task 3.

If a certain degree of cleaning performance shall be achieved, one factor can only be reduced (e.g. temperature, resulting in lower energy demand), if another factor is accordingly increased (e.g. time). This effect can be observed in case of household washing machines: The programme duration of "coloured 60°C" in household washing machines, for example, is 86 minutes, whereas only 56 minutes in professional washing machines. Thus, if for professional washing machines the detergents would be used in the same concentration as for household machines, the cleaning result, of course, would be less satisfactory. In order to achieve a reasonable compensation, a special detergent or more detergent compared to the amount used in household would be necessary.[6]

This fact also becomes visible when comparing manual washing and machine washing: In the case of manual washing, mechanical action is much more important than in the case of machine washing, where higher temperatures are used and the chemicals are more aggressive. However, both processes (should) lead to the same result.

Without increasing another factor, the contribution of one factor can only be reduced, if the washing performance can be decreased (e.g. when the textiles are less soiled).

In addition to the four cleaning factors, water also plays an important role since it serves as solvent for soluble substances and as carrier for washing chemicals and thermal energy. The amount of water influences the energy consumption. In addition, the water quality influences the washing process.

5 http://www.winterhalter.biz/winterhalter/information/dishwashing-hygiene/index.html

6 http://www.miele-professional.ch/ch/professional/produkt/141_796.htm

In short, the Sinner's Circle explains two facts:

a) Only the interaction of all factors leads to the required cleaning performance.

b) The reduction of one factor necessitates additional use of other factors if the washing performance shall be held constant. Of course, this is only possible within certain limits.

In the following sections, the user parameters and the influence of different user behaviour on these factors is described in detail.

2 Typical capacity and use intensity of professional washing machines and dryers

The "one and only" professional washing machine or dryer does not exist. Different customer requirements for professional washing machines and dryers result in a range of different product categories available on the market (see Task 1). The user behaviour also depends on the main application. Thus, the different categories of washing machines and dryers identified in Task 1 were assigned to key market / customer areas (see Task 2).

Table 1 and Table 2 give an overview of the main applications of these product categories thus providing a first indication of a possible use intensity of professional washing machines and dryers.[7]

Table 1 Key market segments of professional washing machines according to spatial requirements

Product category	Key market segment	Spatial requirements	Filling ratio[8]	Main operator / user type	Life time (cycles)
WM1: Semi-professional washer extractor	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	Rather small amount of space available / necessary	1:8–1:10	Mainly private customers and non trained personnel (with few exemptions)	10 000–15 000
WM2: Professional washer extractor, <15 kg					
WM3: Professional washer extractor, 15-40 kg	Hospitality Laundry (HPL)	Medium amount of space necessary. Used in different market segments.	1:9–1:12	Non and trained personnel	30 000
WM5: Professional washer dryer					
WM6: Professional barrier washer	Healthcare Laundry (HCL)				
WM4: Professional washer extractor, >40 kg	Commercial Industrial Laundry (CIL)	Large amount of space required. Used in large laundries	1:10–1:12	Trained personnel	40 000 resp. 40 000 h
WM7: Washing tunnel machine					

[7] Source: own compilation based on stakeholder feedback from working paper and comments on draft report.

[8] The applicable filling ratio depends on the density of the laundry to be washed/dried

Table 2 Key market segments of professional dryers according to spatial requirements

Product category	Key market segment	Spatial requirements	Filling ratio[8]	Main operator / user type	Life time (cycles)
D1: Semi-professional dryer, condenser	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	Rather small amount of space available / necessary	1:18–1:25	Mainly private customers and non trained personnel (with few exemptions)	10 000–15 000 (D3: 20 000)
D2: Semi-professional dryer, air vented					
D3: Professional cabinet dryer					
D4: Professional tumble dryer, <15 kg					
D5: Professional tumble dryer, 15-40 kg	Hospitality Laundry (HPL)	Medium amount of space necessary. Used in different market segments.	1:18–1:25	Non and trained personnel	30 000
D6: Professional tumble dryer, > 40 kg	Commercial Industrial Laundry (CIL)	Large amount of space required. Used in large laundries	1:20–1:25	Trained personnel	40 000 resp. 40 000 h
D7: Pass-through (transfer) dryer					

Semi-professional and small size professional washing machines and dryers are used mainly in the coin & card operated laundry as well in the apartment house laundries (WM1-2 and D1-4); only a rather small amount of laundry ware is to be cleaned per day. The end-users (mostly private consumers) have no special training. Only in some cases also semi-professional machines could be operated by trained people e.g. when setting up a machine in a commercial laundry.

Categories WM3, WM5-6 and D5 are often used both by non trained persons or trained employees – it depends on the different customer segments; whereas the industrial or heavy duty appliances WM4, WM7 and D6-7 are generally operated by well trained persons.The customers within the market segments and the respective countries obtain their equipment e.g. by purchasing, leasing or renting contracts (cf. Task 2). The heavy duty categories (e.g. tunnelwashers or pass-through dryers) require a quite high amount of laundry to be cleaned per day and also a large amount of space. They are therefore mainly used in commercial or industrial laundries, for example in large hospitals. The categories WM3 and D5 are used in the hospitality sector (hotels, restaurants etc.). The barrier washer (WM5) is installed in spaces with very high hygiene demands.

Annual weight of cleaned and dried laundry

The use intensity mainly depends on the main customer segment for each category, as it defines the number of cycles per day, the working days per year and the amount of load to

be treated per cycle. In the following, for each appliance type typical operating conditions in the different customer segments are described to calculate the amount of laundry that is typically cleaned per year. Table 3 and Table 4 show the assumptions regarding the following parameters:

- Typical nominal capacity for each product category
  - in kg per cycle (WM1-6 and D1-6);
  - in kg per hour (WM7 and D7);
- Average load workload (%) in different customer segments;
- Number of average washing and drying cycles per day (categories WM1-6 and D1-6); typical time span (hours) of operation mode per day (categories WM7 and D7)
- Number of working days per year[9] (all categories).

With these input data, for each product category the annual amount (tons) of cleaned or dried laundry is calculated. Especially those data from the most relevant customer segment (marked bold in the following tables) serve as input for the calculations of the annual energy, water and detergent consumption under ideal and real conditions.

[9] Assumptions due to stakeholder feedback from the survey

Washing machines

Table 3 Typical intensity of use of the regarded washing machine categories (main customer segments for each category marked bold)

Washing machine category	Customer segment	Typical nominal capacity in kg/cycle [10]	Average workload in %	Washing cycles per day	Cleaned laundry per day in kg/day	Number of working days per year	Cleaned laundry per year in tons/year [11]
WM1 Semi-professional washer extractor	**Coin & Card / AHL**	**6**	**65%** [12]	**6**	**23**	**300**	**7.0**
	Hospitality	6	70%	8	34	220	7.4
	Health care Hospital	6	70%	8	34	220	7.4
	Health care Nursing home	6	70%	6	25	220	5.5
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
WM2 Professional washer extractor, <15 kg	**Coin & Card / AHL**	**10**	**60%**	**8**	**48**	**300**	**14.4**
	Hospitality	10	80%	10	80	220	17.6
	Health care Hospital	10	80%	10	80	220	17.6
	Health care Nursing home	10	80%	10	80	220	17.6
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
WM3 Professional washer extractor, 15-40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	**24**	**80%**	**10**	**192**	**220**	**42.2**
	Health care Hospital	24	80%	10	192	220	42.2
	Health care Nursing home	24	80%	10	192	220	42.2
	Commercial Laundry	24	80%	12	230	300	69.1
	Speciality Laundry	24	80%	10	192	300	57.6

[10] Identified in Task 2

[11] Calculated value

[12] Applied mainly in Apartment-house-laundry (AHL)

Washing machine category	Customer segment	Typical nominal capacity in kg/cycle [10]	Average workload in %	Washing cycles per day	Cleaned laundry per day in kg/day	Number of working days per year	Cleaned laundry per year in tons/year [11]
WM4 Professional washer extractor, >40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	90	80%	5	360	220	79.2
	Health care Nursing home	90	80%	5	360	220	79.2
	Commercial Laundry	**90**	**80%**	**9**	**648**	**300**	**194.4**
	Speciality Laundry	90	80%	8	576	300	172.8
WM5 Professional washer dryer	Coin & Card / AHL	6	60%	10	36	300	10.8
	Hospitality	**6**	**70%**	**8**	**34**	**220**	**7.4**
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
WM6 Professional barrier washer	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	**32**	**80%**	**10**	**256**	**220**	**56.3**
	Health care Nursing home	**32**	**80%**	**10**	**256**	**220**	**56.3**
	Commercial Laundry	32	80%	5	128	300	38.4
	Speciality Laundry	32	80%	8	205	300	61.4
WM7 Washing tunnel machine	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	**1 500 kg/h (1 000–2 000)**	**85%**	**10h [13]**	**12 750**	**300**	**3 825**
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable or no information available *(Source: own calculations based on stakeholder feedback from survey and literature)*

[13] Typical operating time span per day in hours

Dryers

Table 4 Typical intensity of use of the regarded dryer categories (main customer segments for each category marked bold)

Dryer category	Customer segment	Typical nominal capacity in kg/cycle[14]	Average workload in %	Drying cycles per day	Dried laundry per day in kg/day	Number of working days per year	Dried laundry per year in tons/year[15]
D1 Semi-professional dryer, condenser	**Coin & Card / AHL**	**6**	**60%**	**6**[16]	**22**	**300**	**6.5**
	Hospitality	6	70%	8	34	220	7.4
	Health care Hospital	6	70%	6	25	220	5.5
	Health care Nursing home	6	70%	6	25	220	5.5
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D2 Semi-professional dryer, air vented	**Coin & Card / AHL**	**6**	**60%**	**6**	**22**	**300**	**6.5**
	Hospitality	6	70%	8	34	220	7.4
	Health care Hospital	6	70%	6	25	220	5.5
	Health care Nursing home	6	70%	6	25	220	5.5
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D3 Professional Cabinet dryer	**Coin & Card / AHL**	**8**	**60%**	**6**	**29**	**220**[16]	**6.3**
	Hospitality	8	70%	6	34	220	7.4
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[14] Load capacity depends on typical dryer per each category (see Task 2)

[15] Calculated value

[16] Applied mainly in Apartment-house-laundry (AHL)

Dryer category	Customer segment	Typical nominal capacity in kg/cycle[14]	Average workload in %	Drying cycles per day	Dried laundry per day in kg/day	Number of working days per year	Dried laundry per year in tons/year[15]
D4 Professional tumble dryer, <15 kg	**Coin & Card / AHL**	**10**	**60%**	**8**	**48**	**300**	**14.4**
	Hospitality	10	80%	10	80	220	17.6
	Health care Hospital	10	80%	10	80	220	17.6
	Health care Nursing home	10	80%	10	80	220	17.6
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D5 Professional tumble dryer, 15-40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	**23**	**80%**	**10**	**184**	**220**	**40.5**
	Health care Hospital	23	80%	10	184	220	40.5
	Health care Nursing home	23	80%	10	184	220	40.5
	Commercial Laundry	23	80%	12	221	300	66.2
	Speciality Laundry	23	80%	10	184	300	55.2
D6 Professional tumble dryer, > 40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	70	80%	5	280	220	61.6
	Health care Nursing home	70	80%	5	280	220	61.6
	Commercial Laundry	**70**	**80%**	**10**	**560**	**300**	**168.0**
	Speciality Laundry	70	80%	8	448	300	134.4
D7 Pass-trough (transfer) tumble dryer	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	**400 kg/h (300–500)**	**85%**	**10h[17]**	**3 400**	**300**	**1 020**
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable or no information available so far *(Source: own calculations based on stakeholder feedback from survey and literature)*

[17] Typical operating time span per day in hours

Dosage and consumption of detergent

According to A.I.S.E.[18] customers generally ask for good wash performance (i.e. fewer cases of rewash) with the lowest cost per wash (i.e. with the possible lowest detergent concentration). Safety and simplicity combined with a good service level are further requests of customers. Further, according to A.I.S.E, customers tend to look for more automatic and controlled dosing systems, easy and simple systems to use, convenience and ergonomics, multi component systems, hygiene claims, powders and liquids, lower temperatures (40-60°C), sustainable solutions – i.e. energy, water, but also cost savings.

Professional laundries do not simply buy a product or range of products from their suppliers. They buy a full service – the solution to their specific laundry problems – in order to make their operation satisfactory. Suppliers to professional laundries must therefore offer complete systems including installations, control systems and dosing equipment or other hardware. The laundries also demand other services such as training of personnel, advice on effluent control measures and monitoring of wash performance and hygiene.

Modern detergent systems, powder, liquid, paste and combination systems can be automatically or manually dosed into the washing machine. Automatic dosing equipment can provide the benefits of reduced work, reduced manual handling, minimized chemical exposure, accurate repeated dosing and process validation.[19]

The various use patterns and framework conditions with regard to professional laundry washing result in a rather complex product category, with broad variety of needs, conditions and applications across Europe.[20]

- Regional variance of water quality is huge – from Norway with low water hardness to Spain and Turkey / Switzerland with water hardnesses over 30°DH. This results in the need for different detergent products or different dosing levels to achieve the best wash result within different hardness of the water (soft, medium or hard water)
- Many machines have fixed temperatures and programs.
- Besides the overall EU Detergent Regulation, different legislations also exist across countries, leading for example to the possible limitation of some raw materials (e.g. phosphate, EDTA) in professional laundry products.
- Customer perception of product effectiveness can also vary and may depend on whether the product can clean market segment specific soils (e.g. blood in laundry from medical applications, oil in industrial applications). Together with different cost

[18] International Association for Soaps, Detergents and Maintenance Products

[19] http://www.laundry-sustainability.eu/en/html/module_4_detergents.html, sighted on 23 Juli 2010

[20] A.I.S.E professional EU ecolabel criteria for laundry/autodish detergents, Ecolabelling Denmark

acceptance by customers, this leads to significant variations in product dosage over various European countries.

The dosage of detergent and laundry aid can be provided upon by

- special service providers,
- the manufacturers of the washing machines or
- the operators of the washing machines.

In case of industrial equipment, manufacturers rather only deliver the appliances or systems. The specifications of the washing process (i.e. the "recipe" of the process, including programme time, temperature, dosage of chemicals, water/laundry ratio, etc.) can be defined individually. This definition of the recipe is mostly done by the customer himself or the detergent provider. The energy, water and detergent consumption depends on this definition of the recipe. Further, the differences in detergent consumption of the product categories also arise from the different load ratio, types of dosing system and water consumption per functional unit.

During the course of our study, we could not get reliable information about differences in the composition and the use of detergent and laundry aid in different EU countries. Also A.I.S.E. could not provide data with such level of detail.[21] For the purposes of the study and the further calculations, the following **concentration values for detergents including laundry aid** have been assumed (in brackets: range of data).[22]

- WM 1+2: 17 g/kg[23]
- WM 3+5: 14 g/kg (8-20 g/kg)[24,25]
- WM 4+6: 18 g/kg (15-20 g/kg)[25]
- WM 7 = 9 g/kg[25]

[21] According feedback from A.I.S.E

[22] Feedback on consumption data with regard only to specific wash ware (24 g/kg for blue work wear) could not be taken into account as it could not be allocated to the different machine categories. Another feedback provided extremely high consumption of up to 36 g/kg compared to the other input values; thus, this value was not taken into account as it was not considered to be typical detergent consumption.

[23] Source: Öko-Institut e.V., Orientative life-cycle assessment (LCA) of fabric softeners. Substudy 2 within the UFO-Plan project 296 64 145 „LCA of laundry detergent and cleaning agent raw materials and their use in commercial washing", Freiburg 2000

[24] Source: ISO 9398-4:2003(E): Table 2 – Test cycle B for industrial washer extractors

[25] Source: According to feedback from manufacturers

3 Ideal user behaviour

3.1 Ideal operating conditions and user behaviour

Information by manufacturers about the energy, water and detergent consumption of professional washing machines and dryers is usually given under “ideal” use conditions. This means that

- “Standard” laundry type is used (e.g. cotton with standard soiling);
- The capacity in kg (or drum volume in l) of the washing machine / dryer is fully used;
- The most frequently used washing or drying programme (duration and temperature) is used (cf. Table 18 and Table 19);
- Detergents and laundry aids are used in the required form and concentration;
- External influences independent from the machine are not considered;
- Energy consumption in low-power modes (e.g. end-of-programme) is not included;
- Washing tunnels: average “standard” model with a “standard” configuration chosen (pre-wash, main wash, rinse, neutralisation, extraction);
- Dryers: systemic influences (interaction of washing and drying appliances) are taken into account in that respect that the residual moisture of the laundry coming out of the washing process is “ideal” with respect to each laundry type and market segment for the following drying process.

3.2 Energy, water and detergent consumption under ideal conditions

Table 5 and Table 6 provide an overview of the specific average energy, water and detergent (incl. laundry aid) consumption of the different washing machine and dryer categories. The given data is based on the main customer segment (see Task 2), on cold water connection (water temperature 15°C) and on the main energy source (cf. Section 5.2), the consumption range given in brackets reflects the different ranges of capacity sizes and heating options within each machine category. The tables show the consumption values of washing machines and dryers with an average technology (not including special BAT) being offered currently on the market. They are used for preliminary calculation of energy, water and detergent consumption during the use phase under ideal conditions in order to give an overview on the environmental relevance of the different washing machine and dryer categories and to subsequently determine the influence of specific aspects of of user behaviour which are not included under ideal conditions.

Note: The following data corresponds to 1 kg laundry as specified by manufactures data. As there is no applied European measurement standard the exact measuring conditions may

vary between different manufacturers. The values are therefore presented with a certain degree of uncertainty. Further, the values were provided under ideal conditions as described above.

Table 5 Specific energy, water and detergent consumption of an average current device of different washing machines categories under ideal conditions

Washing machine category	Energy consumption (range) *kWh/kg laundry*	Water consumption (range) *l/kg laundry*	Detergent / laundry aid consumption (range) *g/kg laundry*
WM1: Semi-professional washer extractor	0.15 (0.12–0.18)	9 (8–10)	17
WM2: Professional washer extractor, <15 kg	0.17 (0.14–0.20)	12 (10–14)	17
WM3: Professional washer extractor, 15-40 kg	0.21 (0.17–0.25)	13 (10–16)	14 (8–20)
WM4: Professional washer extractor, >40 kg	0.35 (0.20–0.50)	14 (10–18)	18 (15–20)
WM5: Professional washer dryer	0.80 (Wash and Dry)	10 (8–12)	14 (8–20)
WM6: Professional barrier washer	0.39 (0.28–0.50)	16 (14–18)	18 (15–20)
WM7: Washing tunnel machine	0.35 (0.30–0.40)	6 (4–8)	9

(Source: specified manufactures data and feedback from survey)

Table 6 Specific energy consumption of an average current device of different dryer categories under ideal conditions

Dryer category	Energy consumption (range) kWh/kg laundry
D1: Semi-professional dryer, condenser[26]	0.60
D2: Semi-professional dryer, air vented[26]	0.56
D3: Professional Cabinet dryer	0.75 (0.60–0.90)
D4: Professional tumble dryer, <15 kg	0.55 (0.40–0.70)
D5: Professional tumble dryer, 15-40 kg	0.65 (0.55–0.75)
D6: Professional tumble dryer, > 40 kg	0.85 (0.75–0.95)
D7: Pass-trough (transfer) tumble dryer	0.80 (0.70–0.90)

(Source: specified manufactures data and feedback from working paper and draft report)

[26] Data for categories D1 and D2 taken over from Lot 16

Based on the annual weight of cleaned and dried laundry given in Table 3 and Table 4, the following Table 7 and Table 8 show the annual consumption of energy, water and detergent (incl. laundry aid) for each of the washing machine and dryer categories **under ideal conditions.**

Table 7 Annual energy, water and detergent consumption of different professional washing machine categories under ideal conditions

Category	Cleaned laundry	Energy consumption	Water consumption	Detergent / laundry aid consumption
	tons/year	*kWh/year*	*litres/year*	*kg/year*
WM1: Semi-professional washer extractor	7.0	1 050	63 000	119
WM2: Professional washer extractor, <15 kg	14.4	2 448	172 800	245
WM3: Professional washer extractor, 15-40 kg	42.2	8 862	548 600	591
WM4: Professional washer extractor, >40 kg	194.4	68 040	2 721 600	3 499
WM5: Professional washer dryer	7.4	5 920	74 000	104
WM6: Professional barrier washer	56.3	21 957	900 800	1 013
WM7: Washing tunnel machine	3 825	1 338 750	22 950 000	34 425

(Source: calculated data based on the stakeholder feedback)

Table 8 Annual energy consumption of different professional dryer categories under ideal conditions

Category	Dried laundry	Energy consumption
	tons/year	*kWh/year*
D1: Semi-professional dryer, condenser	6.5	3 900
D2: Semi-professional dryer, air vented	6.5	3 640
D3: Professional cabinet dryer	6.3	4 725
D4: Professional tumble dryer, <15 kg	14.4	7 920
D5: Professional tumble dryer, 15-40 kg	40.5	26 325
D6: Professional tumble dryer, > 40 kg	168	142 800
D7: Pass-trough (transfer) tumble dryer	1 020	816 000

(Source: calculated data based on the stakeholder feedback)

4 Real-life user behaviour

In technical information sheets of professional washing machines and dryers, the energy, water and detergent / laundry aid consumption is usually specified under ideal conditions as described in Section 3.1. However, there are several reasons why there are considerably differences between ideal and real-life consumption:

- The **user behaviour** during continuous operation is not "ideal":
  - Customer segments: depending on the specific customer segment the machines might be used differently (cf. Table 3 and Table 4);
  - Workload: compared to the rated capacity the machines might not be fully loaded, leading to a higher consumption per kg laundry;
  - Other programs: the consumption data usually represent the consumption of the most used program. However, the machines are also used in other programmes;
  - Maloperation: Mistakes in user behaviour (e.g. incorrect dosage of the detergent and laundry aid) lead to increased consumption. Or: systemic influences (interaction of washing and drying appliances) are not taken into account so that the residual moisture of the laundry coming out of the washing process is not ideal with respect to each laundry type and market segment for the following drying process, leading to increased energy consumption.
- Washing machines or dryers can also be in low-power modes; the duration e.g. in left-on mode[27] might represent a quite long period of time causing additional **standby consumption**.

In the following sections, we will describe these parameters in more detail and show their influence compared to the consumption under ideal conditions. However, some of the parameters queried in the working paper are difficult to specify by stakeholders. Hence, the "average" values are best-possible estimates by either stakeholders or authors of this study.

4.1 Influence of user behaviour

4.1.1 Customer Segments

As outlined in Task 1, six customer segments were defined in which each of the seven washing machine and dryer categories are used to a different degree.

Within the customer segments also the typical user behaviour might be diverse. For example, the use of a semi-professional washer extractor (category WM1) in the customer

[27] Status of appliances at the end of a programme, while waiting for user attention

segment Hospitality laundry (HPL) might result in another energy and water consumption compared to the use of the same machine type in the customer segment Coin & Card Laundry (CCL), as the types or soiling of the laundry and the average user behaviour (private customers vs. trained personnel) might be different.

At the beginning of the stakeholder process within EuP Lot 24, we were asked for specifying the different consumption values with regard to all relevant customer segments. However, no quantification of the consumption data at this detailed level was provided by stakeholders; as the study is addressing the average energy and other resources consumption, in the further tasks we will only focus on the typical machines and applications in the key customer segment for each washing machine and dryer category.

4.1.2 Partial workload

In the technical information sheets of professional washing machines and dryers, the energy, water and detergent consumption is usually specified under optimal conditions and full load. In real life, however, the workload (kg of laundry in the drum) of washing machines and dryers might be considerably lower. This results from the fact that despite of the professional, thus profit-oriented operation of the machines the processes are customer and laundry type specific; i.e. no mix of laundry from different customers or different laundry types is applied reducing the possibilities to always use full load capacities. Further, in customer segments with mainly non-professional users like in Coin & Card Laundry or Apartment House Laundry, the partial workload can be assumed to be similar to that in household applications. The impact of lower workload in general is difficult to quantify and can be very different depending on the customer segments. Moreover, it depends on the organisation of the laundry process in total.

For the purposes of the study and further calculations we assume that in the respective main customer segment the influence of real workload on the consumption of energy, water and detergent is in the range of[28]

- Washing machines:
  - Categories WM1-7: **+10%** compared to the ideal **energy** consumption
  - Categories WM1-3, WM5: **+20%** compared to the ideal **water and detergent** consumption and
  - Categories WM4, WM6-7: **+10%** compared to the ideal **water and detergent** consumption.

Note: The concentration of the detergent solution has always to be kept at a constant level (less concentration would lead to insufficient cleaning results; overdosage on the other hand

[28] According to feedback from manufacturers at the final Lot 24 stakeholder meeting and at the International Detergency Conference (IDC) in Düsseldorf, Germany, 3 to 5 May 2011

should be avoided as it might result in undesirable detergent remains on the laundry and also is a cost factor). The concentration of the detergent depends on the amount of water used for cleaning the laundry. Thus, the proportionally increased water consumption due to partial load leads to an equivalent increase of the detergent consumption.

- Dryers:
  - +10% compared to the ideal **energy** consumption.

4.1.3 Use of other programmes

The performance of the washing process depends on the following factors (cf. Section 1.3):

- Thermal action (i.e. water temperature),
- Mechanical action,
- Chemical action (i.e. detergent concentration), and
- Time.

Thus, choosing another temperature or programme duration by the selection of different washing or drying programmes in the use phase would also influence the overall energy, water and detergent consumption.

The following Tables 9 and 10 provide an overview of the typically used programmes (temperature, programme duration) for each product category in the respective main customer segment (for typically used programmes in other customer segments, see Annex section 7.4).

Besides the most used programme, other common programmes are selectable which mainly differ by their duration, temperature and the respective cleaning performance, thus also resulting in different consumption values. However, as many of the professional washing machine and dryer categories are operated by trained personnel (cf. Table 1) the influence of the use of other – less effective – programmes would be relevant most likely for the appliances used by non trained personnel in CCL and AHL market segments.

A quantified influence of the use of other programmes will be presented within the next section (influence of maloperation on energy, water and detergent consumption).

Table 9 Programme selection of professional washing machine categories

Type of appliance	Main customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
WM1: Semi-professional washer extractor	Coin & Card Laundry + Apartment Household Laundry	35–55 min	60%	40°C
WM2: Professional washer extractor, <15 kg	Coin & Card Laundry + Apartment Household Laundry	35–55 min	60%	40°C
WM3: Professional washer extractor, 15–40 kg	Hospitality Laundry	50 min	60%	60°C
WM4: Professional washer extractor, >40 kg	Commercial Industrial Laundry	30 min (programmable)	60%	60°C
WM5: Professional washer dryer	Hospitality Laundry	75 min (wash+dry) 50 min (wash)	60%	60°C
WM6: Professional barrier washer	Healthcare Hospital Laundry	45 min (programmable)	60%	>60°C
WM7: Washing tunnel machine	Commercial Industrial Laundry	30 min	>90%	Pre-rinse / main wash / rinse zone 40°C / 70-80°C / 40°C

Table 10 Programme selection of professional dryer categories

Type of appliance	Main customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
D1: Semi-professional dryer, condenser	Coin & Card Laundry + Apartment Household Laundry	30–45 min	100%	70°C
D2: Semi-professional dryer, air vented	Coin & Card Laundry + Apartment Household Laundry	30–45 min	100%	70°C
D3: Professional cabinet dryer	Coin & Card Laundry + Apartment Household Laundry	130 min	60%	90°C
D4: Professional tumble dryer, <15 kg	Coin & Card Laundry + Apartment Household Laundry	30 min	>95%	70°C
D5: Professional tumble dryer, 15-40 kg	Hospitality Laundry	20–30 min	>95%	70°C
D6: Professional tumble dryer, >40 kg	Commercial Industrial Laundry	15–20 min	80%	60°C
D7: Pass-through (transfer) tumble dryer	Commercial Industrial Laundry	15–25 min	> 90 min	Fresh air ~200°C Exhaust air ~100°C

4.1.4 Maloperation

Maloperation of professional washing machines and dryers can influence the energy, water and detergent and laundry aid consumption. There are following main reasons for the maloperation of professional washing machines and dryers:

- The “wrong” program, e.g. with regard to temperature and time is chosen (see also Section 4.1.3 above) and the laundry process has to be repeated because the result of the washing or drying process is not satisfactory. This effect arises e.g. in case of mixed laundry, as temperature is usually oriented to the most delicate laundry item.
- The concentration of detergent and laundry aid is not sufficient and the result of the washing process therefore not acceptable. The washing process has to be repeated. This occurs when the container for the detergent or laundry aid is empty and the user does not pay attention to the corresponding signal.
- The concentration of detergent is too high resulting of a high waste water amount and possibly residues on the textiles. This effect arises e.g. in case of mixed heavily and light soiled laundry, as the detergent concentration is usually oriented to the most soiled laundry item.

The dosage of the detergent and laundry aid can be decided upon by

- Special service providers,
- The manufacturers of the washing machines or
- The operators of the washing machines.

In the first two cases, incorrect dosage of the detergent rarely occurs because service providers and manufacturers have a strong interest to deliver good washing results with least possible detergent input and will therefore pay high attention to ensure that the right concentration of detergent and laundry aid will be available. In the third case, incorrect dosage might occur from time to time, e.g. in the case of non-trained personnel.

The impact of maloperation is difficult to quantify as it can vary significantly from user to user and also depends on the overall organisation of the laundry process. For example, in market segments with professional washing machines and dryers used by manual programme settings, manual dosage and rather untrained personnel, the error rate might be higher than in market segments with highly trained personnel and machines with higher automatisation rate. Thus, due to lack of differentiated feedback from customers, for the purposes of the study and further calculations we assume that the influence on the consumption of energy, water and detergent is on average

- **Washing machines:**
  - Categories WM1-3, WM5: **+15%** and
  - Categories WM4, WM6-7: **+10%** compared to ideal energy, water and detergent consumption.

- **Dryers:**[29]
  - Categories D1-5: **+15%** and
  - Categories D6-7: **+10%** compared to ideal energy consumption.

4.2 Influence of low-power modes consumption

Washing machines and dryers might not be switched off directly after the end of the programme and therefore remain a certain time in "left-on mode". In this low-power mode[30], the equipment may persist for an indefinite time after completion of the programme without any further intervention by the end-user besides unloading of the appliances.

The following Tables 11 and 12 show the typical time and power consumption of professional washing machines and dryers in low-power mode.

For household appliances, the aim is to reduce the low power modes consumption (in case the user does not switch off the appliance after operation). For especially the larger professional machines and dryers the consumption of the low-power mode is negligible due to optimized machine performance. Only for washing machine and dryer categories WM1–3 and D1–3 standby data could be quantified and thus will be outlined in the further chapters of this study. The power consumption in off-mode has not been considered as it is negligible compared to the overall energy consumption of the machines.

Table 11 Typical time in low-power mode(s) consumption of professional washing machines

Washing machine category	Time in low-power modes per day	low power modes consumption (in kWh/h)
WM1: Semi-professional washer extractor	120 min	~0.003
WM2: Professional washer extractor, <15 kg	120 min	~0.003
WM3: Professional washer extractor, 15-40 kg	120 min	~0.003
WM4: Professional washer extractor, >40 kg	negligible	negligible
WM5: Professional washer dryer	n.a.	n.a.
WM6: Professional barrier washer	n.a.	n.a.
WM7: Washing tunnel machine	negligible	negligible[31]

n.a. = no information available (Source: manufacturers' data)

[29] According to feedback from manufacturers at the final Lot 24 stakeholder meeting.

[30] According the Directive 2009/125/EC with regard to ecodesign requirements for household washing machines.

[31] Washing tunnel machines and transfer dryers are usually heated by steam or gas (sometimes hot water or thermo oil). Only 5% (washing tunnels) resp. 10% (transfer dryers) of the total energy consumption is by electricity (e.g. motor) (see Task 4). The time in low-power mode is negligible due to the optimized machine performance, resulting in standby consumption in a per mille area.

Table 12 Typical time in low-power mode(s) consumption of professional dryers

Dryer category	Time in low-power mode per day	Low-power mode consumption (in kWh/h)
D1: Semi-professional dryer, condenser	180 min	~0.0025
D2: Semi-professional dryer, air vented	180 min	~0.0025
D3: Professional cabinet dryer	180 min	~0.003
D4: Professional tumble dryer, <15 kg	n.a.	n.a.
D5: Professional tumble dryer, 15-40 kg	n.a.	n.a
D6: Professional tumble dryer, > 40 kg	negligible	negligible
D7: Pass-trough (transfer) tumble dryer	negligible	negligible[31]

n.a. = no information available (Source: manufacturers' data)

4.3 Energy, water and detergent consumption under real-life usage conditions

The following tables summarise the different influence parameters of the sections above and show the annual consumption of energy, water and detergent (incl. laundry aid) for each of the seven washing machine and dryer categories under real-life conditions in the main customer segment. The results show that under real-life conditions the additional consumption of energy, water, detergent and laundry aid might be 20 to 35% higher compared to ideal conditions.

Table 13 Annual energy, water and detergent consumption (real life conditions) of all washing machine categories

Category	Energy consumption	Water consumption	Detergent / laundry aid consumption
	kWh/year	litres/year	kg/year
WM1: Semi-professional washer extractor	1 332	85 050	161
WM2: Professional washer extractor, <15 kg	3 026	233 280	330
WM3: Professional washer extractor, 15-40 kg	10 973	740 610	798
WM4: Professional washer extractor, >40 kg	81 648	3 265 920	4 199
WM5: Professional washer dryer	7 400	99 900	140
WM6: Professional barrier washer	26 461	1 080 960	1 216
WM7: Washing tunnel machine	1 606 500	27 540 000	41 310

Table 14 Annual energy consumption (real life conditions) of all dryer categories

Category	Energy consumption kWh/year
D1: Semi-professional dryer, condenser	4 877
D2: Semi-professional dryer, air vented	4 552
D3: Professional cabinet dryer	5 924
D4: Professional tumble dryer, <15 kg	9 936
D5: Professional tumble dryer, 15-40 kg	32 805
D6: Professional tumble dryer, > 40 kg	171 360
D7: Pass-through (transfer) tumble dryer	979 200

4.4 Measures to optimise user behaviour and consumption parameters

According the analysis of Task 3 and Task 4 it is evident that a better use of laundry appliances can save a substantial amount of resources and costs. On the other hand, the additional consumption which is due to real-life conditions and behaviour will be reduced with the development and use of more efficient washing machines and dryers.

The additional consumption through real-life use results from five major reasons which could be improved by education, incentives and responsibilities. For example, it is important to explain the consequences of partial loading the machine to users as this aspect leads to increased energy, water and detergent/rinse aid consumption. To avoid maloperation during the dishwashing process, responsibilities clearly assigned to users might be helpful, e.g. concerning the dosage of the detergent and laundry aid.

In case of washing machine and dryer operators not being well informed about low power modes consumption, a first step could be to educate them about such consumption in order to facilitate reduced times in low power modes of the machines (e.g. not switching on machines until needed, switching off if not needed any more).

A more detailed discussion of technical improvement options (BAT) compensation real life user behaviour, like for example automatic information and control systems, sensor systems regulating the water consumption of washing machines or the residual moisture control of dryers, will be accomplished in Task 6.

5 Local Infrastructure

This section aims at identifying opportunities and obstacles linked to the local infrastructure which can influence the choice of professional washing machines and dryers.

5.1 Water supply

The water for the laundry process can be received by municipal supply or by usage of self supply (e.g. fresh water taken from wells, springs, rivers and – theoretically - rain water that mainly has to be pre-treated before application in laundry). Water acts as heating medium, transport medium and solvent for detergents and soil, and additionally it transfers the mechanical action of the washing machine to the laundry.

Professional washing machines can either be connected to cold and/or warm water supply. The machines also occupy a drain valve for the waste water. According to stakeholders' feedback connection only to warm water does not make sense; also low temperatures are needed as using only hot water could fix stains like blood or other proteins on the textiles.

5.2 Energy infrastructure of different heating options

This section aims at identifying the different ways to heat the water of washing machines and the air of dryers depending on the infrastructure available on site, which might influence the overall choice for a specific type of washing machine or dryer. On the other side, the different heating systems result in different environmental impacts and different operating costs accordingly.

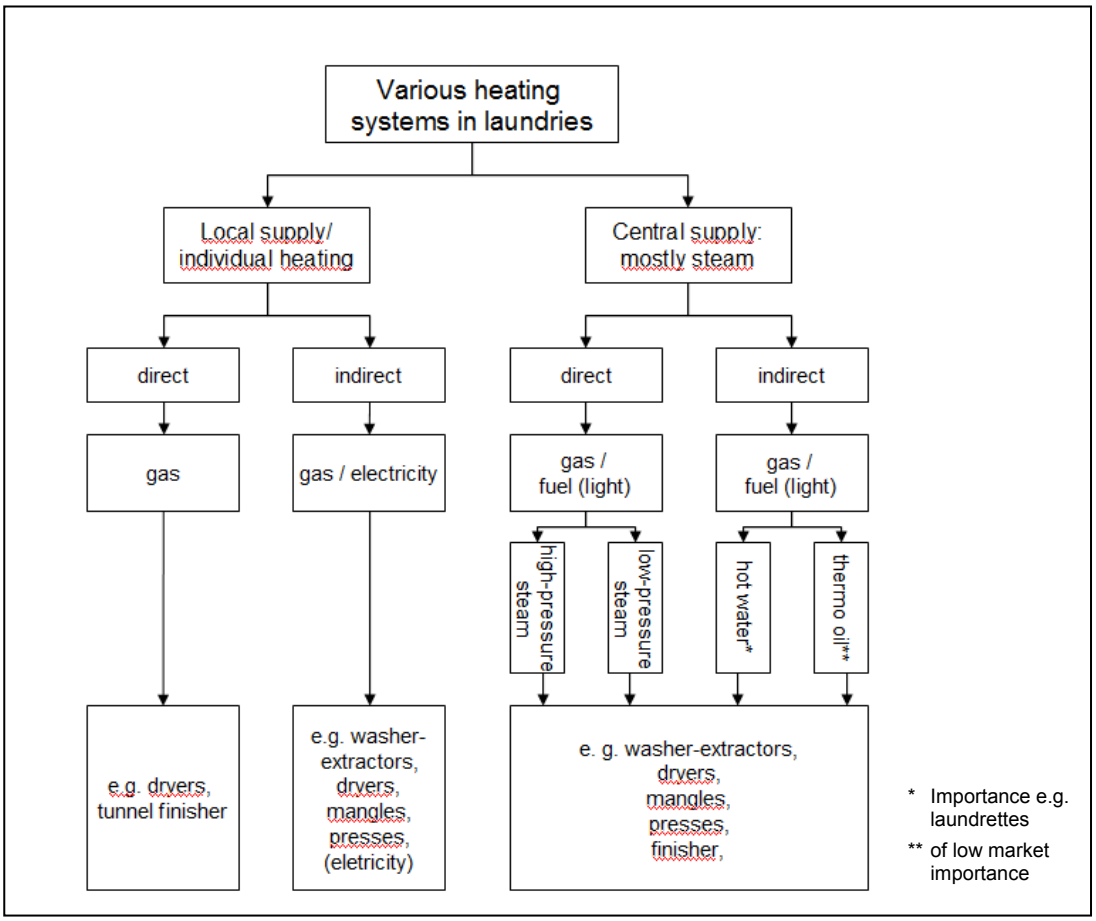
For heating processes in laundries, different energy sources can be used[32]: electricity, steam, hot water, natural gas, and thermo oil[33] (extra light or heavy). Hot water or steam is generally used to generate process heat; electricity and gas are used for direct machine heating as well as for indirect application to heat transfer media. Thermo oil is normally applied in industrial plants (see following figure).

The specific advantages or disadvantages of the different heating mediums will be described in Task 6.

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[32] The energy consumption of a washing machine or a dryer is defined as the number of kilowatts hours of steam, gas, electricity or heat-transport fluid required for washing, extraction as well for drying of the load.

[33] Thermo or thermal oil in heat transfer systems is used to transmit thermal energy. It is heated in a heater and transported by pipeline to the places where a machines needs to be heated. An advantage of thermal oil compared to conventional heat sources such as hot water is the much higher boiling point. For example, the temperature reaches above 300°C. Thermal oil can be produced from both synthetic and organic oils.



(Source: BDEW, http://www.gewerbegas-online.de/index.php?id=262)

Figure 2 Various heating systems in laundries

Regarding the internal or external heating[34] for washing machines and dryers, the different water or air heating options can be structured as follows:

- internal
  - electric heating,
  - natural gas heating,
  - steam heating,
- external heating (washing machines: the supplied water is already warm; dryers: hot air input from external source) by any sources like e.g. gas or fuel, and
- others.

[34] **Internal heating** refers to a heating process that takes place within the machine (direct heating); whereas **external heating** refers to a process that takes place outside the machine (i.e. the air or water already arriving at the machine is already heated up so that the machine itself does not need any more energy for heating).

The following tables show the share of different energy sources to heat up the water for washing machines and the air for dryers in the main customer segments.

Table 15 Energy Sources for water heating in professional washing machines

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

(Source: own assumptions based on http://www.gewerbegas-online.de and stakeholder feedback)

Table 16 Energy Sources for heating in new professional dryers

Dryer category	Internal heating, Electricity in %	Internal heating, Natural gas in %	Internal heating, Steam in %	External heating (hot air input), any source (gas, fuel, …)	Others (please specify): ... in %
D1: Semi-professional dryer, condenser	100	0	0	0	0
D2: Semi-professional dryer, air vented	65	35	0	0	0
D3: Professional cabinet dryer	100	0	0	0	0
D4: Professional tumble dryer, <15 kg	45	50	5	0	0
D5: Professional tumble dryer, 15-40 kg	30	45	25	0	0
D6: Professional tumble dryer, > 40 kg	10	50	40	0	0
D7: Pass-trough (transfer) tumble dryer	0	65	35	0	0

(Source: own assumptions based on http://www.gewerbegas-online.de and stakeholder feedback)

Washer-dryers, semi-professional condenser dryers and cabinet dryers are only available with electric heating. According to stakeholders, other heating sources do not make sense as throughputs are lower and the necessary infrastructure is often not available for these categories.

Only a small share of washing maschines (5 to 18%) uses internal heating with natural gas. For dryers, gas heating is significantly more common (35 to 60%). The use of gas as energy source for heating is economically[35] and ecologically more efficient compared to the average European electricity generation mix[36], however it requires special connections and a special tube for exhausting the air[37].

In most washing machines categories, except for washer dryers, large washer extractors and tunnel washing machines, a certain share of appliances is heated by externally heated hot water. Washing tunnel machines (WM7) and heavy duty dryers (D7) are either heated by steam or by gas.

Further findings can be drawn:

- Other heating options, e.g. solar energy, are not yet adopted in practice. The producers of laundry equipiment do not have any experience in this field.
- No significant variations of the existing infrastructure between the different EU Member States have been reported by stakeholders.

In large professional laundries usually a wide range of machinery and options are used to process the different types of laundry. To optimize the laundry operation both under economical and environmental aspects, the machines used for washing, extraction, drying and finishing are often integrated into a comprehensive energy and water management system. Thus, in such laundries the water and energy consumption per kg laundry is often lower compared to the operation of single machines. Such an infrastructural optimisation however cannot be conducted on a single-product basis but only on basis of the whole laundry process system, considering key factors like available energy and water sources, amount of laundry and existing floor space. It therefore goes beyond the scope of the preparatory Lot 24 study at hand.

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35 See gas and electricity prices in Task 2.

36 The share of the electricity from renewable sources in EU27 is 15.6%. However, for instance in Norway the share of the hdryo power generation is 105.1% and therefore more ecologically efficient than the use of gas. (Source: Eurostat, May 2009 and Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.

37 A more detailed discussion of the different heating options will be accomplished in Task 6.

6 Maintenance and repairs, end-of-life behaviour

Regular maintenance of the machines has a preventive function, thus ensuring that signs of wear at the machinery can be detected and replaced betimes. Furthermore, it can be assumed that damaged professional devices are rather repaired than replaced due to the relatively high purchase costs of professional washing machines and dryers. At a certain point, however, the user will replace the machine with a new one.

Professional washing machines and dryers with high capacities usually are regularly maintained, at least once a year. Thus, laundries with a high demand of washware (and therefore a high risk in case of failure) usually have a service and inspection contract with the manufacturer or a special service provider. For smaller devices (semi-professional), this is not usual. The repairs are almost exclusively done at the customers' premises. No additional transport of the devices is necessary. In this context, fast availability of a qualified technician by customer service is important.

If the washing and drying demand of a customer changes over time, he can sell the washing machine or dryer on the second-hand market where devices offered in most cases have lower performance and higher consumption data than models manufactured/sold new on the market. However, there is only a relative small market for used washing machines and dryers (UK,[38] Germany[39] and in Eastern Europe). Disadvantage for purchasera might be that they usually get no warranty for the product. In some cases, manufacturers or their sellers can act as brokers, if one of their customers wants to exchange a still operating appliance, and another customer is looking for a used device.

Almost no professional washing machines and dryers will end at a landfill, as the materials (mostly stainless steel) are too valuable. For this reasons, the products would always either be refurbished or recycled for scrap parts or materials. However, it could not be excluded that difficult recyclable residues such us printed circuit boards (PCB) are disposed of.

At the end of their life, professional washing machines and dryers are usually received in payment by the manufacturer of the new machine as the largest proportion of the machine is of valuable stainless steel. They are sold by the user to be scraped or to second hand dealers. Some parts of the machine can directly be reused; the rest of the machine will be sold to recycling companies.

The smaller semi-professional machines are collected by certified scrap dealers. According to stakeholder feedback, the owner of an old washing machine or dryer will usually get small revenue of about 50 to 100 Euros from the scrap dealer, depending on the prices of commodities.

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[38] Mainly in UK, http://www.clmlaundry.co.uk/used_machines.php, sighted on 10 August 2010

[39] http://waeschereitechnik.com/shop_produkt.php?c=164,168&pid=624

7 Annex

7.1 Stakeholder involvement

The working paper containing preliminary assumptions on aspects regarding main applications of professional washing machines and dryers, the typical user behaviour, the influence of real-life conditions on ideal consumption and specific consumption values was circulated to the following stakeholders. The table also indicates from whom responses have been received.

Table 17 Documentation of institutions to which the working document on use phase has been sent out and their responses

	Working paper use phase (covering Task 3 and some aspects of Task 4)	
	Sent out	Feedback
Manufacturers and Industry Associations		
CENELEC (TC59X/SWG 1.12)	Yes	Yes
Electrolux Professional (currently not member of an industry association)	Yes	Yes
Fagor Industrial	Yes	No
GIRBAU	Yes	Yes
IMESA	Yes	No
IPSO		
Miele Professional (sub divison laundry equipment currently not member of an industry association)	Yes	Yes
PRIMUS	Yes	Yes
Schulthess	Yes	No
VDMA, German Engineering Federation – “Garment and Leather Technology”, representing	Yes	Yes
▪ Kannegiesser	Yes	Yes
▪ Jensen Group	Yes	Yes
▪ Eazy Clean (manufacturer dry-cleaning)	Yes	No
▪ Veith	Yes	No
▪ Seibt Kapp	Yes	No
Xeros ltd.	Yes	Yes
A.I.S.E. International Association for Soaps, Detergents and Maintenance Products	Yes	Yes
Henkel AG & Co. KGaA (Detergents)	Yes	Yes
User associations		
ETSA (European Textile Services Association)	Yes	No
DTV-Bonn (Germany, Deutscher Textilreinigungsverband e.V.)	Yes	No

	Working paper use phase (covering Task 3 and some aspects of Task 4)	
	Sent out	Feedback
INTEX (Germany, Industrieverband Textil Service)	Yes	No
AFEHC (Spanish exporting manufacturers association for the hospitality industry)	Yes	No
Others		
Danish Technological Institute	Yes	Yes

7.2 Working Paper "Task 3" and additional questions for stakeholders

The general working paper and additional questions for the final report concerning heating options are provided separately in the following documents:

- EuP_Lot24_Wash_T3_T4_Annex_Workingpaper.pdf
- EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

7.3 Stakeholder feedback to draft versions of Task 3

Please note that the feedback refers to prior versions of draft Task 3 report; thus the indicated numerations of chapters, tables, figures or pages might have changed.

Stakeholder	Clause	Comment	Response
Electrolux Laundry Systems	1.2-1	Standards IEC/EN 60456 and IEC/EN 61121 must be mentioned. In the scope of these standards the user segments of apartment hoses and launderettes are mentioned and therefore a large part of the semi-professional and professional segments are covered	Considered in revision
	Table 1	We would not recommend that performance standards for professional laundry equipment include sanitation as this will interfere with other standards within the hygienic sector. If wear shall be included this means a test of at least 50 washes (unrealistic)	Considered in revision
	Table 2 and other tables	The abbreviations are not stringent. All market segments shall have abbreviations and they shall be stringent within all tables in the report.	Considered in revision
	2.2	2nd last part. As the standard for tumble dryers is very high.... Unclear Last part: It is not the different types of machine that are operated by different kind of users. Also semi-professional machines can be operated by trained people in industrial market segments. This part must be rewritten saying that private customers use the machines in apartment house and launderette segments and trained and non trained operators may use the equipment in hospitality and healthcare sectors	Considered in revision

Stakeholder	Clause	Comment	Response
	Table 3	The table must be changed according to the comments above. Type of users follows market segments and not the type of machines	Considered in revision
	2.3	1st part. Last sentence is not clear. Rewrite? 2nd part page 13.Text is wrong. Hand washing has not a more important part in mechanical action. For hand washing action is lower, temperature (usually) lower and amount of detergent less compared with normal machine washing. The difference is the performance level of the wash result. 3rd part. Text wrong. Water is not an extra factor. Water is a large (dominating) part within the chemistry sector of the circle. 1st part page 14.Last sentence: Time can reduce energy. Longer programmes do not need the same temperature for equal performance	Considered in revision
	Table 4	WM1. Delete washing machine in text Semi-professional washing machine and washer-extractor. No comments will be given in this table and all other tables regarding detergent consumption.	Considered in revision
	Table 5	A range should be given for the energy consumption as in table 4	Considered in revision
	Table 6	WM5 the 100% shall be in hospitality and not CCL/HAL. See also comment table 2.	Considered in revision
	Table 7	Water consumption shall be 12 litre/kg load	Considered in revision
	4.3.1 Table 10	WM1 Duration of CCL/AHL semi professional machine shall be 35–55 min. Most common temperature is 40°C WM2 Time shall be 35–50 min and most common temp 40°C WM3 CCL/AHL most majority is n/a. Time hospitality 50 min and time health care hospital 50–60 min. Temp health care hospital is 60C+	Considered in revision
	Table 11	D1–D2 Use of std programme shall be 100% on all. Temp shall be 70C on all. D3 Time CCL/AHL and Hospitality shall be 45–60 min. Temperature shall be 60°C. Std programme 100% D4 and D5 Temp shall be 70C. Std programme 100%	Considered in revision
	4.4 Table 14	Time standby for WM2 and WM3 120 min	Considered in revision
	4.5	2nd part page 36. Do not believe that industrial laundries consume only 10–20% detergent /kg compared to domestic. Less but not so little.	Noted
	5.3	3rd part. Few machines are received in payment at replacement. They are sold by the user to be scrapped or to second hand dealers	Considered in revision
	Table 17	No washing machine (or extremely few) is direct heated with gas. The warm water may be heated by gas. Therefore column 3 and 4 should be merged. The values for column 4 may be correct.	Considered in revision
	Table 18	D3: 0% for Electricity & gas. D4 Electricity 60% Elctricity & gas 40% Steam 0%. D5. Electricity30% Elctricity & gas 50% Steam 20%, D6 Electricity20% Elctricity & gas 60% Steam 20%	Considered in revision
	Table 19	Use of warm water WM1 50%, WM2 70% WM3 100% and WM4 (0–20)%	Considered in revision

Stakeholder	Clause	Comment	Response
	6.1.3	Second last sentence. Adding only hot water in first wash (main wash) is not a good practice as hot water will fixate stains of blood and other proteins. Therefore the savings should only be calculated on half the amount of water in main wash.	Noted
	Table 21	Column must be added with conditions according to EN/IEC 60456. The accuracy of the specified parameters in ISO 9398-4 are too wide to be useful in a performance standard.	Considered in revision
	Table 22	Column must be added with conditions according to EN/IEC 61121 The accuracy of the specified parameters in ISO 9398-2 is also too wide to be useful in a performance standard.	Noted
Miele Professional	Page 7	It should be noticed, that the described washing process in ISO 9398-4 does not decribe the common used process in the industry. Especially the use of chlorine bleach is most likely not used anymore.	Noted
	Page 8	Data for a possible standard test can't be "partly sanitation". This should be taken out of the spread sheet. Reason: As soon as it comes down to hygienic aspects there are specific requirements in different countries which need to be fullfilled during the wash process. Mostlikely the hygiene process is related to a specific temperature profile or to a specific process which includes also the use of specific soap/disinfectant. Pending in the definition it might be important at what time step during the wash cycle the soap/disinfectant needs to get dispensed.	Noted
		Consumption data: The amount of detergent should be standardized (e.g. ISO 60456). Reason for that is, to get also the performance of the wash included in the possible standard test. If the amount of soap would be not clearly defined, the result will be not comparable. Even the mark indicates the same approche; it should be taken out of the table.	Noted
	Page 10	Similar to WM1 to WM4	
		In general...washing machine is to clean, rinse and extract.	
	2.2 Page 11	Cancle the word "excess"	Considered in revision
		Cancle → (single product solution or comprehensive laundries)	Considered in revision
		The type of soiling instead the type of pollution	Noted
		Instead of sanitary field → health care sector	Noted
		High capacities and short running times → that's what usually accounts	Noted
		Instead of spatial requirements → dimensions of the appliance	Noted
		The fact that somebody is well trained doesn't mean automatically that industrial processes are more economical than professional appliances.	Noted
		Operator: Semi-professional → Trained and non trained personnel should be included Professional → dto. Heavy duty → dto.	Considered in revision
		The customer group definition should be from Task 1 to Task 7 the same	Noted

Stakeholder	Clause	Comment	Response
		Domestic → 1:6, X to 1:9 Semi Professional → 1:8 to 1:10 Professional → 1:9 to 1:12 Heavy duty → 1:10 to 1:12 All those numbers are based on standard cotton load	Considered in revision
		Domestic → 1:16 to 1:18 Semi Professional → 1:18 to 1:25 Professional → 1:18 to 1:25 Heavy duty → 1:20 to 1:25 All those numbers are based on standard cotton load	Considered in revision
		Domestic → 2 500 – 5 000 I doubt that heavy duty is designed for more than 30 000 cycles – from our point of few there is no difference to the Professional equipment.	Considered in revision.
		Typo – cleaning efficiency.	
		Wash time domestic for 60°C from xx to yy – here I would recommend to use some wash times from differen manufacturers	
		Wash time professional washer from xx to yy e.g. 30 min to 60 min.	Considered in revision.
		... . In addition, water quality (water hatdness, heavy metal conc.) will inluenece the washing cycle	Noted
		The capacity ... , with a filling ratio of 1:10, depending on the declaration of the manufacturer	
		The given data is based on cold water connection and some numbers are based on hot water connection (most likely with 60°C)	
		Mostlikely the detergent is not based on ISO 9398-4 – reason is, that the desribed cycles are not really common cycles in the market (still using hypochlorite etc.)	
		I would add: While the extraction process, especially with the development of high speed washers, the following drying process is getting influenced by the washer more and more.	
		As long as there is no specific wash cycle defined the table doesn't make sense. E.g. Are those parameters reflecting the consumption data of a 60°C cycle where the machine will achieve 60°C – or will the machien achieve only 40°C? As long as the parameters of a wash cycles are not defined the range from to has to be enlarged quite a bit. For example WM1 – from 0.1 to 0.24 kWh/kg This has to be discussed in general! The average use of soap should be defined by the detergent manufacturer.	Noted
		Same as comment above re the washing machines. As long as we have no specific drying cycle defines the numbers are not relevant. The range can go from 0.4–0.6 kWh/kg.	Noted
		In technical leaflets is no information re the usage of detergent/laundry aid	

7.4 Use of other programmes in different customer segments

Besides the most used programme, other common programmes are selectable which mainly differ by their duration, temperature and the respective cleaning performance, thus also resulting in different consumption values. Section 4.1.3 provides an overview of the typically used programmes (temperature, programme duration) for each product category in the respective main customer segment. Data for typically used programmes in other customer segments are given in the following Table 18 and Table 19.

Table 18 Programme selection of professional washing machine categories, further customer segments

Customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
WM1: Semi-professional washer extractor			
Coin & Card / AHL	**35–55 min**	**60%**	**40°C**
Hospitality	35–55 min	70%	60°C
Health care Hospital	35–55 min	70%	>60°C
Health care Nursing home	35–55 min	80%	60°C
Commercial Laundry	n.a.	n.a.	n.a.
Speciality Laundry	n.a.	n.a.	n.a.
WM2: Professional washer extractor, <15 kg			
Coin & Card / AHL	**35–55 min**	**60%**	**40°C**
Hospitality	30–50 min	60%	40°C
Health care Hospital	30–50 min	80%	>60°C
Health care Nursing home	30–50 min	80%	60°C
Commercial Laundry	25–45 min	80%	60°C
Speciality Laundry	45 min	60%	60°C
WM3: Professional washer extractor, 15-40 kg			
Coin & Card / AHL	30 min	60%	60°C
Hospitality	**50 min**	**60%**	**60°C**
Health care Hospital	50–60 min	80%	>60°C
Health care Nursing home	45 min	80%	60°C
Commercial Laundry	30 min	80%	60°C
Speciality Laundry	30 min	60%	60°C
WM4: Professional washer extractor, >40 kg			
Coin & Card / AHL	n.a.	n.a.	n.a.
Hospitality	50 min	80%	60°C
Health care Hospital	45 min (programmable)	60%	>60°C
Health care Nursing home	45 min (programmable)	60%	60°C
Commercial Laundry	**30 min (programmable)**	**60%**	**60°C**
Speciality Laundry	30 min (programmable)	60%	60°C
WM5: Professional washer dryer			
Coin & Card / AHL	75 min (wash and dry) 50 min washing time	60%	60°C
Hospitality	**75 min (wash and dry) 50 min washing time**	**60%**	**60°C**
Health care Hospital	n.a.	n.a	n.a.

Customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
Health care Nursing home	n.a.	n.a	n.a.
Commercial Laundry	n.a.	n.a	n.a.
Speciality Laundry	n.a.	n.a	n.a.
WM6: Professional barrier washer			
Coin & Card / AHL	n.a.	n.a	n.a.
Hospitality	n.a.	n.a	n.a.
Health care Hospital	**45 min (programmable)**	**60%**	**>60°C**
Health care Nursing home	**45 min (programmable)**	**60%**	**>60°C**
Commercial Laundry	45 min (programmable)	60%	n.a.
Speciality Laundry	n.a.	n.a.	n.a.
WM7: Washing tunnel machine[40]			
Coin & Card / AHL	n.a.	n.a	n.a.
Hospitality	n.a.	n.a	n.a.
Health care Hospital	n.a.	n.a	n.a.
Health care Nursing home	n.a.	n.a	n.a.
Commercial Laundry	**30 min**	**>90%**	**Pre-rinse / main wash / rinse zone 40°C / 70–80°C / 40°C**
Speciality Laundry	n.a.	n.a	n.a.

n.a. = not applicable or no information available so far (Source: specified manufacturers' data)

Dryers

Table 19 Programme selection of professional dryer categories, further customer segments

Customer segment	Duration of the typically used drying programme	Share of the typically used drying programme	Temperature of the typically used drying programme
D1: Semi-professional dryer, condenser <8kg			
Coin & Card / AHL	**30–45 min**	**100%**	**70°C**
Hospitality	45 min	100%	70°C
Health care Hospital	45 min	100%	70°C
Health care Nursing home	45 min	100%	70°C
Commercial Laundry	n.a.	n.a.	n.a.
Speciality Laundry	n.a.	n.a.	n.a.
D2: Semi-professional dryer, air vented <8kg			
Coin & Card / AHL	**30–45 min**	**100%**	**70°C**
Hospitality	45 min	100%	70°C
Health care Hospital	45 min	100%	70°C
Health care Nursing home	45 min	100%	70°C
Commercial Laundry	n.a.	n.a.	n.a.
Speciality Laundry	n.a.	n.a.	n.a.

[40] Transfer time through all compartments of the washing tunnel machine

Customer segment	Duration of the typically used drying programme	Share of the typically used drying programme	Temperature of the typically used drying programme
D3: Professional cabinet dryer			
Coin & Card / AHL	**130 min**	**60%**	**90°C**
Hospitality	n.a.	n.a	n.a.
Health care Hospital	n.a.	n.a	n.a.
Health care Nursing home	n.a.	n.a	n.a.
Commercial Laundry	n.a.	n.a	n.a.
Speciality Laundry	n.a.	n.a	n.a.
D4: Professional tumble dryer, <15 kg			
Coin & Card / AHL	**30 min**	**>95%**	**70°C**
Hospitality	30 min	>95%	70°C
Health care Hospital	30 min	>95%	70°C
Health care Nursing home	30 min	>95%	70°C
Commercial Laundry	20 min	>95%	70°C
Speciality Laundry	20 min	>95%	70°C
D5: Professional tumble dryer, 15-40 kg			
Coin & Card / AHL	30 min	>95%	70°C
Hospitality	**20–30 min**	**>95%**	**70°C**
Health care Hospital	30 min	>95%	70°C
Health care Nursing home	30 min	>95%	70°C
Commercial Laundry	20 min	>95%	70°C
Speciality Laundry	20 min	>95%	70°C
D6: Professional tumble dryer, > 40 kg			
Coin & Card / AHL	n.a.	n.a.	n.a.
Hospitality	30 min	60%	60°C
Health care Hospital	30 min	60%	60°C
Health care Nursing home	30 min	60%	60°C
Commercial Laundry	**15–20 min**	**80%**	**60°C**
Speciality Laundry	20 min	80%	60°C
D7: Pass-trough (transfer) tumble dryer[41]			
Coin & Card / AHL	n.a.	n.a	n.a.
Hospitality	n.a.	n.a.	n.a.
Health care Hospital	n.a.	n.a.	n.a.
Health care Nursing home	n.a.	n.a.	n.a.
Commercial Laundry	**15–25 min**	**> 90 min**	**Fresh air ~200°C Exhaust air ~100°C**
Speciality Laundry	n.a.	n.a.	n.a.

n.a. = not applicable or no information available so far
(Source: specified manufacturers' data and stakeholder feedback from survey)

[41] Transfer time of a transfer dryer

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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

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Final Report,
Part: Washing Machines and Dryers

Task 4: Technical Analysis of Existing Products

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For reasons of better readability, two Task 4 reports were prepared.

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

The Task 4 report on *professional dishwashers*
is published separately.

For the benefit of the environment, this document has been optimised for **double-sided printing**.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective

Task 4 entails a general technical analysis of current products on the EU market. It comprises the Bill of Materials and the whole life cycle analysis of the 14 product categories identified (see Task 1). It provides first results on annual the energy, water and detergent consumption of professional washing machines and dryers over their lifetime. Furthermore, Task 4 serves as a basis for the subsequent Tasks, especially Task 5, definition of base cases as well as the identification of the improvement potential (Task 7).

1.2 Methodology and assessment of data quality

All information has been collected through a self-administrated survey amongst stakeholders. For this purpose, first of all a working paper including preliminary assumptions on the use phase parameters has been prepared on the basis of discussions with stakeholders (two on site manufacture visit) and available literature. The working paper included all aspects regarding the use phase, i.e. user behaviour, specific consumption and changes of consumption parameters with regard to changes in user behaviour, thus covering Task 3 (user behaviour) and certain aspects of Task 4. It has been circulated to stakeholders (manufacturers, industry associations, user associations, see annex 5.1) for both Tasks 3 and 4. Additionally, an Excel file and further questions with respect to the manufacturing, distribution and end-of-life phase (see annex 5.2 and 1.1) have been distributed amongst manufacturers and their industry associations (see annex 5.1).

Five stakeholders answered to the first working document regarding the use phase. As outlined in Task 3 their answers can be judged as reliable, trusted with regard to information on user behaviour. The same argumentation is true for the appliance specific information asked for in the working document: the manufacturers answering to the working document represent a substantial share of the European manufacturer market (60 to 70%) which also includes the Eastern European market as the responding manufacturers also sell and represent the major market share in these countries. The lack of responding users / use associations is not of relevance with regard to technical information, assuming that they cannot contribute to product specific questions in such detail.

Regarding the questions on manufacturing, distribution and end-of-life phase, only two manufacturers provided feedback. Thus, we supplemented manufacturers feedback on these life cycle phases by own assumptions based on specified manufacturers' data (e.g. booklets).

2 Technical analysis of professional washing machines

2.1 Technical analysis of the production phase

The technical analysis of the production phase provides product weight and Bill-of-Materials (BOM), distinguishing the weight of different materials fractions and electronic components at the level requested by the EuP EcoReport Unit Indicators as proposed in the MEEUP report. This includes packaging materials and an assessment of the primary scrap production during metal sheet manufacturing.

2.1.1 Main operating principles of professional washing machines

The following table gives an overview of the seven washing machine categories identified in Task 1 and their main characteristics. For a more detailed description see Task 1.

Table 1 Categorisation of professional washing machines and main characteristics

<table>
<tr><th>Product category</th><th>Key market segment</th><th>Main operator / user type</th><th>Filling ratio[1]</th><th>Type of loading</th><th>Product dimensions</th><th>Application</th></tr>
<tr><td>WM1: Semi-professional washer extractor</td><td rowspan="2">Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)</td><td rowspan="2">Mainly private customers and non trained personnel (with few exemptions)</td><td rowspan="2">1:8 - 1:10</td><td rowspan="4">Manual, front / loading</td><td>Typical dimension: height x width x depth
850 x 600 x 600 mm</td><td>Semi-professional</td></tr>
<tr><td>WM2: Professional washer extractor, <15 kg</td><td rowspan="5">Dimensions are rather variable depending on amount / type of textiles to be washed and dried and spatial possibilities</td><td rowspan="5">Professional</td></tr>
<tr><td>WM3: Professional washer extractor, 15-40 kg</td><td rowspan="2">Hospitality Laundry (HPL)</td><td rowspan="2">Non and trained personnel</td><td rowspan="3">1:9 - 1:12</td></tr>
<tr><td>WM5: Professional washer dryer</td></tr>
<tr><td>WM6: Professional barrier washer</td><td>Healthcare Laundry (HCL)</td><td rowspan="3">Trained personnel</td><td>front / side / top loading</td></tr>
<tr><td>WM4: Professional washer extractor, >40 kg</td><td rowspan="2">Commercial Industrial Laundry (CIL)</td><td rowspan="2">1:10 - 1:12</td><td>manual or automatic top, loading and tilt unloading</td></tr>
<tr><td>WM7: Washing tunnel machine</td><td>Pass-trough</td></tr>
</table>

[1] The applicable filling ratio depends on the density of the laundry to be washed/dried.

To keep track of the various washing machine categories and their main characteristics, the following section presents an analysis of the principal function of each washing machine category. The analysis describes the most important components of the different professional washing machines and is completed with the amount of material (Bill-of-Material, BOM) used for each category.

2.1.1.1 Category WM1: Semi-professional washer extractor

With a load capacity of up to 7 kg, washing machines and washer extractors for the semi-professional use belong to the category with the smallest appliances being similar to the household washing machines. They are operated by professional or non-professional users. Three different types of manual loading are possible: front, side and top loading. The top loading design is especially popular in the United States, Canada and Australia. In Europe and the Middle East, front or side loading is most common. Semi-professional washing machines and washer extractors always have a hot and a cold water connection and are operated according to pre-fixed programmes or are manually programmed. An example of a front-loading semi-professional washer extractor is illustrated in Figure 1.



(Source: Miele, http://www.miele-ebrochures.co.uk/professional/files/Little_Giants_April06.pdf, sighted 07.09.2010)

Figure 1 Semi-professional washer extractor (category WM1)

The wash process works as follows: At the beginning of each wash cycle, the water management system ensures that the detergent is automatically flushed out of the appropriate chamber of the dosing system. The drum is perforated to ensure proper flushing of the laundry. The laundry is lifted up by paddles on the inside wall of the drum and then dropped. This motion flexes the creases of the fabric and forces water and detergent solution through the load. As the paddles are also perforated, they carry the water up and sprinkle the laundry from above.

The mechanical energy for cleaning the laundry is provided by the drum movement rotating alternatively clockwise or counter-clockwise. To obtain a good washing result for different textiles, the speed and frequency of the drum rotation varies between the different washing programmes. In programmes for delicate fabrics such as silk, for example, the drum rotates

at a slower speed than in the cotton programme. Another factor influencing the washing process is the temperature. Heat pipes located below the washing drum heat up the washing water. As soon as the set temperature is reached, the actual washing phase begins in which the dirty textiles are exposed to the washing liquor. At the end of the washing phase, the drain pump drains off the washing liquor including the soil particles.

Table 2 gives an overview of the characteristics of two typical front-loaded appliances of this category. The following BOM, however, is also valid also for the other loading types (top and side loaded appliances).

Table 2 Characteristics of semi-professional washer extractors (category WM1)

Main characteristics of category WM1	**Data**	
Feature of performance	**Model A**	**Model B**
Washing capacity, kg	5.5	7
Drum volume, litres	54	65
Filling Ratio	1:8–1:10	1:8–1:10
Max. Spin speed, rpm	1500	1300
Residual moisture %	43	50
G Factor	526	350
Number of fixed (optional) washing programs	6 (9)	4 (12)
Dimensions		
Height, mm	850	1115
Width, mm	590	720
Depth, mm	550	690
Weight net, kg (without packaging)	70–106	97–154
Heating and water connection		
Voltage, V	230–440 1–3 phase	230–440 1–3 phase
Total load electric, kW	2.1–4.8	2.2–7.4
Cold and warm water connection	Yes	Yes
Others		
Type of loading	front	front

According to stakeholders, the material composition is equivalent to that of a household washing machine as described in the preparatory study on “washing machines and dish-washers” (Lot 14).[2] The following Bill of Materials (BOM) is taken from task 4 report of that study, scaled to a **6 kg** washing machine and partially interpolated for a typical semi-professional washing machine

[2] Further information Lot14 Final Report Tasks 3-5: www.ecowet-domestic.org

Table 3 Material composition of a semi-professional washer extractor (category WM1)

Material / Component	weight in g	weight in %	Material category
Stainless Steel	20 606	27.9%	3-Ferro
Steel Sheet galvanized	564	0.8%	3-Ferro
Cast Iron	11 192	15.2%	3-Ferro
Polypropylene (PP)	8 021	10.9%	1-BlkPlastics
Polyamide (PA)	94	0.1%	2-TecPlastics
Polycarbonate	190	0.3%	2-TecPlastics
Epoxy	260	1.6%	2-TecPlastics
Acrylonitrile Butadiene Styrene (ABS)	1 145	0.9%	1-BlkPlastics
Polystyrene (PS)	678	0.0%	1-BlkPlastics
Polybutylene Terephthalate (PBT)	8	0.3%	1-BlkPlastics
Polyvinylchloride (PVC)	221	2.4%	1-BlkPlastics
EPDM-rubber	1 752	1.5%	1-BlkPlastics
Plastics others	1 101	3.0%	1-BlkPlastics
Aluminium	2 233	1.8%	4-Non-ferro
Cu wire	1 305	0.1%	4-Non-ferro
CuZn38 cast	99	2.4%	4-Non-ferro
Chrome	1 761	0.1%	4-Non-ferro
Bitumen	38	24.6%	7-Misc.
Concrete	18 205	2.4%	7-Misc.
Glass	1 773	0.4%	7-Misc.
Wood	2 452	3.3%	7-Misc.
Electronics (control)	165	0.2%	6-Electronics
Total net	**73 863**	**100%**	
Packaging			
PE-Foil	51		1-BlkPlastics
Wood	2 452		7-Misc.
Cardboard and paper	223		7-Misc.
Total weight	**76 589**		

The “ferro” material is mainly used for the drum and the tube. The porthole is composed of glass. The concrete is needed to counterbalance the vibrations during the spinning phase.

2.1.1.2 Category WM2, WM3, WM4: Professional washer extractors

Figure 2 and Figure 3 show a typical professional washer extractor with a loading capacity of maximum 15 kg (category WM2) and a washer extractor with a loading capacity from 15 to 40 kg (category WM3).



(Source: Electrolux W4105H, 11 kg)

Figure 2 Manually loaded professional washer extractor <15 kg (category WM2)



(Source: Primus RS22, 22 kg)

Figure 3 Manually loaded professional washer extractor <40 kg (category WM3)

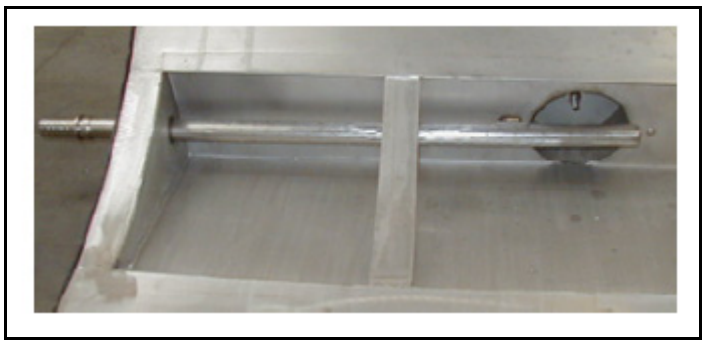
Those washer extractors are larger than semi-professional washing machines and are built to be extremely durable, to handle the high g-force of the spin cycles. Professional washer extractors are loaded manually either from the front or the side. Like semi-professional appliances, they are equipped both with a warm and a cold water connection as standard and are partly or fully programmable. Moreover, they have various heating options: electric heating is applicable for machines with a maximum load capacity of 62 kg.[3] In addition to electric heating (see Figure 4) and direct steam heating (see Figure 5), there are various alternatives with regard to heating, such as gas, hot water, indirect steam heating (one possibility: see Figure 6) or a combination of direct steam and electric heating.

3 http://www.gewerbegas-online.de/index.php?id=264#c687



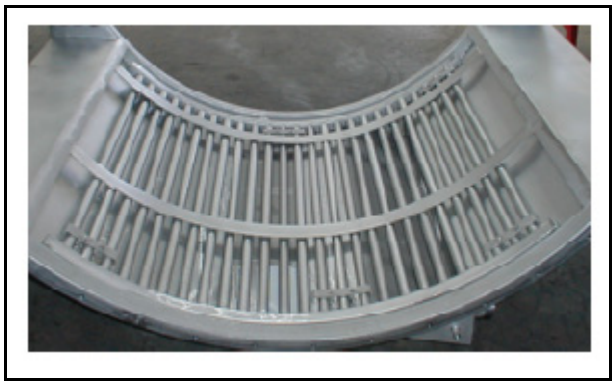
(Source: http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-2_Washer_Extractors.PDF, sighted on 20.09.2010)

Figure 4 Heat resistance for electrical heating



(Source: http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-2_Washer_Extractors.PDF, sighted on 20.09.2010)

Figure 5 Direct steam injection



(Source: http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-2_Washer_Extractors.PDF, sighted on 20.09.2010)

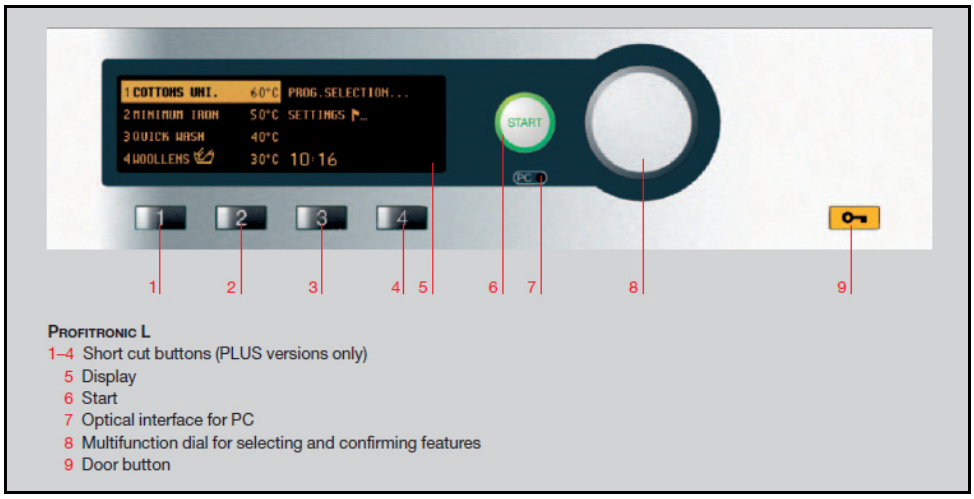
Figure 6 Stainless steel piping for indirect heating with hot water, thermo oil or steam

Further basic elements of washer extractors are:

- Outer case fitted with a door through which machine can be loaded and unloaded, and an immovable liquor tank.

- Inner drum: Perforated cylinder which rotates on a horizontal axis within an outer case (see above); depending on the load capacity, the inner drum can be subdivided into sections (cf. Figure 13 and Figure 14).
- Reversing mechanism which allows the inner drum to make several rotations in one direction followed by the same number of rotations in the opposite direction, to avoid the load becoming tangled and knotted,
- Electric drive, heating elements or steam coils, inlet and outlet valves (water, steam), electronic control system.
- Drain valve, an electromagnet opens the valve and the wash liquor flows out. Therefore it is necessary that the drain hose have an appropriate slope.

The appliances are usually equipped with an electronic control, providing the customer a wide range of programmes, both predefined standard programmes and others, being freely programmable. An example of electronic control is shown in Figure 7.



(Source: Miele, http://www.miele-ebrochures.co.uk/professional/files/Little_Giants_April06.pdf*, sighted 07.09.2010)*

Figure 7 Electronic control

Further, the control systems allow to display and control the laundry process by connecting the washer extractor to a multimedia workstation (personal computer (PC)). If several washer extractors are in use, they can be interconnected to a network, thus enabling the operator to view and control each machine of the system from one single PC.

Figure 8 illustrates a typical professional washer extractor of category WM4 with a load capacity of 57 kg.



(Source: Girbau, HS-6057, sighted 07.09.2010)

Figure 8 Typical professional washer extractor (category WM4), load capacity 80 kg

Category WM4 includes also heavy duty washer extractors which need to be operated by trained personnel. They are fully programmable and offer for most applications (customer segments) a large variety of additional equipment. Their front or side loading is either manual or automatic. Since the loading capacity may reach up to 400 kg, heavy duty washer extractors can be equipped with an optional tilting system for an easy loading and unloading.



(Source: Kannegiesser FAVORITplus 20-270 kg, sighted 07.09.2010)

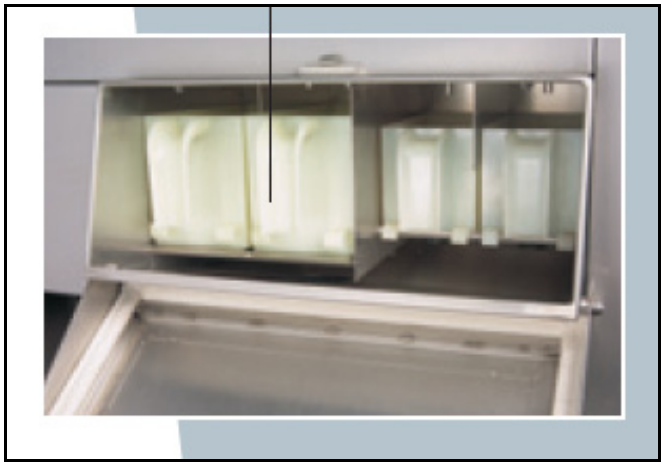
Figure 9 Heavy duty washer extractor (category WM4)



(Source: http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-2_Washer_Extractors.PDF)

Figure 10 Automatically top loaded and tilt unloaded washer extractor

In addition, this kind of appliances automatically calculates the amount of water and detergent necessary to achieve an effective chemical concentration. It is possible to wash with both powder and liquid detergents. An example of a dosing box is shown in Figure 11.



(Source: ISPO)

Figure 11 Example of dosing box

Those appliances have a wide variety of drum designs. The most common ones are illustrated in the following figures: Open Pocket, Pullman Division and Y-Division.

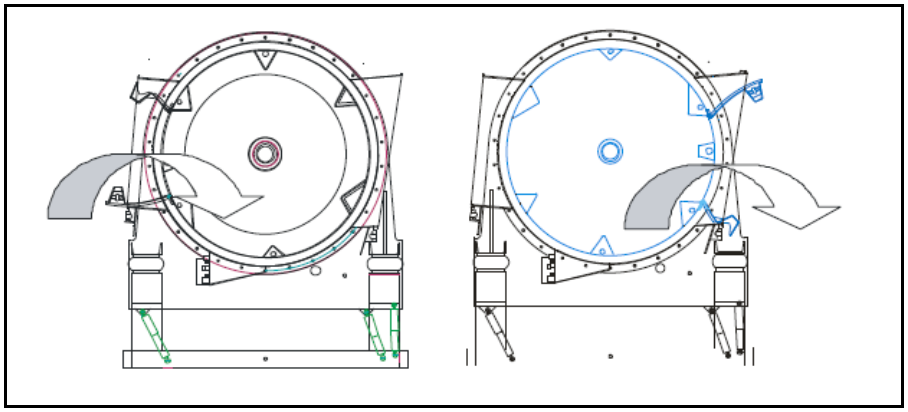


Figure 12 Drum Design: Open Pocket

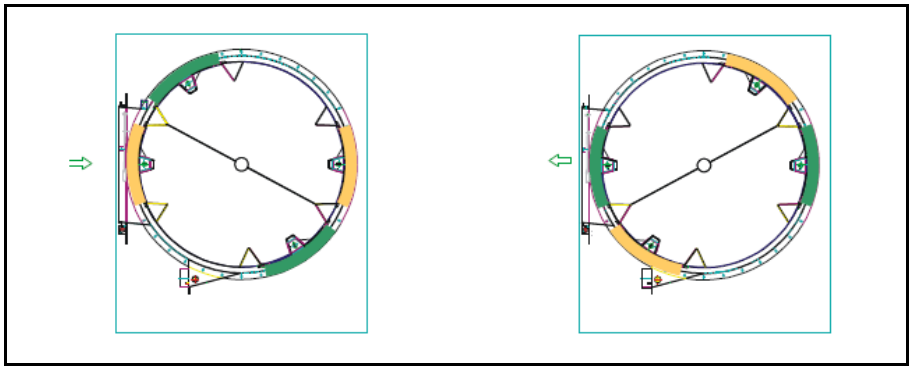


Figure 13 Drum design: Pullman Division

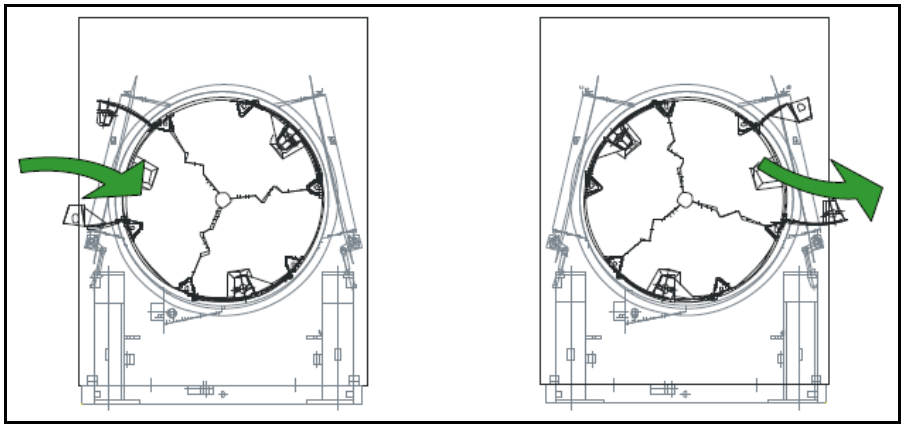


Figure 14 Drum design: Y Division

Depending on the wash speed, the different drum designs have advantages and disadvantages. With a higher wash speed, the Pullman-Division and the Open Pocket perform the best regarding friction, compression and flow through. With a lower wash speed, the Pullman-Division performs the best followed by the Y-Division and the Open Pocket.

Category WM2: Main characteristics and material composition

Table 4 gives an overview of the characteristics of three typical professional washer extractors <15 kg (category WM2).

Table 4 Characteristics of a professional washer extractor <15 kg (category WM2)

Main characteristics[4] of category WM2	**Data**		
Feature of performance	**Model A**	**Model B**	**Model C**
Washing capacity, kg	8	11	14
Drum volume, L	80	105	136
Filling Ratio	1:8–1:10	1:8–1:10	1:8–1:10
Spin speed, rpm	580–1 200	500–1 150	400–1 000
G Factor	375	350–475	350
Residual Moisture %	49	49	49
Number of fixed washing programs	10–40	10–40	10–40
Construction details			
Height, mm	1 020	1 200	1 325
Width, mm	700	830	800
Depth, mm	730	705	890
Weight net, kg	140–180	201–264	330–410
Electricity and water connection			
Voltage, V	230–400	230–400	230–400
Total load electric, kW	2–6 1–3 phase	9.7 1–3 phase	9–12 1–3 phase
Total load gas, kW	n.a.	n.a.	n.a.
Total load steam, kg/h	18–21	23–26	27–31
Cold and Warm water connection	Yes	Yes	Yes
Others			
Type of loading	front	front	front

The following table shows the BOM of a typical professional washer extractor of category WM2. The weight data indicates details on the shares of the different materials for a "typical“ professional washer extractor. Besides, the data were validated by additional, more detailed response of two manufacturers with regard to the materials that are assigned. Furthermore, the amount of material is shown as percentage of the weight of the product. The packaging material is listed separately.

[4] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of three typical models within category WM2.

Table 5 Materials composition of a professional washer extractor <15 kg (category WM2)

Material / component	Weight in g[5]	Weight in %	Material category according to MEEuP
Stainless steel	52 625	25%	3-Ferrous
Galvanized steel	105 250	50%	3-Ferrous
Cast Iron	18 945	9%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	5 200	2.5%	1-BlkPlastics
Zinc	630	0.3%	4-Non-ferrous
Aluminium	13 900	6.6%	4-Non-ferrous
Copper	3 500	1.7%	4-Non-ferrous
PVC (cables)	210	~0.1%	1-BlkPlastics
Electronics	4 300	2%	6-Electronics
EDPM rubber	2 740	1.3%	1-BlkPlastics
Glass	2 100	1%	7-Misc.
Polyamid (PA)	1 050	0.5%	2-TecPlastics
Total net	**210 450**	**100%**	
Packaging			
Polystyrene	500		1-BlkPlastics
Wood	14 000		7-Misc.
Cardboard	4 000		7-Misc.
Total weight	**228 950**		

Category WM3: Main characteristics and material composition

Table 6 gives an overview of the characteristics of typical professional washer extractor 15–40 kg (category WM3).

Table 6 Characteristics of a professional washer extractor 15–40 kg (category WM3)

Main characteristics[6] category WM3	Data		
Feature of performance	**Model A**	**Model B**	**Model C**
Washing capacity, kg	16	24	34
Drum volume, L	165	234	304
Filling Ratio	1:9–1:12	1:9–1:12	1:9–1:12
Spin speed, rpm	250–1 100	250–1 100	250–1 100
G Factor	350–500	350–542	300–475
Residual Moisture %	50	49	50
Number of washing programs	10–40	10–40	10–40
Washing time, min	60	60	60

[5] Average weight value is based on a typical washer extractor with 10 kg washing capacity.

[6] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of three typical models within category WM3.

Main characteristics[6] category WM3	Data		
Feature of performance	**Model A**	**Model B**	**Model C**
Construction details			
Height, mm	1 175	1 500	1 530
Width, mm	780	900	1 060
Depth, mm	998	1 010	1 147
Weight net, kg	363–454	534–640	620–731
Electricity and water connection			
Voltage, V	230–400	230–400	230–400
Total load, kW	16.8	28.2	33.6
Cold and Warm water connection	Yes	Yes	Yes

The following table shows the BOM of a typical professional washer extractor of category WM3. The weight data indicates on the one hand details on the share of the different materials for a "typical“ professional washer extractor. Besides, the data were validated by additional, more detailed response of two manufacturers with regard to the materials that are assigned. The amount of material is shown as percentage of the weight of the product. The packaging material is listed separately.

Table 7 Material composition of a professional washer extractor 15–40 kg (category WM3)

Material / component	Weight in g[7]	Fraction in %	Material category according to MEEuP
Stainless steel	133 200	22%	3-Ferrous
Steel tube	72 800	12%	3-Ferrous
Galvanized steel	163 500	27%	3-Ferrous
Cast Iron	102 900	17%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	12 700	2.1%	1-BlkPlastics
Zinc	2 400	0.4%	4-Non-ferrous
Aluminium	54 500	9%	4-Non-ferrous
Copper	23 000	3.8%	4-Non-ferrous
PVC (cables)	1 800	0.3%	1-BlkPlastics
Electronics	18 200	3.0%	6-Electronics
EDPM rubber	9 100	1.5%	1-BlkPlastics
Glass	7 900	1.3%	7-Misc.
Polyamid (PA)	3 600	0.6%	2-TecPlastics
Total net	**605 600**	**100%**	
Packaging			
Polystyrene	800		1-BlkPlastics
Wood	38 000		7-Misc.
Cardboard	10 500		7-Misc.
Total weight	**654 800**		

[7] Average weight value is based on a typical washer extractor with 24 kg washing capacity.

Category WM4: Main characteristics and material composition

Table 8 gives an overview of the characteristics of a typical professional washer extractor >40 kg (category WM4).

Table 8 Characteristics of a typical professional washer extractor >40 kg (category WM4)

Main characteristics[8] category WM4	**Data**			
Feature of performance	**Model A**	**Model B**	**Model C**	**Model D**
Washing capacity, kg	44	63	90	122
Drum volume, L	400	569	850	1100
Filling Ratio	1:10–1:12	1:10–1:12	1:10–1:12	1:10–1:12
Spin speed, rpm	up to 825	275–800	275–720	250–680
G Factor	up to 380	up to 390	up to 390	up to 390
Number of washing programs (programmable)	20 (190)	20 (190)	20 (190)	20 (190)
Construction details				
Height, mm	1 794	1 925	2 230	2 256
Width, mm	1 390	1 570	1 600	1 838
Depth, mm	1 455	1 493	1 700	2 058
Weight net, kg	1 200–1 400	1 500–1 930	2 200–2 600	~4 000
Electricity and water connection and consumption				
Voltage, V	230–480	230–480	230–480	230–480
Total load electric, kW	36 3 phase	36–54 3 phase	45–50	45–50
Total load gas, kW	n.a.	n.a.	n.a.	n.a.
Total load steam, kW	5.5	n.a.	n.a.	n.a.
Cold and Warm water connection	Yes	Yes	Yes	Yes
Others				
Type of loading	front / side / top	front / side / top	front / side / top	front / side / top

n.a. = not applicable

The following table shows the BOM of a typical washer extractor of category WM4, the share of the different materials and the category to which the materials are assigned. The share of the amount of material is comparable to category WM3. The packaging material is listed separately.

[8] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of four typical models within category WM3.

Table 9 Material composition of a professional washer extractor >40 kg (category WM4)

Material / component	Weight in g[9]	Weight in %	Material category according EcoReport
Stainless steel	506 000	22%	3-Ferrous
Steel tube	276 000	12%	3-Ferrous
Galvanised steel	621 000	27%	3-Ferrous
Cast Iron	391 000	17%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	48 300	2.1%	1-BlkPlastics
Zinc	9 200	0.4%	4-Non-ferrous
Aluminium	207 000	9%	4-Non-ferrous
Copper	87 400	3.8%	4-Non-ferrous
PVC (cables)	6 900	0.3%	1-BlkPlastics
Electronics	69 000	3.0%	6-Electronics
EDPM rubber	34 500	1.5%	1-BlkPlastics
Glass	29 900	1.3%	7-Misc.
Polyamid (PA)	13 800	0.6%	2-TecPlastics
Total net	**2 300 000**		
Packaging			
Polystyrene	4 500		1-BlkPlastics
Wood	165 000		7-Misc.
Cardboard	38 000		7-Misc.
Total weight	**2 507 500**		

2.1.1.3 Category WM5: Professional washer dryer

The following figure shows a typical professional washer dyer (category WM5).



(Source: Electrolux WD4130, 6.5 kg)

Figure 15 Example of typical professional washer dryer (category WM5)

[9] Average weight value is based on a typical washer extractor with 90 kg washing capacity.

As washing and drying is done in one machine, there is no need for re-loading[10]. Therefore, it is also possible to use both functions separately. Washer dryers usually require less space (being optimum for apartment-house-laundry) compared to a separate washing machine and clothes dryer of the same capacity. Many washer dryer units are also designed to be portable in such a way that they can be attached to a sink instead of requiring a separate water line. Designed to handle different types of fabrics and garments such as clothes, sheets or towels, professional washer dryers usually have functions such as temperature controls and customizable cycle controls for washing and drying. For the washing process, washer dryers need space for a water tank around the drum which limits the drum capacity compared to a conventional tumble dryer of the same size.

Table 10 gives an overview of the characteristics of a typical professional washer dryer (category WM5).

Table 10 Characteristics of a typical professional washer dryer (category WM5)

Main characteristics[11] category WM5	**Data**	
Feature of performance	**Model A**	**Model B**
Washing / drying capacity, kg	8/18	15/33
Drum volume, L	130	240
Washing only capacity, kg	14	27
Drying only capacity, kg	8	15
Spin speed, rpm	980	890
G-factor	350	350
Dimensions		
Height, mm	1 330	1 450
Width, mm	910	1 020
Depth, mm	1 110	1 350
Weight net, kg	382	555
Electricity and water connection		
Voltage, V	230–415	230–415
Electric heating (washing/drying), kW	20.5 (12.5/8.0)	35.9 (19.4/16.5)
Gas (drying), kW	10	19
Non-heated (washing)	n.a.	n.a.
Cold and warm water connection	Yes	Yes

The following table shows the BOM of a typical washer dryer (category WM5), the shares of the different materials and the category to which the materials are assigned. The packaging

[10] Source: by Electrolux Professional

[11] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of two typical models within category WM5.

material is listed separately. The weight in percentage is based on direct stakeholder input and provides average values of this category.

Table 11 Material composition of a professional washer dryer (category WM5)

Material / component	Weight in g[12]	Weight in %	Material category according EcoReport
Stainless steel	30 560	8%	3-Ferrous
Steel tube	19 100	5%	3-Ferrous
Galvanized steel	267 400	70%	3-Ferrous
Cast Iron	15 280	4%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	7 640	2%	1-BlkPlastics
Zinc	7 640	2%	4-Non-ferrous
Aluminium	7 640	2%	4-Non-ferrous
Copper	15 280	4%	4-Non-ferrous
PVC	764	0.2%	1-BlkPlastics
Electronics	10 696	2.8%	6-Electronics
Total net	382 000		
Packaging			
Polystyrene	1 500		1-BlkPlastics
Wood	17 500		7-Misc.
Cardboard	6 000		7-Misc.
Total weight	407 000		

2.1.1.4 Category WM6: Professional barrier washer

The following figure shows a typical professional barrier washer (category WM6).



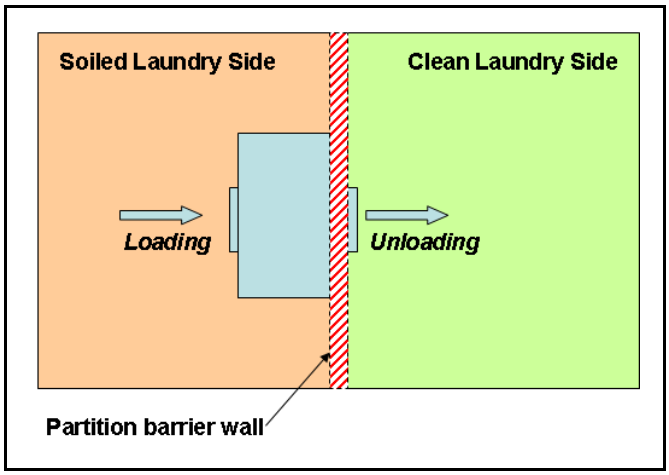
(Source: Stahl)

Figure 16 Example of professional barrier washer with side loading

[12] Average weight value is based on a typical washer dryer with 8/18 kg capacity (wash/dry).

Where sanitation demands are particularly high, e.g. in hospitals, nursing homes, prisons, or in the pharmaceutical, medical, micro-electronic, cosmetic, food or nuclear industries, a so-called "barrier washer extractor" is used. Synonyms are “hygienic barrier washer extractor”, “medical barrier washer” or “pass-through concept”. To ensure the highest standards of hygiene, a special "barrier" wall physically separates the soiled loading side of the washer from the clean unloading side. The laundry is loaded into the drum through a door opening on one side of the laundry, the soiled side. After the laundry has been washed, the clean linen is removed from the washer extractor into another room, the clean side of the laundry area. By use of this dual door design (soiled and clean room), contact between contaminated linen and sanitised laundry can be avoided.

Professional barrier washer extractors are either manually loaded from the top or from the side or automatically top loaded and tilt unloaded (see also Figure 10).



(Source: own compilation)

Figure 17 Schematic illustration of the functionality of a barrier washer

The following table gives an overview of the characteristics of a typical professional barrier washer extractor (category WM6).

Table 12 Characteristics of a typical professional barrier washer extractor (category WM6)

Main characteristics[13] category WM6	**Data**		
Model	**Model A**	**Model B**	**Model C**
Washing capacity, kg	32	67	110
Drum volume, L	320	667	1080
Filling ratio (recommended)	1:10	1:10	1:10
Spin speed, rpm	up to 975	up to 975	up to 975

[13] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of three typical models within category WM6.

Main characteristics[13] category WM6	Data		
Model	**Model A**	**Model B**	**Model C**
G Factor	up to 350	up to 975	up to 975
Number of washing programs (programmable)	40 (200)	9 (200)	9 (200)
Residual moisture %	50%	50%	50%
Construction details			
Height, mm	1 720	1 690	2 040
Width, mm	1 300	1 965	1 956
Depth, mm	1 180	1 053	1 363
Weight net, kg	930–1 050	1 570	~2 900
Electricity and water connection and consumption			
Voltage, V	380–415	230–400	380–415
Total electric load, kW	27–31	50–54	~72
Total gas load, kW	n.a.	n.a.	n.a.
Total steam load,	n.a.	n.a.	n.a.
Cold and warm water connection	Yes	Yes	Yes
Others			
Type of loading	front / side	front / side	front / side

n.a. = not applicable

The following table shows the BOM of a typical barrier washer extractor of category WM6, the shares of the different materials and the category to which the materials are assigned. Besides, the data were validated by additional, more detailed response of two manufacturers. Furthermore, the amount of material is shown as percentage of the weight of the product. The packaging material is listed separately.

Table 13 Material composition of a typical professional barrier washer extractor (category WM6)

Material / component	Weight in g[14]	Weight in %	Material category according EcoReport
Stainless steel	441 500	44%	3-Ferrous
Steel tube	170 600	17%	3-Ferrous
Galvanized steel	50 100	5%	3-Ferrous
Cast Iron	80 300	8%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	48 200	4.8%	1-BlkPlastics
Zinc	20 100	2%	4-Non-ferrous
Aluminium	30 100	3%	4-Non-ferrous
Brass	20 100	2%	
Copper	30 100	3%	4-Non-ferrous

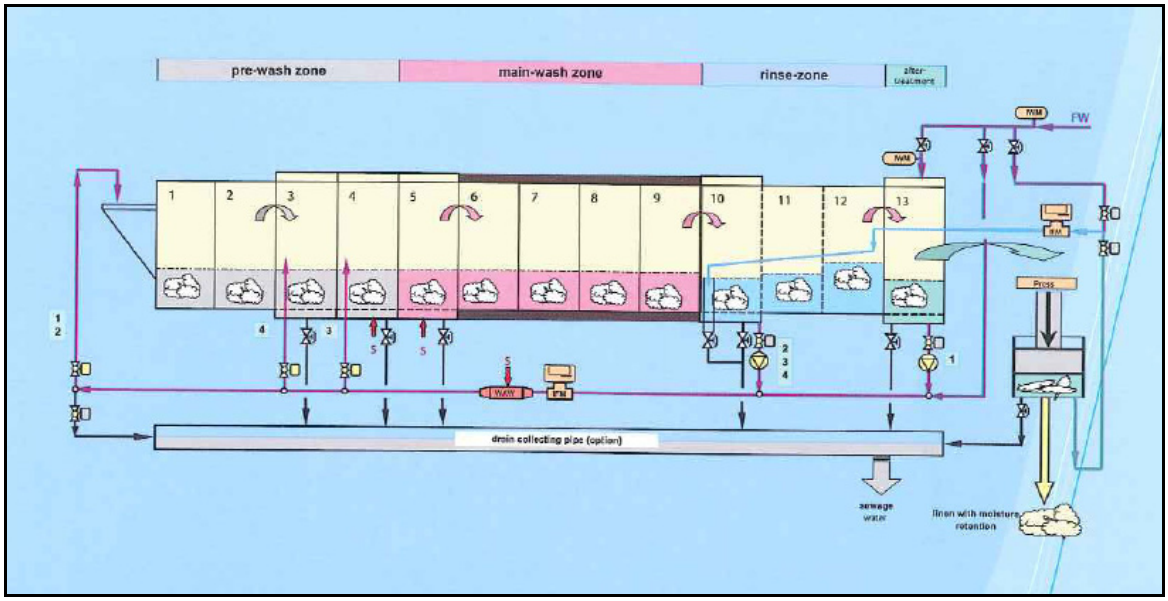
[14] Average weight value is based on a typical barrier washer extractor with 32 kg washing capacity.

Material / component	Weight in g[14]	Weight in %	Material category according EcoReport
PVC (cables)	2 000	0.2%	1-BlkPlastics
Electronics	60 200	6%	6-Electronics
EDPM rubber	20 100	2%	1-BlkPlastics
Glass	10 000	1%	7-Misc.
Polyamid (PA)	20 100	2%	2-TecPlastics
Total net	**1 003 500**		
Packaging			
Polystyrene	2 800		1-BlkPlastics
Wood	53 000		7-Misc.
Cardboard	15 000		7-Misc.
Total weight	**1 074 300**		

2.1.1.5 Category WM7: Washing tunnel machine

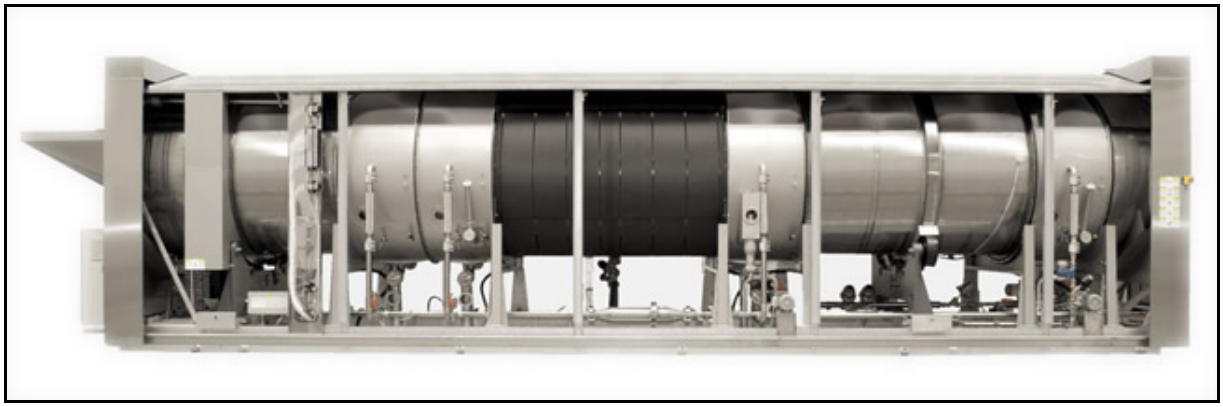
Tunnel washers, also called washing tunnels, tunnel batch washers or continuous (batch) washers are used for large quantities of laundry. The tunnel in the machine consists of several sections, each with its own function: pre-wash, main wash, rinse, after treatment and extraction. Normally, this category is heated by steam (low-pressure steam).

The following figure illustrates exemplary tunnel washers (category WM7).



(Source: Jensen, Senking continuous Batch, Universal SL)

Figure 18 Schematic illustration of a tunnel washer



(Source: Jensen, Universal)

Figure 19 Continuous batch washer (category WM7)

The laundry is transported through the sections of the tunnel, each section of the tunnel leading the laundry on to the next section. As the water flows in the opposite direction to the laundry, the laundry gets thoroughly soaked and washed.

While, at the end of a cycle, one batch of linen arrives at the following mechanical dewatering system (press or centrifuge), the first compartment is emptied and can be filled again with soiled linen. Since tunnel washers do not have to be stopped for the loading and unloading of linen, they provide a more continuous flow of clean laundry.

Within tunnel washing machines, principally two different design processes can be distinguished regarding the drum movement: Oscillating washing action with bottom transfer and rotating washing action with centred transfer (see Figure 20).

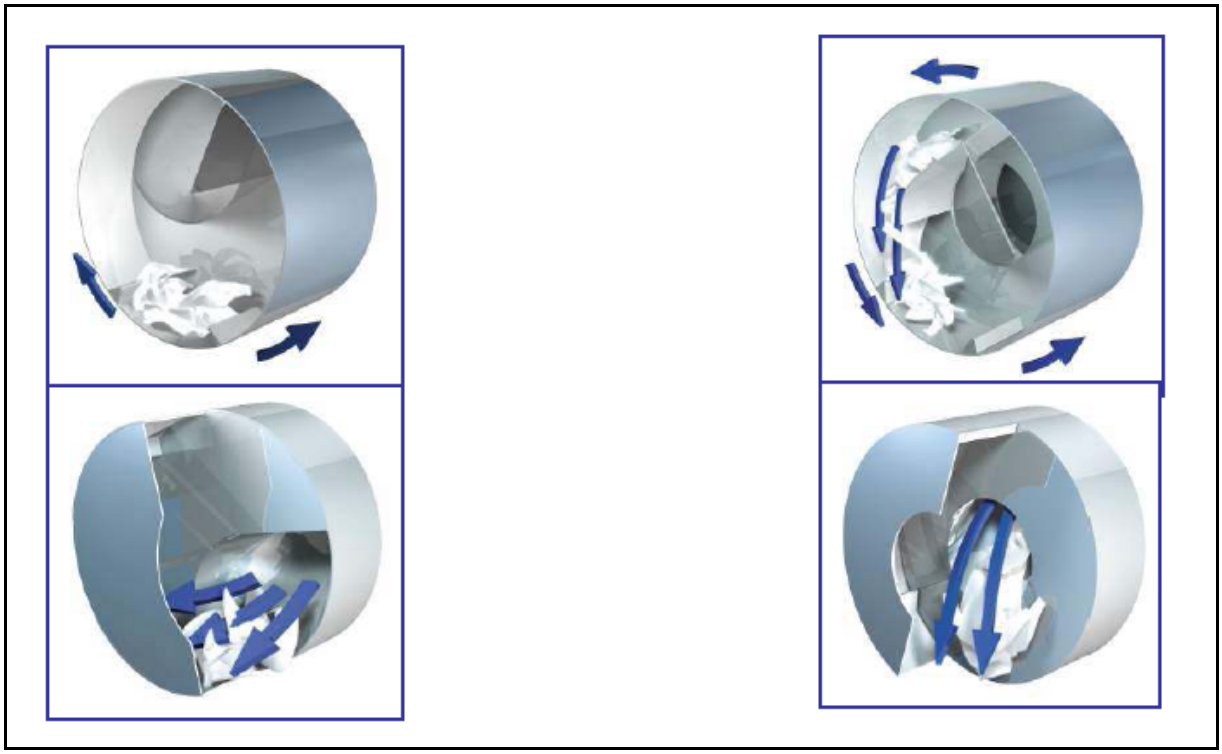


Figure 20 Oscillating drum movement (left side) and rotating drum movement (right side)

By using the oscillating drum movement, the linen is moved by beaters. Due to the mechanical action on the textile surface there is a constant fold-over and friction of the linen. In contrast, the rotating drum movement works with a penetrative mechanical action. During the washing process the linen is compressed and in free fall.

The mechanical action of the drum designs is shown in Figure 21, visualizing the fact that the share of rubbing within the rotating drum movement is reduced in favour of compression and flow through.

Washer programmable control is provided by a modular industrial-type programmable logic controller. It might be programmed in ladder logic[15] and constructed in such a way that, if necessary, the customer's staff themselves may replace and programme it.[16]

[15] Ladder logic is a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay-based logic hardware (Source: http://en.wikipedia.org/wiki/Ladder_logic)

[16] http://www.geneva-scientific.com/pdf/SL1200%20Specifications.pdf

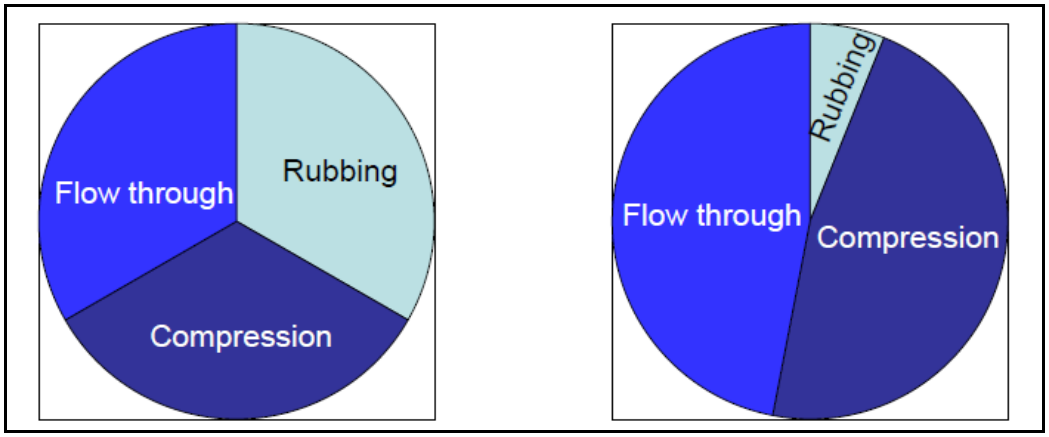


Figure 21 Components of the mechanical action: oscillating washing action and rotating washing action

Rotating cylinder movements are more efficient regarding the adsorption of detergents, the dilution of chemicals during rinsing and the treatment of the linen.

Table 14 gives an overview of the characteristics of a typical washing tunnel machine (category WM7).

Table 14 Characteristics of a typical washing tunnel machine (category WM7)

Main characteristics[17] category WM7	**Data**
Program	**Model A**
Batch capacity, kg	36–120
Washing capacity, kg/h	500–4 000
Filling ratio	1:48–1:83 (depends on rotating movement)
Inside drum, mm	1 600–1 900
Number of compartments	5–20
Number of washing programs	Up to 100 free programmable washing programmes
Steam demand, kg/kg dry linen	0.45
Construction details	
Height, m	1.9–2.5
Width, m	2.2–2.5
Length of tube, m	4.7–18
Weight net, kg	6 600–18 000
Electricity and water connection	
Connection load in kW	10–36
Water connection in DN mm	50–65
Steam connection in DN mm	50–65

[17] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of a typical tunnel washer within category WM7.

The following table shows the BOM of a typical washer extractor of category WM7, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately. The weight in percentage is based on direct stakeholder input and provides average values of this category.

Table 15 Composition of materials of a typical washing tunnel machine (category WM7)

Material / component	**Weight in g**[18]	**Weight in %**	**Material category according EcoReport**
Stainless steel	9 600 000	80%	3-Ferrous
Galvanized steel	1 200 000	10%	3-Ferrous
Cast iron	600 000	5%	3-Ferrous
Copper (cable)	240 000	2%	4-Non-ferrous
EPDM rubber	< 120 000	< 1%	1-BlkPlastics
Electronics	120 000	1%	6-Electronics
PE	< 120 000	<1%	1-BlkPlastics
PVC (cables)	< 120 000	<1%	1-BlkPlastics
Total net	**~12 000 000**		
Packaging[19]			
Polystyrene	n.a.		1-BlkPlastics
Wood	n.a.		7-Misc.
Cardboard	n.a.		7-Misc.
Total weight			

About 90 percent of a continuous tunnel washing machine is a steel construction. All wetted parts (doors, wash and rinse tanks, etc.) shall be of stainless and galvanized steel.

2.1.1.6 Overview of all professional washing machine categories

In the following table an overview of the shares of the material categories according to MEEuP (including packaging material) is shown for the different categories of professional washing machines.

[18] Average weight value is based on a typical tunnel washer with 12 numbers of compartments and a typical load capacity of 1 500 kg/h.

[19] Due to the heavy machines the distribution is realised without packaging (source: stakeholder feedback).

Table 16 Share of material categories (according to MEEuP) for the different categories of professional washing machines (including packaging)

Materials-category	Unit	WM1	WM2	WM3	WM4	WM5	WM6	WM7
Bulk Plastics	g	16,9%	3.8%	3.7%	3.8%	2.4%	6.8%	3.0%
Tec Plastics	g	0,7%	0.5%	0.5%	0.6%	0.0%	1.9%	0.0%
Ferrous	g	42,3%	77.2%	72.1%	71.5%	81.7%	69.1%	96.0%
Non-ferrous	g	7.0%	7.9%	12.2%	12.1%	7.5%	9.3%	0.0%
Coating	g	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electronics	g	0,2%	1.9%	2.8%	2.8%	2.6%	5.6%	1.0%
Misc.	g	32.8%	8.8%	8.6%	9.3%	5.8%	7.3%	0.0%
Total weight	**g**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

WM1: Semi-professional washer extractor
WM2: Professional washer extractor, <15 kg
WM3: Professional washer extractor, 15-40 kg
WM4: Professional washer extractor, >40 kg
WM5: Professional washer dryer
WM6: Professional barrier washer
WM7: Washing tunnel machines

In all categories, the share of ferrous metal (mainly stainless steel) is with 42% to 96% (including packaging) predominant.

2.1.2 Other materials

According to MEEuP, certain material categories are assessed. In professional dishwashers, there are some further materials not covered by MEEuP which are described below.

- **Mercury**: According to stakeholders' feedback, the professional washing machines and dryers do not contain mercury. All materials used within the products comply with the restrictions set out in the RoHS Directive.[20]
- **Silver ions**:
  - Application: Nowadays there is a wide range of products containing silver because of its antibacterial activity. Silver can be applied individually as a solution, as a suspension or in the form of nanoparticles. Whenever silver is exposed to moisture, silver ions are released. Their antibacterial characteristic is used in following scopes and products: Water treatment, washing, medical applications, impregnation of fibres etc[21].

[20] Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0019:0023:EN:PDF) (see Task 1).

[21] http://www.umweltdaten.de/publikationen/fpdf-l/3673.pdf

- Advantages: Silver provides advantages e.g. when they are added to wall paints which are used in surgeries to improve the hygienic conditions. Used in washing machines, silver prevents retention of bacteria on laundry after the cleaning process.
- Disadvantages: There are also negative aspects which have to be mentioned. For example, due to the increasing use of silver as a bactericide, environmental impacts could be bacterial resistance to silver ions because of a pollution of sludge in sewage plants. Further, there is lack of knowledge concerning possible impacts of silver ions, e.g. toxicity for terrestrial and sediment organisms, residuals in municipal wastewater, characteristic and quantity of emissions from products containing silver, toxicity of silver nanoparticles in comparison to silver compounds, occurring of different reactions in the environment, etc.
- Use of silver in washing machines: According to stakeholders' feedback, the use of silver is not applied anymore. In Germany, warnings from the German Federal Institute for Risk Assessment[22] with regard to possible harmful aspects and missing comprehensive data to allow conclusive risk assessments, especially for nano-silver, induced a rethinking process on the market. Moreover, according to stakeholders there is no need of silver ions in washing machines, because there are other possibilities (temperature, chemistry, steam) to guarantee the same hygienic standard. As the negative aspects associated with the use of silver outweigh the positive ones, silver is not longer considered an acceptable alternative

[22] Bundesinstitut für Risikobewertung (BfR) www.bfr.bund.de

2.2 Technical analysis of the distribution phase

The following table shows the average volume of the final packaged product. These values are used to calculate the environmental impacts resulting from distribution. We know that especially in case of transport of professional washing machines there are quite large differences. However for the Eco-report tool we need only the value of the average volume of the final product.

Table 17 Average volume of the final packaged product of the different categories of professional washing machines (Source: information provided by data sheets of manufacturers)

Washing machine category	Average volume of the final packaged product	Source of information
WM1: Semi-professional washer extractor	0.75–1.14 m³	According to Lot 14
WM2: Professional washer extractor, <15 kg	0.94–1.14 m³	Information provided by stakeholders
WM3: Professional washer extractor, 15-40 kg	1.14–3.30 m³	Information provided by stakeholders
WM4: Professional washer extractor, >40 kg	3.00–9.30 m³	Based on assumed dimensions from the technical data sheets
WM5: Professional washer dryer	1.61–2.42 m³	Information provided by stakeholders
WM6: Professional barrier washer	3.99–6.09 m³	Based on assumed dimensions from the technical data sheets
WM7: Washing tunnel machine[23]	~16.58 m³	Based on assumed dimensions from the technical data sheets

2.3 Technical analysis use phase (product)

This section provides an assessment of the annual resources consumption (energy, water, detergent) during product life. Usually, the consumption values should be measured according to existing test standards. However, there are no standardised measurement methods for quantifying the energy and water consumption of professional washing machines (see Task 1). Therefore, the assessment of data quality and comparability in the following sections should be seen with regard to this context.

2.3.1 Ratio of energy use in professional washing machines

This section exemplifies how much energy is used for the different washing phases in a typical professional washing process.

[23] Corresponds to the average volume of the machine as the distribution is realised without packaging.

The relative energy consumption of professional washing machines can be mainly sub-divided into energy used for water heating and energy needed for the motor for mechanical action and for the functioning of the electronic components. The following table shows the respective energy consumption for each machine category.

Table 18 Share of the average energy consumption in the different categories of professional washing machines (Source: information provided by manufacturers)

Washing machine category	Percentage of energy consumed for motor and electronic components etc. (always electricity)	Percentage of energy consumed for water heating
WM1: Semi-professional washer extractor	13.5%	86.5%
WM2: Professional washer extractor, <15 kg	13.5%	86.5%
WM3: Professional washer extractor, 15-40 kg	13.5%	86.5%
WM4: Professional washer extractor, >40 kg	12.5%	87.5%
WM5: Professional washer dryer	20%	80%
WM6: Professional Barrier washer	12.5%	87.5%
WM7: Washing tunnel machine[24]	5.0%	95.0%

Depending on the category, 5 to 13% of the incoming energy is used to drive motors, pumps and electronic components to control the whole system (always electricity). Most of the energy input, however, is used to heat up the water: approximately 95% of the total energy consumption. As outlined in Task 3, electric energy is one energy source for water heating in professional washing machines. Other energy sources used for heating the water are natural gas, steam (or thermo oil as a heat transfer medium, cf. Task 3). The different heating systems will result in different environmental impacts, and different operating costs in the end.

In the following Tasks, we will further use these inputs to derive the environmental impacts and the improvement potential of the technological options.

2.3.2 Typical composition of detergents and laundry aids for professional washing machines

As in the case of professional dishwashers, there is no defined standard composition of detergents and laundry aids for professional washing machines. To keep the use of raw materials in the washing process to a minimum, suppliers of detergents for professional washing machines offer a great variety of products, adjusting the constituents of a product to the individual requirements of various types of laundry. The modular system allows an almost limitless number of mixes which can be tailored to fit the customer's needs, thus avoiding

[24] Only the average volume of the machine due to the distribution ensued without packaging.

chemical waste and unnecessary disposal into the environment[25]. However, all detergents (powder, liquid, paste) use fundamentally the same ingredients to achieve the wash performance; most often modular detergent systems comprise an alkali booster, a sequestrant builder, a surfactant blend, an enzymatic additive and peroxy bleach.

In their latest sustainability report, A.I.S.E provides a short description of the different types of professional laundry detergents: fully formulated detergents, powder/liquid detergents, prewash additives, boosters, pH-adjustment, water hardness regulators, bleach additives, disinfectant detergents/additives for hygienic laundry (hospital, food industry), fabric softeners, starch finishing, ironing aid, fragrance rinse, etc.

The Leonardo da Vinci project[26] provides some general information with regard to the usage of detergents and the background of ingredients in commercial laundering processes. The detergent options are quite numerous depending on the increasing number of laundry classifications:

- Auto-dosed powders;
- Stock solution powders;
- Dry feed powders;
- Single shot liquid auto-dosed from bulk;
- Multi liquid systems auto-dosed from bulk;
- Detergent pastes with auto-dose system.

According to A.I.S.E., the institutional laundry detergent segment has developed towards a higher acceptance of concentrated detergents, both for granular and liquid detergents. This development has moved forward faster in the last few years and is expected to continue.

The industrial laundry market uses mostly concentrated granular detergents and liquids. 'Paste-type' products or anhydrous liquids can also be found. The use of concentrates reduces the amount of packaging and chemicals and therefore might have a reduced total environmental impact.[27]

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[25] Source : A.I.S.E., "Industrial & Institutional Sector – Environmental dossier on Professional laundry", (2000). A.I.S.E., the international Association for soaps, detergents and maintenance products represents the industry which manufactures these products for household and for industrial and institutional (I&I) use.

[26] http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_4_-_1_Backg__ingredients.PDF

[27] So called volume concentrates have a higher bulk density (0.6-0.9 g/cm^3) compared to regular detergents (0.5-0.6 g/cm^3). However, the ingredients do not differ considerably besides the almost total absence of the bulking agent sodium sulphate. Thus, with volume concentrates not the entry of chemicals into the waste water is reduced but the packaging, as the same amount is realised with a smaller volume. A further development is provided by the so called super concentrates. Besides a higher bulk density and the absence of bulking agents, the composition is changed resulting in less pollution of the waste water – optimum dosage provided.
(Source: http://www.oekoplus.sepeur-media.de/fp/archiv/RUBsonstiges/Waschmittelkonzentrate.php)

The following figure shows an example of a modular detergent system and wash programme, specifically for blue work wear.[28]

Soiling	Mineral oil, Pigment		
Textile	PES/Cotton 65/35		
Washing Machine	CBW		
Water hardness	0-2°dH		
Water Consumption total	12 l/kg		
Liquor/Cloth Ratio	1:5		
Temperature	Pre-wash: 35°C Main wash: 70°C		
Wash time total	45 Minutes		
Dosage: (g/kg Wash)	Pre-wash	Main wash	Total
Main wash Detergent A	12	12	24
Booster B	3	2	5
Acid C (Rinse)		0.5	0.5
Formulation Model-Products			
Main wash Detergent A	**%**		**Ingredients in Liquor g/kg Wash**
Sodiummetasilicate 5aq	50		12
Sodium triphosphate	15		3.6
Soda ash	24		5.76
Polycarboxylate	2		0.48
LAS	2		0.48
Fatty alcohol ethoxylate C12-14, 5 EO	5		1.2
Carboxymethylcellulose	1		0.24
Methylcellulose	1		0.24
Water	0		0
Sum	**100**		**24**
Booster B			
Fatty alcohol ethoxylate C12-14, 5 EO	97		4.85
Water	0		0
Alcohol	3		0.15
Sum	**100**		**5**
Acid C			
Formic acid	100		0.5
Water	0		0
Sum	**100**		**0.5**

Remark : Dosage dependent on: Degree of soiling, machine type, quality level

Figure 22 Example of a modular detergent system and wash programme, specifically for blue work wear

No further data could be obtained regarding the composition of professional laundry detergents. The following figure additionally provides a typical composition of detergents for

[28] Industrial & Institutional Sector Environmental dossier on Professional laundry
Source: http://www.aise.eu/downloads/AISE_pro_laundry_dossier.pdf

household washing machines.[29] As appliances in the major semi-professional market segments, Coin & Card Laundry (CCL) and Apartment Household Laundry (AHL) are mainly operated by non-professional users, the use conditions with regard to laundry types, types of soil, and thus also the detergents are expected to be similar to the conditions in household use.

(Massenanteile der Bestandteile in %)

Funktions-bausteine	Beispiele	Voll-WM Normalware Kompaktat Zeolithbasis	Voll-WM Normalware Kompaktat Lösliche Enthärter-systeme	Color-WM Normalware Kompaktat Lösliche Enthärter-systeme	Voll-WM Super-kompakt	Color-WM Super-kompakt
Anionische Tenside	LAS, FAS	8 - 15	8 - 15	10 - 20	10 - 25	10 - 25
Nichtionische Tenside	FAEO	1 - 5	1 - 5	1 - 5	5 - 15	5 - 15
Seife		1 - 3	1 - 3	1 - 3	< 1	< 1
Gerüststoffe	Zeolith A	25 – 50	-	-	20 - 40	20 - 40
	Lösliche Silicate (Natriumdisilicat)	5 - 10	5 - 10	1 - 5		
Alkalien	Soda	20 - 40	20 - 40	20 - 40	1 - 5	1 - 5
Co-Builder	Polycarboxylate	3 - 5	3 - 5	3 - 5	2 - 8	2 - 8
Bleichmittel	Natriumper-carbonat	10 - 25	10 - 25	-	10 – 20	-
Bleich-aktivatoren	Tetraacetylethylen-diamin - TAED	1 - 3	1 - 3	-	3 – 10	-
Stabilisatoren	Phosphonate, andere Komplex-bildner	0 – 1	0 – 1	0 - 1	0 – 1	0 – 1
Enzyme	Proteasen, Amylasen, Lipasen, Cellulasen, Mannanasen	0 – 1	0 – 1	0 - 1	0,5 – 2,0	0,5 – 2,0

Figure 23 The essential components of a laundry detergent for household use (Europe 2009)

[29] Source: Waschmittel, Guenther Wagner, ISBN: 978-3-527-32678-5

Detergent components for laundry disinfection[30]

Disinfection of textiles is achieved by a combination of physical removal (promoted by the combination of detergent, water, mechanical action and subsequent rinsing) and inactivation of microbes, whereby the latter may be achieved by thermal means (i.e. washing at higher temperatures) and/or by chemical inactivation by a biocidal ingredient, assisted in both cases by a final drying, which may also use high temperatures. It is important to ensure that microbes that are physically removed rather than inactivated are thoroughly rinsed away, and not re-deposited elsewhere in the same, or a following load. Different countries specify different conditions in terms of times and temperatures for achieving disinfection by thermal means alone (thermal disinfection).

Chemical inactivation of microbes in the laundry process is most often delivered by oxidising agents such as peroxygen or hypochlorite bleaches. These products release amongst others peracetic acid or hypochlorite respectively. Peracids bleaches (such as perborate or percarbonate) work most efficiently at higher temperatures (70°C and above), though peracetic acid can be used to help reach disinfection at lower temperatures. Hypochlorite and similar bleaches are used in many countries for bleaching and disinfecting white textiles at low temperatures.

The professional detergent products are often part of complete delivery systems requiring special packaging, dosing and control equipment. The objective for industrial and institutional (I&I) companies is considered three-fold:

- to ensure hygienic conditions for all customers segments,
- to safeguard users;
- to protect the environment.

The products can be supplied in a small trigger-spray bottle (0.75 to 1 litre) for institutional use and up to delivery in bulk (above 3 tons)[31] for commercial customer segments.

2.3.3 Energy, water and detergent consumption

In general, the primary function of a (professional) washing machine is to clean and rinse textiles using water. The machine may also have a system for extracting excess water from the textiles. Further important functional parameters are the hygienic performance, energy consumption, water consumption or the detergent consumption (cf. Task 1).

There are some requirements for professional laundry appliances that have to be taken into account and that vary to a great extent for different customer groups:

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[30] Source: A.I.S.E “Industrial and Institutional Sector – Professional Hygiene for Health and Well-being” (2004)

[31] An introduction to the industrial & institutional sector of A.I.S.E.; September 2005

- The amount of laundry and types of fabrics to be washed are very different depending on the application.
- High capacities / short running cycles are usually important.
- The spatial requirements are different depending on the customer segments.

As described in Task 3, the energy, water and detergent consumptions of professional washing machines are influenced by different real-life usage parameters and also depend on the usage in the relevant market or customer segment.

The following input parameters were specified to define the respective energy, water and detergent consumptions of professional washing machines during the use phase. The parameters have already been compiled and discussed in Task 3 on user behaviour. The following sections summarise the assumptions and the annual consumption of the different washing machines categories.

2.3.3.1 Category WM1: Semi-professional washer extractor

The following data are based on cold water connection of the washing machines.

Table 19 Energy, water and detergent consumption of a semi-professional washer extractor

	Energy	Water	Detergent
Main customer segment	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)		
Typical use intensity: Annual amount of cleaned laundry (kg/year) for a typical machine capacity of 6 kg	7 000		
Specific consumption operation (ideal conditions)	*0.15 kWh/kg laundry*	*9 litres/kg laundry*	*17 g/kg laundry*
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 20%	+ 20%
Additional consumption through maloperation	+ 15%	+ 15%	+ 15%
Specific consumption operation (real life user behaviour)	*0.19 kWh/kg laundry*	*12 litres/kg laundry*	*23 g/kg laundry*
Annual consumption operation (real life user behaviour)	*1 330 kWh*	*85 050 litres*	*161kg*
Annual consumption standby	1.8 kWh	-	-
Annual consumption (real life)	***1 332 kWh***	***85 050 litres***	***161 kg***

2.3.3.2 Category WM2: Professional washer extractor <15 kg

Table 20 Energy, water and detergent consumption of a professional washer extractor <15 kg (category WM2)

	Energy	Water	Detergent
Main customer segment	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)		
Typical use intensity: Annual amount of cleaned laundry (kg/year) for a typical machine capacity of 10 kg	14 400		
Specific consumption operation (ideal conditions)	0.17 kWh/kg laundry	12 litres/kg laundry	17 g/kg laundry
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 20%	+ 20%
Additional consumption through maloperation	+ 15%	+ 15%	+ 15%
Specific consumption operation (real life user behaviour)	0.21 kWh/kg laundry	16 litres/kg laundry	23 g/kg laundry
Annual consumption operation (real life user behaviour)	*3 024 kWh*	*233 280 litres*	*330 kg*
Annual consumption standby	1.8 kWh	-	-
Annual consumption (real life)	***3 026 kWh***	***233 280 litres***	***330 kg***

For comparison:

Since 2008, the Danish Technological Institute (DTI)[32] has been measuring data on energy and water consumption, cycle duration (time) and washing, spin extraction and rinsing performance as well as washing temperature for around ten different professional washing machines (comparable to washing categories WM1 and WM2). The data have been determined for five manufacturers. In November 2010, the website www.faellesvaskeri.dk only contained data from five washing machines/programmes which is probably due to the fact that manufacturers may ask to remove older test results as soon as newer tests have been performed by DTI on the manufacturer's demand. All test data are the property of the manufacturer.

The modifications follow as far as possible the European standard EN 60456 for household washing machines (see also cf. Task 1).

The following table gives an overview of the DTI results compared to the data provided from manufacturers for EuP Lot 24 and the results achieved in Lot 14.

[32] www.dti.dk

Table 21 Comparison of performance data of professional and household washing machines

	Energy consumption kWh/kg laundry			Water consumption litres/kg laundry		
Source	**EuP Lot 24**	**DTI[33]**	**EuP Lot 14[34]**	**EuP Lot 24**	**DTI**	**EuP Lot 14**
	0.12-0.18 (WM1) 0.14-0.20 (WM2)	0.10-0.19	0.187	8-10 (WM1) 10-14 (WM2)	4.2-12.6	9.3
Average value	**0.16**	**0.15**	**0.19**	**11**	**8.2**	**9.3**

2.3.3.3 Category WM3: Professional washer extractor 15–40 kg

Table 22 Energy, water and detergent consumption of a professional washer extractor 15–40 kg (category WM3)

	Energy	Water	Detergent
Main customer segment	Hospitality Laundry		
Typical use intensity: Annual amount of cleaned laundry (kg/year) for a typical machine capacity of 24 kg	42 200		
Specific consumption operation (ideal conditions)	0.21 kWh/kg laundry	13 litres/kg laundry	14 g/kg laundry
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 20%	+ 20%
Additional consumption through maloperation	+ 15%	+ 15%	+ 15%
Specific consumption operation (real life user behaviour)	0.26 kWh/kg laundry	18 litres/kg laundry	19 g/kg laundry
Annual consumption operation (real life user behaviour)	*10 972 kWh*	*740 610 litres*	*798 kg*
Annual consumption standby	1.3 kW/h	-	-
Annual consumption (real life)	***10 973 kWh***	***740 610 litres***	***798 kg***

[33] Source DTI: http://faellesvaskeri.dk/index.asp?m=1. The 5 latest tests present on the website.

[34] EuP Lot 14, Base case page 381

2.3.3.4 Category WM4: Professional washer extractor >40 kg

Table 23 Energy, water and detergent consumption of a professional washer extractor >40 kg (category WM4)

	Energy	Water	Detergent
Main customer segment	Commercial Industrial Laundry		
Typical use intensity: Annual amount of cleaned laundry (kg/year) for a typical machine capacity of 90 kg	194 400		
Specific consumption operation (ideal conditions)	0.35 kWh/kg laundry	14 litres/kg laundry	18 g/kg laundry
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 10%	+ 10%
Additional consumption through maloperation	+ 10%	+ 10%	+ 10%
Specific consumption operation (real life user behaviour)	0.42	17	22
Annual consumption operation (real life user behaviour)	*81 648 kWh*	*3 265 920 litres*	*4 199 kg*
Annual consumption standby	negligible	-	-
Annual consumption (real life)	***81 648 kWh***	***3 265 920 litres***	***4 199 kg***

2.3.3.5 Category WM5: Professional washer dryer

Table 24 Energy, water and detergent consumption of a professional washer dryer (category WM5)

	Energy	Water	Detergent
Main customer segment	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)		
Typical use intensity: Annual amount of cleaned laundry (kg/year) for a typical machine capacity of 8 kg	7 400		
Specific consumption operation (ideal conditions)	0.80 kWh/kg laundry	10 litre/kg laundry	14 g/kg laundry
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 20%	+ 20%
Additional consumption through maloperation	+ 15%	+ 15%	+ 15%
Specific consumption operation (real life user behaviour)	1.00	14	19
Annual consumption operation (real life user behaviour)	*7 400 kWh*	*99 900 litres*	*140 kg*
Annual consumption standby	n.a.	-	-
Annual consumption (real life)	***7 400 kWh***	***99 900 litres***	***140 kg***

2.3.3.6 Category WM6: Professional barrier washer

Table 25 Energy, water and detergent consumption of a professional barrier washer (category WM6)

	Energy	Water	Detergent
Main customer segment	Healthcare Laundry		
Typical use intensity: Annual amount of cleaned laundry (kg/year) for a typical machine capacity of 32 kg	56 300		
Specific consumption operation (ideal conditions)	0.39 kWh/kg laundry	16 litres/kg laundry	18 g/kg laundry
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 10%	+ 10%
Additional consumption through maloperation	+ 10%	+ 10%	+ 10%
Specific consumption operation (real life user behaviour)	0.47	19	22
Annual consumption operation (real life user behaviour)	*26 461 kWh*	*1 080 960 litres*	*1 216 kg*
Annual consumption standby	n.a.	-	-
Annual consumption (real life)	***26 461 kWh***	***1 080 960 litres***	***1 216 kg***

2.3.3.7 Category WM7: Washing tunnel machine

Table 26 Energy, water and detergent consumption of a professional washing tunnel machine (category WM7)

	Energy	Water	Detergent
Main customer segment	Commercial Industrial Laundry		
Typical use intensity: Annual amount of cleaned laundry (kg/year)	3 825 000		
Specific consumption operation (ideal conditions)	0.35 kWh/kg laundry	6 litres/kg laundry	9 g/kg laundry
Real-life user behaviour			
Additional consumption through partial workload	+ 10%	+ 10%	+ 10%
Additional consumption through maloperation	+ 10%	+ 10%	+ 10%
Specific consumption operation (real life user behaviour)	0.42	7	11
Annual consumption operation (real life user behaviour)	*1 606 500 kWh*	*27 540 000 litres*	*41 310 kg*
Annual consumption standby	negligible	-	-
Annual consumption (real life)	***1 606 500 kWh***	***27 540 000 litres***	***41 310 kg***

2.3.3.8 Overview of all professional washing machine categories

The following Table 27 summarizes the annual energy, water and detergent consumption to be used as input data for Task 5 (environmental impact assessment of base cases).

Table 27 Annual energy, water and detergent consumption (real life conditions) of all professional washing machine categories

Category	Energy consumption	Water consumption	Detergent / laundry aid consumption
	kWh/year	*litres/year*	*kg/year*
WM1: Semi-professional washer extractor	*1 332*	*85 050*	*161*
WM2: Professional washer extractor, <15 kg	*3 026*	*233 280*	*330*
WM3: Professional washer extractor, 15-40 kg	*10 973*	*740 610*	*798*
WM4: Professional washer extractor, >40 kg	*81 648*	3 265 920	4 199
WM5: Professional washer dryer	*7 400*	*99 900*	*140*
WM6: Professional barrier washer	*26 461*	1 080 960	1 216
WM7: Washing tunnel machine	*1 606 500*	27 540 000	41 310

2.4 Technical analysis of the use phase (system)

Professional washing machines are used in hotels, clinics, health care, laundrettes and in many other places (see Task 3). The surroundings of these places may be quite different and can influence the energy and water consumption of the washing machines. This section provides an overview on how different ambient conditions can influence the energy, water and detergent consumption of the professional washing machines.

Type of laundry: Textiles can be made from different materials and fabrics (cotton, wool, mineral, synthetic etc) and result in particular types of laundry (work wear, hospital linen, high visibility garments etc.). The majority of the laundry is washed using the cotton programme. However there are some types of fabrics retaining the water more than other fabrics, thus increasing the amount of energy needed to dry them. Different products and systems take account of varying needs in accordance with the different types of clothes to be washed.

Wash temperature: The wash temperature has a strong influence on the energy consumption. The higher the temperature, the more energy is needed. According to the sinner's circle (cf. Task 3), temperature, chemistry, time and mechanics interact and have to be optimally adjusted. Thus, if one factor is reduced, another has to be increased.

Contamination/Soiling: The soiling of the clothes can greatly vary within the different customer segments. Depending on the treatment required (e.g. hygienic requirements in the sanitary field, preservation of the protective function of fire protection suits etc.), a different range of product and programme solutions exist. As a consequence, the user may choose different appliances and programs of the washing machines. In case of none satisfying washing results, additional washing cycles might be necessary leading to an increased overall energy and water consumption.

The spin speed (g-factor) of the washer extractor: The g-factor is a measure of centrifugal force which has a significant effect on laundry during spinning. A higher spin speed results in a higher g-force and thus less residual moisture in the laundry. The lower the residual moisture (%) of the washed laundry, the less energy is required in the subsequent drying process.[35]

2.5 Technical analysis of the end-of-life phase

This section provides information regarding the end-of-life of the professional washing machine's material flows for handling as pure waste (landfill, pyrolytic incineration), heat recovery (non-hazardous incineration optimised for energy recovery) and/or re-use or closed-loop recycling.

At the end of their life, heavy duty and larger washing machines are usually taken back by the manufacturer. In some cases, parts of the machine can be reused, the rest of the machines – mostly valuable stainless steel – will be sold to recycling companies where they are cleaned up, shredded and disassembled. Reusable materials are separated and then returned to the material production. The semi-professional and smaller washing machines could be also dismantled by certified scrap dealers.

As already described in Task 3, only 1–5% by weight of the material from professional washing machines is not recovered (i.e. go to landfill), as the materials (mostly stainless steel, >50-80%) are too valuable. According to stakeholders, more than 95% of the products are recyclable and will always either be refurbished or recycled for scrap parts or materials.

[35] http://www.miele-professional.de/us/professional/13_490.htm

Table 28 Landfill (fraction of products not recovered) in % of professional washing machines (based on stakeholder input)

Washing machine category	Landfill (fraction of products not recovered) %
WM1: Semi-professional washer extractor	5
WM2: Professional washer extractor, <15 kg	5
WM3: Professional washer extractor, 15-40 kg	5
WM4: Professional washer extractor, >40 kg	~1
WM5: Professional washer dryer	5
WM6: Professional barrier washer	~1
WM7: Washing tunnel machine	~1

The plastic share of all professional washing machines is less than 10% of their overall weight. All plastic components weighing more than 50 grams are marked in accordance with ISO 1043[36]. According to stakeholder information this plastic parts are disposed of as follows:

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

Printed wiring boards (PWB) are used in the professional washing machines of all categories. According to stakeholder information, these parts are easy to dismantle and are completely recycled by certified scrap dealers.

If a professional washing machine with an installed heat pump is dismantled, specialized technicians will extract the refrigerant from the heat pump. In this process, only a technically unavoidable, small amount of refrigerant will escape.

3 Technical analysis of professional dryers

3.1 Technical analysis of the production phase

In this chapter entails a general technical analysis and description of each dryer category. This description explains the function of the different components of a dryer and is completed with an average bill of material (BOM) for each technology.

[36] ISO 1043 – Part 1, Plastics – Symbols and abbreviated terms – Basic polymers and their special characteristics

3.1.1 Main operating principles of professional dryers

The following table gives an overview of the seven dryer categories identified in Task 1 and their main characteristics. For a more detailed description see Task 1.

Table 29 Categorisation of professional dryers

Product category	Key market segment	Main operator / user type	Filling ratio[37]	Type of loading	Product dimensions	Application
D1 Semi-professional dryer, condenser	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	Mainly private customers and non trained personnel (with few exemptions)	1:18 - 1:25	Manual, front loading	Typical dimension: height x width x depth 850 x 600 x 600 mm	Semi-professional
D2 Semi-professional dryer, air vented						
D3 Professional cabinet dryer				Hangers, front loading	Dimensions are very variable depending on amount / type of textiles to be dried and spatial possibilities	Professional
D4 Professional tumble dryer <15 kg				front loading manual or automatic		
D5 Professional tumble dryer 15-40 kg	Hospitality Laundry (HPL)	Non and trained personnel				
D6 Professional tumble dryer >40 kg	Commercial Industrial Laundry (CIL)	Trained personnel	1:20 - 1:25			
D7 Pass-through (transfer) dryer				Pass-through, Automatically, loading and unloading, doors on opposite sides		

[37] The applicable filling ratio depends on the density of the laundry to be washed/dried.

3.1.1.1 Category D1: Semi-professional dryer, condenser

A typical semi-professional condenser dryer is shown in the following figure.

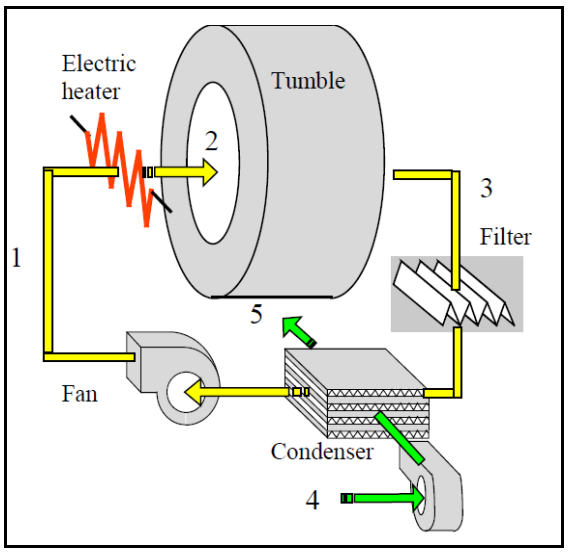


(Source: Miele Duo-Star 6.5 kg, http://www.miele-professional.de/de/prof/produkt/33_14148.htm, sighted on 07.09.2010)

Figure 24 Semi-professional dryer, condenser (D1)

A condensation dryer passes heated air through the load. However, instead of exhausting this air, the dryer uses a heat exchanger to cool the air and condense the water vapour into either a drain pipe or a collection tank. Two types of condenser dryers can be found on the market: air condenser or water condenser dryers. The difference lies in the heat exchange process, the internal warm air being cooled either using ambient air (air condenser dryers) or cold water (water condenser dryers). Water condensation is the most common system of professional wash and dry machines, whereas the vast majority of professional tumble dryers currently available are air condenser models. We will therefore focus our technical description on this type of condenser dryers.

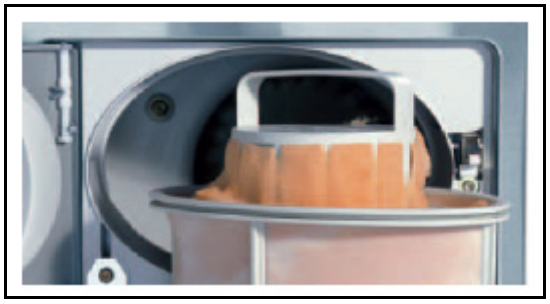
The air circuit (see Figure 25) is mainly constituted of 4 components: an air filter (see Figure 26) at the base part of the tumbler, an air-cooled heat exchanger (condenser), a fan and an electric heater at the tumble inlet. In following figure, the typical condenser principle is shown.



(Source: http://www-cep.ensmp.fr/francais/innov/pdf/ICR0143SLV%20_IIR_IIF%20Conf.pdf)

Figure 25 Condenser dryer principle

These dryers can be equipped with an electronic moisture sensor (residual moisture control – RMC) that monitors the residual moisture level of the load (cf. Task 6).



(Source: Miele, http://www.miele-ebrochures.co.uk/professional/files/Little_Giants_April06.pdf, sighted on 07.09.2010)

Figure 26 Possible filter for a semi-professional dryer

In addition, there are two heating options: only electric or combo electric with heat pump (cf. Task 6). By using the latter, the hot, humid air from the tumbler is passed through a heat pump, where the cold side condenses the water vapour either into a drain pipe or a collection tank and the hot side reheats the air. In this way, the dryer does not only avoid the need for air ducting, but it also conserves much of its heat within the dryer instead of exhausting it into the surroundings.

Table 30 gives an overview of the characteristics of a typical appliance of this category.

Table 30 Characteristics of a semi-professional dryer, condenser (D1)

Main characteristics[38] category D1	Data
Feature of performance	
Drying Capacity, kg	6.5
Drum Volume	130
Filling ratio	1:20
Number of fixed drying programs	12–20
Condensation efficiency	~80%
Construction details	
Height, mm	850
Width, mm	600
Depth, mm	700
Weight net, kg	60–65
Electricity	
Voltage, V	230–400 1–3 phase
Total load, kW	2.2–3.7

According to stakeholders, the material composition is equivalent to that of a household tumble dryer as described in the preparatory study on dryers (Lot 16). The following Bill of Materials (BOM) is taken from task 4 report of that study and partial interpolated for a typical semi-professional condenser dryer with a drying capacity of 6 kg.

Table 31 Material composition of a semi-professional dryer, condenser (category D1)

Material / Component	weight in g	weight in %	Material category
Stainless Steel	34 600	57.5%	3-Ferro
Steel Sheet galvanized	3 500	5.8%	3-Ferro
Cast Iron	2 400	4.0%	3-Ferro
Polypropylen (PP)	7 700	12.8%	1-BlkPlastics
Polyamid (PA)	400	0.7%	2-TecPlastics
Acrylonitrile Butadiene Styrene (ABS)	2 100	3.5%	1-BlkPlastics
Plystyrene (PS)	400	0.7%	1-BlkPlastics
Styropor expandable polystyrene (EPS)	450	0.7%	1-BlkPlastics
Polyvinylchlorid (PVC)	150	0.2%	1-BlkPlastics
Plastics others	2 500	4.2%	1-BlkPlastics
Aluminium	900	1.5%	4-Non-ferro
Cu wire	2 600	4.3%	4-Non-ferro
Glass for lamps	600	1.0%	2-TecPlastics
Electronics (control)	1 900	3.2%	6-Electronics
Total net	**60 200**		

[38] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of one typical model within category D1.

Material / Component	weight in g	weight in %	Material category
Packaging			
PE-Foil	500		1-BlkPlastics
wood	5 000		7-Misc.
cardboard	1 300		7-Misc.
Total weight	**67 000**		

3.1.1.2 Category D2: Semi-professional dryer, air vented

Semi-professional dryers are mostly used by non-professional operators. Air vented dryers operate in this way: the humidity of the washed laundry is evaporated to the ambient air through a tube. Different connections for this tube are offered by manufacturers to adjust the dryer to the location conditions. The air vented dryer is mainly composed of a motor and fan, drum and cabinet, an air circuit system and a control system. Only one motor provides the rotation of the drum and the blower.



(Source: Miele PT 7136, 6.5 kg)

Figure 27 Semi-professional dryer, air vented (category D2)

Table 32 Characteristics of a semi-professional dryer, air vented (category D2)

Main characteristics[39] category D2	Data
Feature of performance	
Drying capacity, kg	6.5
Drum volume	130
Filling ratio	1:20
Number of fixed drying programs	>10

[39] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of one typical model within category D2.

Main characteristics[39] category D2	Data
Construction details	
Height, mm	850
Width, mm	600
Depth, mm	700
Weight net, kg	57–60
Electricity	
Voltage, V	230–400 1–3 phase
Total load, kW	3.2–6.4

According to stakeholders the material composition is equivalent to that of a household washing machine as described in the preparatory study on dryers (Lot 16). The following Bill of Materials (BOM) is taken from task 4 report of that study and partial interpolated for a typical semi-professional air vented dryer with a drying capacity of 6 kg.

Table 33 Materials composition of a semi-professional dryer, air vented (category D2)

Material / Component	weight in g	weight in %	Material category
Stainless Steel	32 800	57.3%	3-Ferro
Steel Sheet galvanized	3 500	6.1%	3-Ferro
Cast Iron	2 800	4.9%	3-Ferro
Polypropylen (PP)	7 200	12.6%	1-BlkPlastics
Polyamid (PA)	400	0.7%	2-TecPlastics
Acrylonitrile Butadiene Styrene (ABS)	2 100	3.7%	1-BlkPlastics
Plystyrene (PS)	400	0.7%	1-BlkPlastics
Styropor expandable polystyrene (EPS)	450	0.8%	1-BlkPlastics
Polyvinylchlorid (PVC)	150	0.3%	1-BlkPlastics
Plastics others	1 500	2.6%	1-BlkPlastics
Aluminium	900	1.6%	4-Non-ferro
Cu wire	2 600	4.5%	4-Non-ferro
Glass for lamps	600	1.0%	2-TecPlastics
Electronics (control)	1 800	3.1%	6-Electronics
Total net	**57 200**		
Packaging			
PE-Foil	500		1-BlkPlastics
wood	5 000		7-Misc.
cardboard	1 300		7-Misc.
Total weight	**64 000**		

As a matter of fact, around 68% of the weight of an air vented tumble dryer is made of ferrous metals. Regarding the plastic parts, the most commonly used plastic is polypropylene (12% of the dryers' weight).

3.1.1.3 Category D3: Professional cabinet dryer

While conventional dryers rely on a tumbling action, drying cabinets simulate an accelerated clothesline in an internal environment by circulating air throughout the cabinet. Drying cabinets (category D3) are mainly used for laundry that should not be dried in a tumble dryer, in order to avoid the risk of shrinkage or damage by the tumbling action. Such laundry could be for example wet and damp clothes, shoes, boots, gloves, hats, or delicate linen like protective clothing. They have proved to be very popular with construction companies, the police force, fire departments, ambulance and offshore rescue services, the army, airport handling services, theatres, sports and leisure clubs and many other applications where there is a need to regularly dry outdoor clothing and work wear without necessarily washing garments every time. Furthermore, drying cabinets are a common way to dry laundry in Scandinavian countries where they are used in addition to traditional clothes tumble dryers.[40]

Drying cabinets operate with two separate heated air systems. One system dries the laundry by blowing warm air through the hangers into the garments and out the arms and legs, thus drying the laundry from the inside. The other system blows warm air from the side of the cabinet around the outside of the garments.

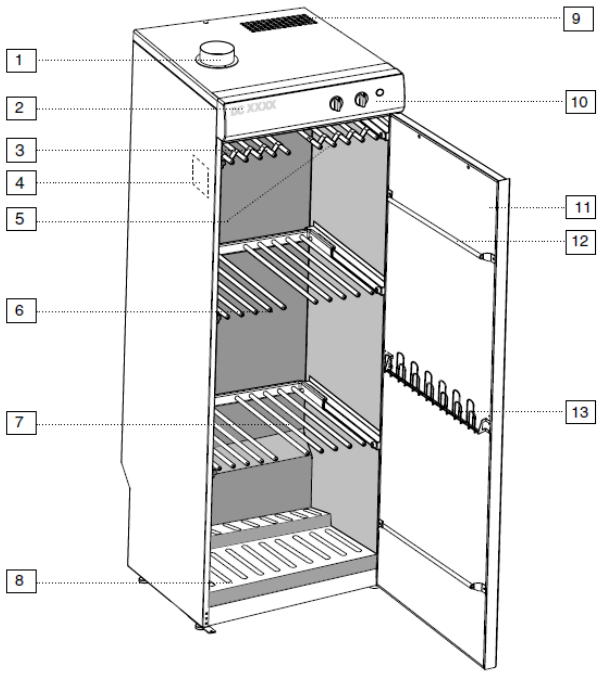
The following illustration shows a typical cabinet dryer.



(Source: Podab TS 6 MPR)

Figure 28 Professional cabinet dryer (category D3)

[40] Source: http://www.staber.com/dryingcabinet, sighted on 23 June 2010



1 Exhaust collar
2 Drying cabinet model
3 Hanger hooks
4 Rating plate (inside)
5 Upper hanger section
6 Middle hanger section
7 Lower hanger section
8 Shoe rack (optional)
9 Air intake
10 Control panel
11 Door
12 Door hanger for lighter articles
13 Glove hanger

(Source: ASKO DC 7171)

Figure 29 Construction of a professional cabinet dryer (category D3)

The following table gives an overview of the characteristics of a typical professional cabinet dryer (category D3).

Table 34 Characteristics of a typical professional cabinet dryer (category D3)

Main characteristics[41] category D3	**Data**	
Feature of performance	**Model A**	**Model B**
Drying capacity, kg	8	16
Number of drying programs	3 (2)	3 (4)
Heater temperature, °C	<90	90
Drying time, min	10–260	10–260
Drying performance, g/min	65–78	93
Air flow, m^3/h	250	300
Noise level, dB(A)	>70	>72
Construction details		
Height, mm	2 080	2 000
Width, mm	1 200	1 800
Depth, mm	750	800
Weight net, kg	120–160	~235

[41] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of two typical models within category D3.

Main characteristics[41] category D3	Data	
Electricity		
Voltage, V	230–400	400
Total load electric, kW	6	9.3

The following table shows the BOM of a typical dryer of category D3, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 35 Composition of materials of a typical professional cabinet dryer (category D3)

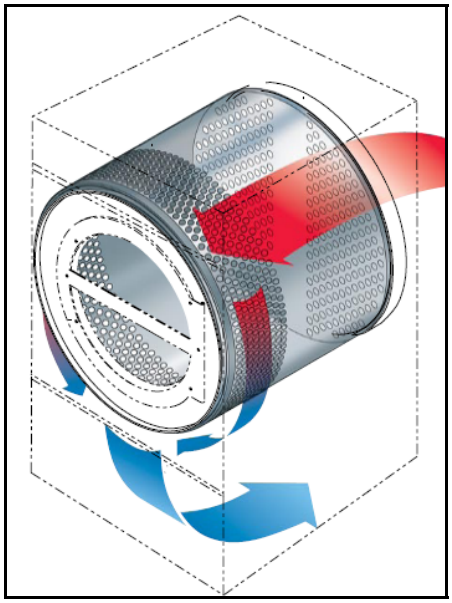
Material / component	Weight in g[42]	Weight in %	Material category
Steel	4 350	3%	3-Ferrous
Steel sheet galvanized	108 750	75%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	2 175	1.5%	1-BlkPlastics
Aluminium	20 300	14%	4-Non-ferrous
Copper	1 450	1%	4-Non-ferrous
PVC	~145	~0.1%	1-BlkPlastics
Electronics	3 045	2.1%	6-Electronics
EDPM	1 450	1%	1-BlkPlastics
Other	3 480	2.4%	7-Misc.
Total net	**145 145**		
Packaging			
Polystyrene	1 800		1-BlkPlastics
Wood	18 600		7-Misc.
Cardboard	6 500		7-Misc.
Total weight	**172 045**		

3.1.1.4 Category D4, D5, D6: Professional tumble dryer

Professional tumble dryers continuously draw in the cool, dry, ambient air around them and heat it by electric, steam or gas before passing it through the moist laundry in the tumbler. The resulting hot, humid air is simply vented outside to make room for more dry air to continue the drying process. Therefore they require an external duct out to open air (open system). The gas or heat pump tumble dryer operate like an air vented dryer; however, the electrical heating element is replaced by a gas burner or a heat exchanger.

The longitudinal air flow draws the heated air from the dryer back along the drum to the front out (axial air flow). On the opposite of this is the radial air flow (from top to bottom) with a perforated drum.

[42] Average weight value is based on a typical cabinet dryer with a drying capacity of 8 kg.



(Source: Primus)

Figure 30 Radial and axial air flow system of an air dryer

Professional dryers are equipped either with freely programmable controls or with electronic controls offering standard programmes. One exemplary control is illustrated in Figure 31.



(Source: Miele Profitronic B Plus)

Figure 31 Temperature and time control of professional tumble dryers

A further type of control is customised for the laundrettes (coin & card laundries), where a simple user operation could be selected for the cycle selection. A visual indicator signal shows the end of the drying cycle, as illustrated in the following figure.



(Source: Primus)

Figure 32 Coin control

Furthermore, the appliances have various design options like final cool down cycle, residual moisture control or drum interior lighting. They are typical for front loading dryers as well as for stacker tumblers[43]. They can be used for all kind of linen and are equipped with the following heating options: electric, steam, gas and heat pump. Steam and gas heating, the two most common alternative heating options are described in Figure 33.

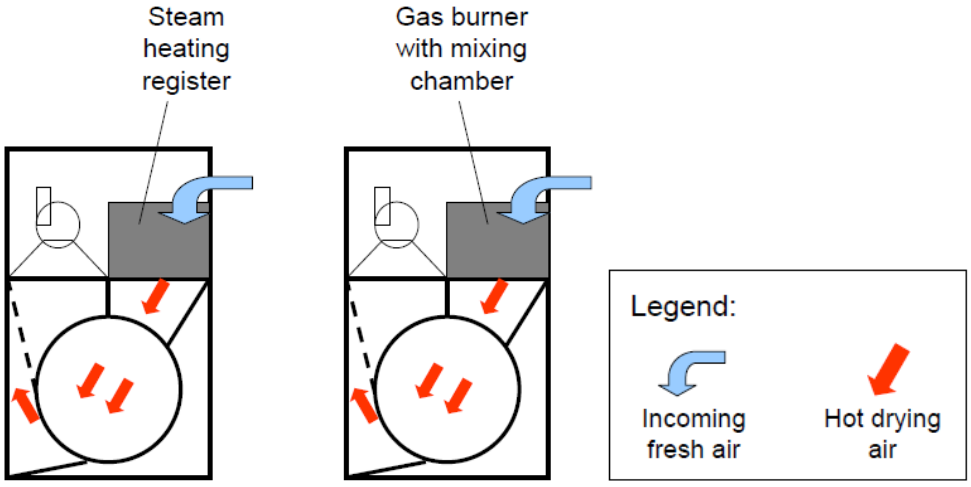


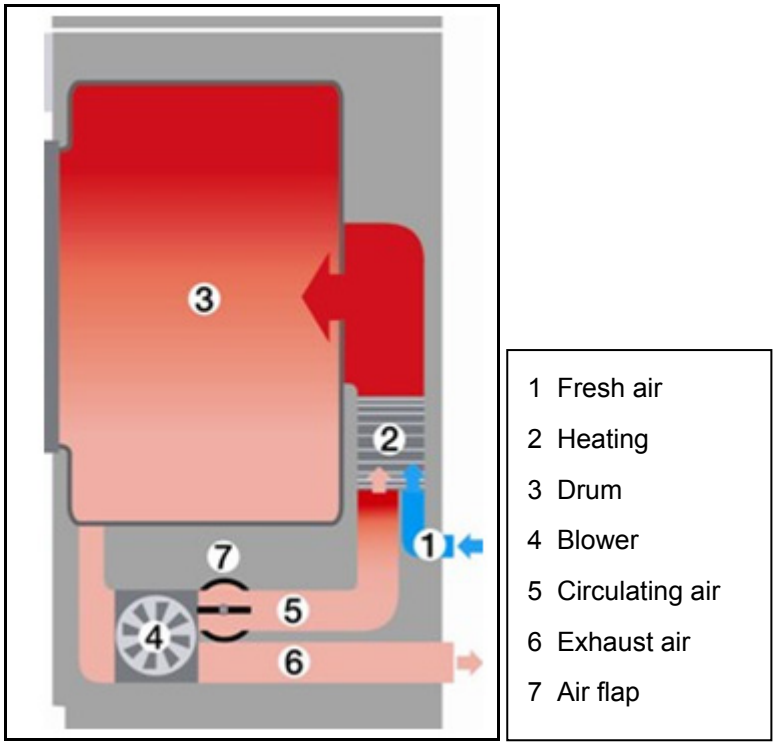
Figure 33 Heating systems of dryers[44]

Many of the appliances operate with a so-called air recycling using the already heated air again for the next drying process (see Figure 34). According to one manufacturer, 60% of the drying air is supplied again for the drying process. With the use of an optional air flap, a

[43] Two dryers on top of each other, http://www.laundrysystems.electrolux.com/node350.aspx?productId=51

[44] Source: http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-5_Drying_of_textiles.PDF, sighted on 06.09.2010

temperature sensor may switch between the used (exhaust) air and the circulating air, resulting in an effective way of drying laundry.



(Source: http://www.miele-professional.de/de/prof/7680_7872.htm#p7681, reviewed on 20.09.2010)

Figure 34 Air recycling

Furthermore, both the rotation speed of the drum as well as the temperature can be controlled.

Tumble dryers of this category usually have a freely programmable control with various standard programmes for special laundry. In addition to the heating options of steam and gas, a heat pump can be used. Heat pump dryers combine a condenser dryer with an integrated heat pump. The warm, moist air from the drum is passed immediately to the heat pump (evaporator) where it is dehumidified; at the condenser the warm, dry air is returned to the drum. Compared to condenser dryers, the process is a closed system (see 3.1.1.1).

In order to specify the duration of the drying process, there are the following options:

- Defining a fixed drying time;
- Determining the switch-off point by the difference between the ingoing and outgoing air;
- Precisely direct measuring of the residual moisture in the textiles by an infrared control system (see also Task 6).

Professional tumble dryers with a load capacity up 15 kg (category D4) can be used for all types of wash ware and are mainly applied in coin and card laundry. A typical professional tumble dryer up to 15 kg is shown in Figure 35.



(Source: Primus Tams13, 13 kg)

Figure 35 Professional tumble dryer <15 kg (category D4)

Category D4: Professional tumble dryer <15 kg

Table 36 gives an overview of the characteristics of a typical professional tumble dryer <15 kg (category D4).

Table 36 Characteristics of a professional tumble dryer <15 kg (category D4)

Main characteristics[45] category D4	**Data**		
Feature of performance	**Model A**	**Model B**	**Model C**
Drying capacity, kg	8–10	10–12	11-13
Drum volume, L	200–170	220–250	250–285
Filling ration	1:18-1:25	1:18-1:25	1:18-1:25
Number of drying programs	5–9	5–9	5–9
Heater Temperature	4 steps, max 70°C	4 steps, max 70°C	4 steps, max 70°C
Drying performance, L/min	0.15	0.17	0.20
Air flow, m^3/h	250	360–600	430–630
Construction details			

[45] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of three typical models within category D4.

Main characteristics[45] category D4	Data		
Height, mm	1 092	1 460–1 640	1 900
Width, mm	711	842	710
Depth, mm	683	793	110
Weight net, kg	70–120	140–160	160–220
Electricity and steam consumption			
Voltage, V	230–400	230–400	230–400
Total load electric, kW	5.05–5.25	15.4	13.5–18
Total load gas, kW	1.1	1.1	1.1
Total load steam output, kW/h	7-10	8–12	13–14

The following table shows the BOM of a typical dryer of category D4, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 37 Material composition of a professional tumble dryer <15 kg (category D4)

Material / component	Weight in g[46]	Weight in %	Material category
Stainless steel	12 240	8%	3-Ferrous
Galvanized steel	107 100	70%	3-Ferrous
Steel	7 650	5%	3-Ferrous
Cast Iron	6 120	4%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	~3 820	~2.5%	1-BlkPlastics
Aluminium	3 060	2%	4-Non-ferrous
Copper	6 120	4%	4-Non-ferrous
PVC	300	0.2%	1-BlkPlastics
Electronics	4 600	3%	6-Electronics
Glass	1 990	1.3%	7-Misc.
Total net	**153 000**		
Packaging			
Polystyrene	600		1-BlkPlastics
Wood	12 500		7-Misc.
Cardboard	1 400		7-Misc.
Total weight	**167 500**		

Category D5: Professional tumble dryer 15-40 kg

Professional tumble dryers with a load capacity of 15–40 kg (category D5) are for example used for hospitality laundry. A typical device of this category is shown in Figure 36.

[46] Average weight value is based on a typical tumble dryer with a drying capacity of 10 kg.



(Source: Miele PT8807, 36 kg)

Figure 36 Professional tumble dryer 15–40 kg (category D5)

Table 38 gives an overview of the characteristics of a typical professional tumble dryer 15–40 kg (category D5).

Table 38 Characteristics of a typical professional tumble dryer, 15–40 kg (category D5)

Main characteristics[47] category D5	**Data**	
Feature of performance	**Model A**	**Model B**
Drying capacity, kg	23	34
Drum volume, L	518	609
Filling ration	1:25–1:18	1:25–1:18
Number of drying programs	5–9	5–9
Heater Temperature	4 steps, max 70°C	4 steps, max 70°C
Drying performance, L/min	0.35	0.48
Air flow, m^3/h	1 062	1 415
Construction details		
Height, mm	1 829–1 910	1 908–1 965
Width, mm	878	970
Depth, mm	1 295	1 270
Weight net, kg	290–370	320–400

[47] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of two typical models within category D5.

Electricity		
Voltage, V	230–400	230–400
Total load electric, kW	30	33
Total load gas, kW	1.5–2	1.5–2
Total load steam output, kW	1–2	1–2

The following table shows the BOM of a typical dryer of **category D5**, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 39 Composition of materials of a professional tumble dryer 15–40 kg (category D5)

Material / component	**Weight in g**[48]	**Weight in %**	**Material category**
Stainless steel	24 400	7%	3-Ferrous
Galvanized steel	243 600	70%	3-Ferrous
Steel	17 400	5%	3-Ferrous
Cast Iron	13 900	4%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	12 200	3.5%	1-BlkPlastics
Aluminium	6 950	2%	4-Non-ferrous
Copper	13 900	4%	4-Non-ferrous
PVC	700	0,2%	1-BlkPlastics
Electronics	10 400	3%	6-Electronics
Glass	4 550	1.3%	7-Misc.
Total net	**348 000**		
Packaging			
Polystyrene	1 000		1-BlkPlastics
Wood	23 000		7-Misc.
Cardboard	2 800		7-Misc.
Total weight	**374 800**		

Category D6: Professional tumble dryer >40 kg

Professional tumble dryers with a load capacity of more than 40 kg (category D6) can be used for all ranges for hotel, work wear, etc. They can be used as isolated applications as well as within a washing system. A typical professional tumble dryer of category D6 is shown in Figure 37.

[48] Average weight value is based on a typical tumble dryer with a drying capacity of 23 kg.



(Source: Electrolux, T4900, T41200, 48–60 kg)

Figure 37 Typical professional tumble dryer >40 kg (category D6)

Table 40 gives an overview of the characteristics of a typical professional tumble dryer > 40 kg (category D6).

Table 40 Characteristics of a typical professional tumble dryer >40 kg (category D6)

Main characteristics[49] category D6	**Data**	
Feature of performance	**Model A**	**Model B**
Drying capacity, kg	48	70
Drum volume, L	1 200	1 410
Filling ration	1:18–1:25	1:18–1:25
Number of drying programs	5–9	5–9
Heater Temperature	4 steps, max 70°C	4 steps, max 70°C
Drying performance, g/min	~900	n.a.
Air flow, m^3/h	2 500	n.a.
Construction details		
Height, mm	2 500	2 500
Width, mm	1 300	1 400
Depth, mm	1 500	1 800
Weight net, kg	440–510	710–790
Electricity		
Voltage, V	230–400	230–400
Total load electric, kW	63–75	n.a.
Total load gas, kW	3–3.5	1.5–2
Total load steam output, kW	3–3.5	1–2

n.a. = not applicable

[49] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of two typical models within the category D6.

The following table shows the BOM of a typical dryer of category D6, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 41 Composition of materials of a professional tumble dryer >40 kg (category D6)

Material / component	Weight in g[50]	Weight in %	Material category
Stainless steel	52 150	7%	3-Ferrous
Galvanized steel	521 500	70%	3-Ferrous
Steel	37 250	5%	3-Ferrous
Cast Iron	29 800	4%	3-Ferrous
Plastics (PP, Polyester, ABS etc.)	26 100	3.5%	1-BlkPlastics
Aluminium	14 900	2%	4-Non-ferrous
Copper	29 800	4%	4-Non-ferrous
PVC	~1 500	~0.2%	1-BlkPlastics
Electronics	22 350	3%	6-Electronics
Glass	~9 650	~1.3%	7-Misc.
Total net	**745 000**		
Packaging			
Polystyrene	n.a.		1-BlkPlastics
Wood	n.a.		7-Misc.
Cardboard	n.a.		7-Misc.
Total weight	**n.a.**		

3.1.1.5 Category D7: Pass-through (transfer) tumble dryer

Pass-trough or batch transfer dryers (category D7) have the loading and unloading of the wash ware on opposite sides. With a load capacity of 40 to 240 kg they belong to the industrial appliances segment.

A typical batch transfer tumble dryer is shown in Figure 38.

[50] Average weight value is based on a typical tumble dryer with a drying capacity of 70 kg.



(Source: Jensen, DT 60-240)

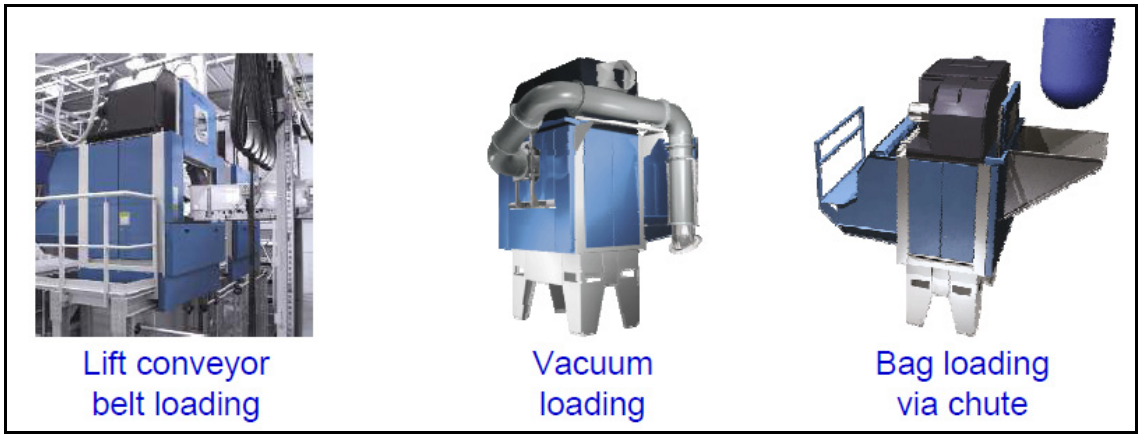
Figure 38 Typical batch transfer tumble dryer (category D7)

Transfer tumble dryers can be equipped with various design options, for example:

- Electric, steam-, gas-, or thermo oil heated,
- Temperature regulation and control,
- Cool-down via partially opened loading door or fresh air flap,
- Heat recovery,
- Infrared control to measure the temperature of the linen,
- Vacuum loading and unloading,
- Residual moisture control (RMC).

Some of these features will be described more detailed in Task 6 (Best Available Technologies).

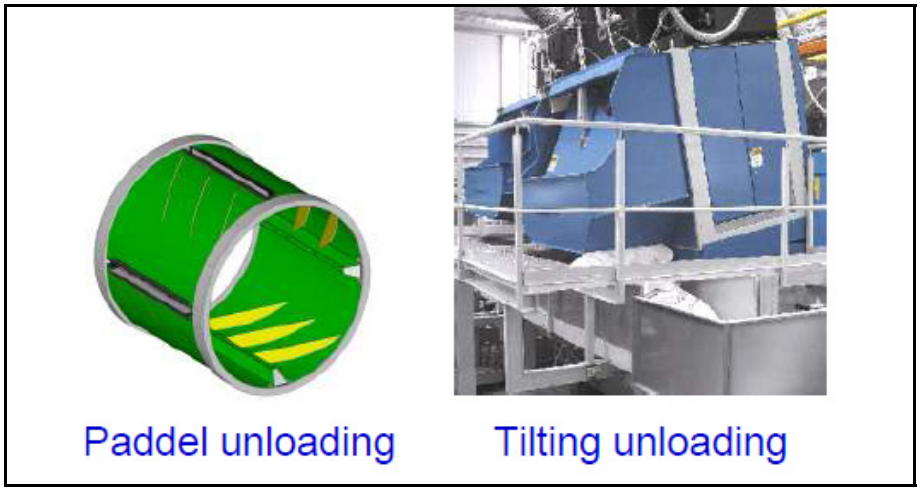
In compliance with their design there are three different loading systems for transfer tumble dryers, as shown in Figure 39. Loading and unloading takes place automatically.



(Source: www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-5_Drying_of_textiles.PDF, sighted on 08.09.2010)

Figure 39 Possible loadings of transfer tumble dryers

According to an e-learning tool for sustainable laundry[51] conducted inter alia by the wfk (Cleaning Technology Research Institute), a lift conveyor belt loading is the most common way of loading. Besides, there are different possibilities for unloading the tumble dryers (see Figure 40).



(Source: http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-5_Drying_of_textiles.PDF, sighted on 08.09.2010)

Figure 40 Possibilities for unloading pass-through tumble dryers

As illustrated in the figure, the pass-through tumble dryers can be unloaded by paddle or by tilting. In addition to these two possibilities, pass-through dryers can also be unloaded by airflow, blowing out the laundry.

[51] http://www.laundry-sustainability.eu/en/index.html

There are several design options like a pneumatic tilting device, temperature control, separate heat and cool down timers or a heat exchanger. The heat exchanger illustrated in Figure 41 uses the energy of the exhausted hot air of the tumble dryer to preheat the fresh incoming air. According to the manufacturer, energy savings are possible by using this technology.

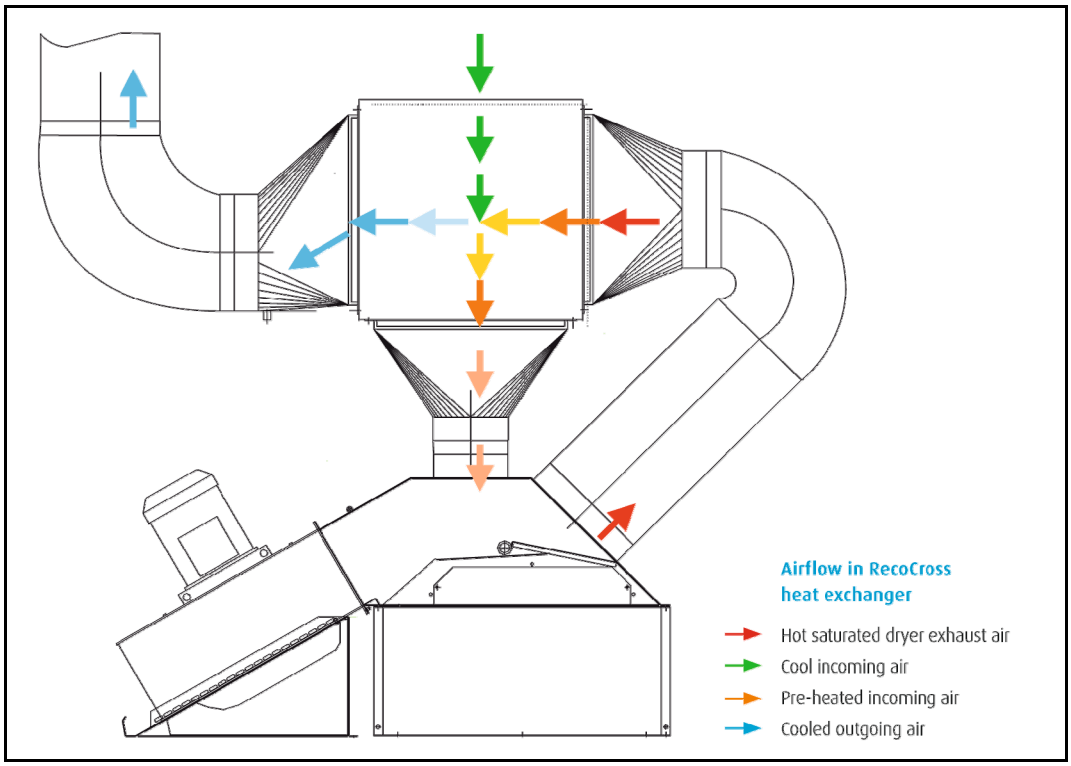


Figure 41 Heat exchanger of Jensen

Table 42 gives an overview of the characteristics of a typical heavy duty industrial pass-through (transfer) tumble dryer (category D7).

Table 42 Characteristics of a typical heavy duty industrial pass-through (transfer) tumble dryer (D7)

Main characteristics[52] category D7	Data
Program	
Drying capacity, kg	1 000–2 000 kg/h
Filling ration	
Heater temperature	Fresh air 200°C, exhaust air 100°C
Drying performance	
Air flow, m^3/h	2 600–9 000
Construction details	
Height, mm	2 000–2 500
Width, mm	2 000–2 600
Depth, mm	2 300–3 300
Weight net, kg	2 150–4 500
Electricity and water connection and consumption	
Electric connection load, kW	14–32
Gas connection load	50–90 m³/h

No data available yet

The following table shows the BOM of a typical dryer of category D7 with the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 43 Material composition of heavy duty industrial pass-through (transfer) tumble dryer (D7)

Material / component	Weight in g[53]	Weight in %	Material category
Stainless Steel	16 600	5%	3-Ferrous
Steel	2 826 600	85%	3-Ferrous
Cast Iron	6 650	2%	3-Ferrous
Copper	6 650	2%	4-Non-ferrous
EPDM rubber	<3 325	<1%	1-BlkPlastics
PE	< 3 325	<1%	1-BlkPlastics
Electronics	3 325	1%	6-Electronics
PVC (cables)	<3 325	<1%	1-BlkPlastics
Total net	**3 325 800**		
Packaging	**negligible**		
Polystyrene	n.a.		1-BlkPlastics
Wood	n.a.		7-Misc.
Cardboard	n.a.		7-Misc.
Total weight			

n.a. not applicable

[52] Main characteristics in this table are based on the analysis of technical product information sheets and shall reflect average values from different manufacturers of a typical model within category D7.

[53] Average weight value is based of a typical heavy duty batch transfer dryer.

3.1.1.6 Overview of all professional dryer categories

In the following table an overview of the shares of the material categories according to MEEuP (incl. packaging material) is shown for the different categories of professional dryers.

Table 44 Share of material categories (according to MEEuP) for the different categories of professional dryers (including packaging)

Materials-category	Unit	D1	D2	D3	D4	D5	D6	D7
Bulk Plastics	g	20.2%	19.3%	12.3%	23.4%	25.4%	53.9%	0.3%
Tec Plastics	g	1,5%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%
Ferrous	g	60,4%	63.1%	69.9%	78.6%	79.9%	86.0%	99.3%
Non-ferrous	g	5.2%	5.6%	8.4%	5.5%	5.6%	6.0%	0.2%
Coating	g	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electronics	g	2,8%	2.9%	8.2%	17.2%	19.0%	46.1%	0.1%
Misc.	g	9.8%	7.5%	79.5%	59.4%	55.5%	0.0%	0.0%
Total weight	**g**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

D 1: Semi-professional dryer, condenser
D 2: Semi-professional dryer, air vented
D 3: Professional cabinet dryer
D 4: Professional tumble dryer, <15 kg
D 5: Professional tumble dryer, 15-40 kg
D 6: Professional tumble dryer, > 40 kg
D 7: Pass-through (transfer) tumble dryer

In all categories, the share of ferrous metal (mainly stainless steel) is with approximately 60% to 99% (incl. packaging) predominant.

3.2 Technical analysis of the distribution phase

The following table shows the average volume of the final packaged product. These values are used to calculate the environmental impacts resulting from distribution.

Table 45 Average volume of the final packaged product of the different categories of professional dryers

Dryer category	Average volume of the final packaged product
D 1: Semi-professional dryer, condenser	0.53 m³
D 2: Semi-professional dryer, air vented	0.53 m³
D 3: Professional cabinet dryer	1.76 m³
D 4: Professional tumble dryer, <15 kg	1.14–1.90 m³
D 5: Professional tumble dryer, 15-40 kg	1.75–3.40 m³
D 6: Professional tumble dryer, > 40 kg	3.90–7.44 m³
D 7: Pass-through (transfer) tumble dryer[54]	> 13m³

(Source: Information provided by data sheets)

[54] Corresponds to the average volume of the machine as the distribution is realised without packaging

3.3 Technical analysis of the use phase (product)

The drying process consists in removing the water with hot air from the wet textile. Therefore, a certain amount of energy is needed to make water evaporate and to evacuate the residual steam.

As described in Task 3, energy is consumed by different processes during a typical working day of professional dryers. The following input parameters were specified to define the respective energy consumption of professional dryers during the use phase. The parameters have already been compiled and discussed in Task 3 on user behaviour. The following sections summarise the assumptions and the annual consumption of the different dryer categories, differentiated according to the processes.

3.3.1 Ratio of energy use in professional dryers

This section exemplifies how much energy is used for the different process steps in a typical drying process.

The relative energy consumption of professional dryers can be mainly subdivided into energy used for air heating and the motor energy for mechanical action or electronic devices. The following table shows the respective energy flows of each category.

Table 46 Share of the average energy consumption in the different categories of professional dryers (Source: information provided by manufacturers)

Dryer category	Percentage of energy for motor and electronic devices etc. (always electricity)	Percentage of energy for air heating
D 1 Semi-professional dryer, condenser	5.0%	95.0%
D 2 Semi-professional dryer, air-vented	5.0%	95.0%
D 3 Professional cabinet dryer	5.0%	95.0%
D 4 Professional tumble dryer, <15 kg	8.0%	92.0%
D 5 Professional tumble dryer, 15-40 kg	8.0%	92.0%
D 6 Professional tumble dryer, >40 kg	15.0%	85.0%
D 7 Pass-trough (transfer) tumble dryer	11.0%	89.0%

Depending on the category, 5 to 15% of the incoming energy is used to drive motors, pumps and electronics components to control the whole system (always electricity). Most of the energy input, however, is used to heat up the air: approximately 95% of the total energy consumption. As outlined in Task 3, electric energy is one energy source for air heating in dryers. Other energy sources used for heating the air are natural gas, steam (or thermo oil). The different heating systems will result in different environmental impacts, and different operating costs in the end.

In the following Tasks, we will further use these inputs to derive resulting environmental impacts and potential improvement options.

3.3.2 Energy consumption

The following input parameters were specified to define the energy consumption of professional dryers during the use phase. The parameters have already been compiled and discussed in Task 3 on user behaviour. The following sections summarise the assumptions and the annual consumption of the different dryer categories.

3.3.2.1 Categories D1 and D2: Semi-professional dryers, condenser and air vented

Table 47 Energy consumption of semi-professional dryers, condenser and air vented

Dryer Category	Condenser dryer (D1)	Air vented dryer (D2)
	Energy	Energy
Main customer segment	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	
Typical use intensity: Annual amount of dried laundry (kg/year) (typical machine's capacity of 6 kg)	6 500	6 500
Specific consumption operation (ideal conditions)	0.60 kWh/kg laundry	0.56 kWh/kg laundry
Real-life user behaviour:		
Additional consumption through partial workload	+ 10%	+ 10%
Additional consumption through maloperation	+ 15%	+ 15%
Specific consumption (operation, real life user behaviour)	0.75 kWh/kg laundry	0.70 kWh/kg laundry
Annual consumption (operation, real life user behaviour)	*4 875 kWh*	*4 550 kWh*
Annual consumption standby	2.25 *kWh*	2.25 *kWh*
Annual consumption (real life)	***4 877 kWh***	***4 552 kWh***

3.3.2.2 Category D3: Cabinet dryer

Table 48 Energy consumption of a professional cabinet dryer

Dryer category D3	**Energy**
Main customer segment	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)
Typical use intensity: Annual amount of dried laundry (kg/year) (typical machine's capacity of 8 kg)	6 300
Specific consumption operation (ideal conditions)	0.75 kWh/kg laundry
Real-life user behaviour:	
Additional consumption through partial workload	+ 10%
Additional consumption through maloperation	+ 15%
Specific consumption (operation, real life user behaviour)	0.94 kWh/kg laundry
Annual consumption (operation, real life user behaviour)	*5 922 kWh*
Annual consumption standby	1.98 kWh
Annual consumption (real life)	***5 924 kWh***

3.3.2.3 Category D4, D5, D6: Professional tumble dryer

Table 49 Energy consumption of professional tumble dryers (category D4-5-6)

	<15 kg (D4)	**15–40 kg (D5)**	**>40 kg (D6)**
Dryer Category	**Energy**	**Energy**	**Energy**
Main customer segment	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	Hospitality Laundry	Commercial Industrial Laundry
Typical use intensity: Annual amount of dried laundry (kg/year)	14 400 (typical capacity of 10 kg machine)	40 500 (typical capacity of 23 kg machine)	168 000 (typical capacity of 70 kg machine)
Specific consumption operation (ideal conditions)	0.55 kWh/kg laundry	0.65 kWh/kg laundry	0.85 kWh/kg laundry
Real-life user behaviour:			
Additional consumption through partial workload	+ 10%	+ 10%	+ 10%
Additional consumption through maloperation	+ 15%	+ 15%	+ 10%
Specific consumption (operation, real life user behaviour)	0.69 kWh/kg laundry	0.81 kWh/kg laundry	1.02 kWh/kg laundry
Annual consumption (operation, real life user behaviour)	*9 936 kWh*	*32 805 kWh*	*171 360 kWh*
Annual consumption standby	n.a.	n.a.	negligible
Annual consumption (real life)	***9 936 kWh***	***32 805 kWh***	***171 360 kWh***

n.a. no information available

3.3.2.4 Category D7: Pass-through (transfer) tumble dryer

Table 50 Energy consumption of a pass-through dryer

Dryer category D7	Energy
Main customer segment	Commercial Industrial Laundry
Typical use intensity: Annual amount of dried laundry (kg/year) (typical machine's capacity of 400 kg/h)	1 020 000
Specific consumption operation (ideal conditions)	0.8 kWh/kg laundry
Real-life user behaviour:	
Additional consumption through partial workload	+ 10%
Additional consumption through maloperation	+ 10%
Specific consumption (operation, real life user behaviour)	0.96 kWh/kg laundry
Annual consumption (operation, real life user behaviour)	*979 200 kWh*
Annual consumption standby	negligible
Annual consumption (real life)	***979 200 kWh***

3.3.2.5 Overview of all dryer categories

The following Table 51 summarizes the annual energy consumption to be used as input data for Task 5 (environmental impact assessment of base cases).

Table 51 Annual energy consumption (real life conditions) of all dryer categories

Category	Energy consumption
	kWh/year
D1: Semi-professional dryer, condenser	*4 877*
D2: Semi-professional dryer, air vented	*4 552*
D3: Professional cabinet dryer	*5 924*
D4: Professional tumble dryer, <15 kg	*9 936*
D5: Professional tumble dryer, 15-40 kg	*32 805*
D6: Professional tumble dryer, > 40 kg	*171 360*
D7: Pass-through (transfer) tumble dryer	979 200

3.4 Technical analysis use phase (system)

Professional laundry dryers are used in hotels, clinics, health care, and laundrettes and in many other places (see Task 3). This section provides an overview of how different ambient conditions can influence the energy consumption of the professional laundry dryers.

Drying temperature: The drying temperature has a strong influence on the energy consumption. The higher the temperature, the more energy is needed.

Type of laundry: Textiles can be made from different materials and fabrics (cotton, wool, mineral, synthetic etc) and result in particular types of laundry (work wear, hospital linen, high visibility garments etc.). The majority of the laundry is dried using the cotton programme. However there are some types of fabrics retaining the water more than other fabrics, thus increasing the amount of energy needed to dry them. Different products and systems take account of varying needs in accordance with the different types of clothes to be dried.

The spin speed (g-factor) of the washer extractor: The energy demand of the laundry dryer depends on the remaining water in the clothes after spinning in the washing machine. The more efficiently clothes have been spun, the smaller the energy is needed for drying them. It appears that a better spin speed and a better g-factor ensure shorter drying times and lower energy consumption.

Ambient air humidity: Regarding air vented dryers the energy demand also depends on the air humidity. The energy demand decreases with a lower air humidity.

3.5 Technical analysis of the end-of-life phase

Our assumptions for End-of-Life Phase for dryers are as follows: While the large heavy duty machines can last for up to 20 years, the semi- professionals and smaller dryers will only have an average lifetime of 10 to 15 years. Industrial machines are used as intensively as the professional (category D3–D6) and semi-professional machines of categories D 1–2 and have to a longer lifetime. According to the manufacturer, the average lifetime is about 12 years. At the end of their life, heavy duty and larger dryers are usually taken back by the manufacturer. In some cases, parts of the machine can be reused, the rest of the machines – mostly valuable stainless steel – will be sold to recycling companies where they are cleaned up, shredded and disassembled. Reusable materials are separated and then returned to the material production. The semi-professional dryers could be also dismantled by certified scrap dealers.

As already described in Task 3, only 1 to 5% of the material from a professional dryer will end at a landfill, as the materials (mostly stainless steel >60%) are too valuable. According to the stakeholders, more than 95% of the products are recyclable and will always either be refurbished or recycled for scrap parts or materials.

The plastic share of all professional dryers is less than 10% related to its overall weight. All plastic components weighing more than 50 grams are marked in accordance with ISO 1043[55]. According to stakeholder information this plastic share is disposed of as follows:

[55] ISO 1043 – Part 1, Plastics – Symbols and abbreviated terms – Basic polymers and their special characteristics

Table 52 Landfill (fraction of products not recovered) in % of professional dryers (based on stakeholder input)

Dryer category	Landfill (fraction of products not recovered) %
D1: Semi-professional dryer, condenser	5
D2: Semi-professional dryer, air vented	5
D3: Professional cabinet dryer	5
D4: Professional tumble dryer, <15 kg	5
D5: Professional tumble dryer, 15-40 kg	~1
D6: Professional tumble dryer, >40 kg	~1
D7: Pass-through (transfer) tumble dryer	~1

The plastic share of all professional dryers is less than 10% related to its overall weight. All plastic components weighing more than 50 grams are marked in accordance with ISO 1043[55].

According to stakeholder information this plastic share is disposed of as follows:

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

Printed wiring boards (PWB) are used in the dryers of all categories. According to stakeholder information, these parts are easy to dismantle and are completely recycled by certified scrap dealers.

4 Recommendation on standardisation needs

On the basis of the analysis carried out in Tasks 1 to 4, this section provides first recommendations for the content of possible mandates to be issued by the European Commission to the European standardisation organisations on (measurement) standards for professional washing machines and dryers.

As already initiated by CENELEC TC59X (see Task 1), a standardised definition of the terms and respective appliances “professional, commercial, and industrial” will be necessary.

To date, there are no directives or regulations in Europe and not even voluntary agreements between manufacturers concerning a consistent and applied measurement methodology for the energy consumption and functional performance measurement for professional washing machines and dryers. This means that data provided by manufacturers is currently neither comparable nor subject to any control. Therefore, end-users willing to buy a professional

washing machine or dryer with a lower environmental impact and least life cycle costs are confronted with the following challenges:

- In many cases no data on the energy consumption of professional washing machines and dryers are provided.
- The information in brochures and catalogues concentrates on the figures for energy consumption reduction (for example 30%) compared to an undefined product of a competing company or of an own product without a clear set of characteristics. The worse comparative value is frequently not communicated at all or in detail.
- If the energy consumption is provided, it is not really comparable to similar information on other appliances of other or sometimes even the same manufacturer, because there is no standard method applied for measuring the performance of professional washing machines and dryers.

This in turn results in the following:

- Consumers base their purchasing decision on non-comparable information.
- Competition between manufacturers is distorted.
- Manufacturers who provide realistic information on energy and water consumption are disadvantaged compared to those who communicate over-optimistic information.
- The development of efficient technologies is slowed.
- Additional environmental impacts may result from purchasing decisions made on the basis of insufficient information.

A further consequence of the current situation is that certain policy instruments cannot be implemented. The setting of performance requirements, energy labelling requirements, the introduction of binding life cycle cost accounting, financial incentives for the promotion of efficient appliances as well as other instruments, presuppose a reliable data basis for assessing the consumption and performance of the appliances. Precondition for the reliable data basis, however, is the development and introduction of a generally applicable measuring method for determining the consumption of professional washing machines and dryers at European level. Note: The existing approaches and considerations have already been set out in Task 1.

A prerequisite for determining the efficiency of a professional laundry process and the washing machine and dryer respectively is the implementation of standardised measuring methods. The following aspects would need to be defined for each of the laundry machine categories in order to deliver comparable results of the performance and consumption parameters:

- Ambient temperature and humidity;
- Energy source for heating water / air;
- Input water temperature;

- Residual moisture of laundry before drying process;
- Selection of program ('standard' washing or drying program);
- Washing / drying capacity (kg laundry per hour); filling ratio
- Type (formulation) and dosage of detergent and laundry aid;
- Standard laundry in terms of type, amount and soiling.

The following parameters would need to be evaluated / measured:

- Cleaning / drying performance and, if necessary, hygienic performance; for washing machines additionally spin extraction performance and rinsing performance;
- Energy and/or water consumption per kg laundry or per standard cycle;
- Energy demand in low-power modes (left-on, and if applicable: off mode); if possible, the definition of low-power modes should follow the definitions of Commission Regulation (EC) No. 1275/2008 on Standby.
- Real-life use conditions: Energy and water consumption in partial load / discontinuous operation; possible declaration of the consumption in other than 'standard' program

Standard conditions should represent real-life conditions as precisely as possible. However, as there is a great variation in the user behaviour of professional washing machines and dryers within the categories as well as customer segments identified, therefore the energy and water consumption in day-to-day operation may still differ from that under standard test conditions. Similar arguments with regard to the variety apply for the amount and type of detergent: manufacturers are in favour of not defining a standard detergent in the measurement standards. Nevertheless a standard detergent would be necessary to be defined for standardised performance measurements.

In summary, the following data categories need to be assessed according to a possible standard test procedure.

Table 53 Data for measuring a possible standard test

	Performance parameters	**Consumption data**
Washing machines	Cleaning performance, spin extraction performance, rinsing performance, time, temperature, (optional: fibre protection)	Energy consumption, water consumption, detergent consumption[56]
Dryers	Drying performance (residual moisture content), time, (optional: fibre protection)	Energy consumption

[56] Detergent consumption is to be fixed in the measurement procedure.

5 Annex

5.1 Stakeholder involvement

The following table provides a list of addressees of the working paper containing preliminary assumptions on aspects regarding main applications of professional washing machines and dryers, the typical user behaviour, the influence of real-life conditions on ideal consumption and specific consumption values. An additional Excel file and questions regarding production, distribution and end-of-life phase was circulated. The table also indicates from whom a response has been received.

Table 54 Documentation of institutions to whom the working document on use phase and the Excel file and questions regarding production, distribution and end-of-life phase have been sent and their responses

	Working paper use phase and Excel file (covering Task 4)	
	Sent out	Feedback
Manufacturers and Industry Associations		
Miele Professional (sub divison laundry equipment currently not member of an industry association)	Yes	Yes
Electrolux Professional (currently not member of an industry association)	Yes	Yes
IMESA	Yes	No
GIRBAU	Yes	No
PRIMUS	Yes	Yes
Schulthess	Yes	No
- VDMA, Germany, representing ▪ Kannegiesser ▪ Jensen Group ▪ Eazy Clean ▪ Veith ▪ Seibt Kapp	Yes Yes Yes Yes Yes Yes	No No Yes No No No
Fagor Industrial	Yes	No
Schulthess	Yes	No
User associations		
ETSA	Yes	No
DTV-Bonn	Yes	No
INTEX	Yes	No
AFEC	Yes	No
Others		
Danish Technological Institute	Yes	Yes

5.2 Working document on use phase and additional questions for stake-holders

The general working paper and additional questions for the final report concerning heating options are provided separately in the following documents:

- EuP_Lot24_Wash_T3_T4_Annex_Workingpaper.pdf
- EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

5.3 Contents of Excel file on production, distribution and end-of-life phase

EuP Lot 24: Professional washing machines, dryers and dishwashers

Task 4 – Technical Analysis of Existing Products – Part on Professional Washing Machines

The data should be valid for a "typical" device of each category.
We know that within each washing machine and dryer category there is a certain degree of variation. Please specify the appliance for which the data is valid in more detail if necessary (e.g. regarding capacity etc.).

The data is used to determine the environmental profile and impact analysis of the identified product categories with the "EuP-EcoReport" tool for:

1. Production Phase
2. Assembling / Distribution Phase
3. Use Phase*
4. End of Life Phase

* data collection included in seperate working paper on use phase, including user behaviour

PRODUCTION (including packaging material)								
Main Materials Category type	**Material (EuP EcoReport)**	**Example Average data Washing Machine 5 kg model[57] [g]**	**WM 1 Semi-profes. washing machine and washer extractor [g]**	**WM 2 Professional washer extractor, small <40kg [g]**	**WM 3 Profess. washer extractor, large >40kg [g]**	**WM. 4 Profes-sional Wash Dryer [g]**	**WM 5 Profes-sional Barrier washer [g]**	**WM 6 Washing tunnel machines [g]**
Bulk Plastics	Low-density polyethylene (LDPE)	1 850						
	High-density polyethylene (HDPE)	51						
	Linear low density polyethylenes (LLDPE)							
	Polypropylene (PP)	8 021						
	Plystyrene (PS)	678						
	Styropor expandable polystyrene (EPS)							
	High Impact Polystyrene (HI-PS)							
	Polyvinylchlorid (PVC)	221						
	Styrol-Acrylnitril (SAN)							
	Acrylonitrile Butadiene Styrene (ABS)	1 145						
Bulk Plastics		***11 966***	***0***	***0***	***0***	***0***	***0***	***0***

[57] (data from Lot 14)

PRODUCTION (including packaging material)								
Main Materials Category type	**Material (EuP EcoReport)**	**Example Average data Washing Machine 5 kg model[57] [g]**	**WM 1 Semi-profes. washing machine and washer extractor [g]**	**WM 2 Professional washer extractor, small <40kg [g]**	**WM 3 Profess. washer extractor, large >40kg [g]**	**WM. 4 Profes-sional Wash Dryer [g]**	**WM 5 Profes-sional Barrier washer [g]**	**WM 6 Washing tunnel machines [g]**
TecPlastics	Polyamide (PA)	94						
	Plolycarbonate (PC)	190						
	Polymethylmetacrylate (PMMA)							
	Epoxy							
	Rigid-Pur							
	Flex-Pur							
	Talcum filler							
	E-glass fibre							
	Aramid fibre							
TecPlastics		***284***	***0***	***0***	***0***	***0***	***0***	***0***
Ferrous metals	Steel Sheet galvanized	564						
	Steel tube/profile							
	Cast Iron	11 192						
	Ferrite							
	Stainless 18/8 coil	20 605						
Ferrous metals		***32 361***	***0***	***0***	***0***	***0***	***0***	***0***
Non ferrous metals	Al sheet/extrusion	1						
	Al diecast	2 232						
	Cu winding wire	869						
	Cu wire	436						
	Cu tube/sheet							
	CuZn38 cast	99						
	ZnAl4 cast							
	MgZn5 cast							
Non ferrous metals		***3 637***	***0***	***0***	***0***	***0***	***0***	***0***

PRODUCTION (including packaging material)								
Main Materials Category type	**Material (EuP EcoReport)**	**Example Average data Washing Machine 5 kg model[57] [g]**	**WM 1 Semi-profes. washing machine and washer extractor [g]**	**WM 2 Professional washer extractor, small <40kg [g]**	**WM 3 Profess. washer extractor, large >40kg [g]**	**WM. 4 Profes-sional Wash Dryer [g]**	**WM 5 Profes-sional Barrier washer [g]**	**WM 6 Washing tunnel machines [g]**
Coating	pre-coating coil							
	powder coating							
	Cu/ni/Cr plating							
	Au/Pt/Pd							
Coating		***0***	***0***	***0***	***0***	***0***	***0***	***0***
Electronics	LCD per m² scrn							
	CRT per m² scrn							
	big caps & coils							
	slots / ext. Ports							
	IC's avg., 5% Si, Au							
	IC's avg., 1% Si							
	SMD/LED's avg.							
	PWB 1/2 lay 3.75kg/m²							
	PWB 6 lay 4.5kg/m²							
	PWB 6 lay 2kg/m²							
	Solder SnAg4Cu0.5							
	controller board							
Electronics		***165***	***0***	***0***	***0***	***0***	***0***	***0***
Miscellaneous	Glass for Lamps	1 773						
	Bitumen	38						
	Cardboard	107						
	Office Paper	116						
	Concrete	18 205						
Miscellaneous		***20 239***	***0***	***0***	***0***	***0***	***0***	***0***
OUT of Scope EUP**	others	260						

PRODUCTION (including packaging material)								
Main Materials Category type	**Material (EuP EcoReport)**	**Example Average data Washing Machine 5 kg model[57] [g]**	**WM 1 Semi-profes. washing machine and washer extractor [g]**	**WM 2 Professional washer extractor, small <40kg [g]**	**WM 3 Profess. washer extractor, large >40kg [g]**	**WM. 4 Profes-sional Wash Dryer [g]**	**WM 5 Profes-sional Barrier washer [g]**	**WM 6 Washing tunnel machines [g]**
	Resins							
	thermostat							
	Cotton							
	Cotton+Resins noise absorbers							
	adhesive							
	PBT polybutylene terephthalate							
	Plastics, others	1 101						
	wood	2 452						
	PU Foam - Insulation							
	Cr	1 761						
OUT of Scope EUP		***5 574***	***0***	***0***	***0***	***0***	***0***	***0***
TOTAL		**74 226**						

** For some materials no correspondance with EuP EcoReport is possible, in that case please allocated the materials in the main category "out of scope"

ASSEMBLING / DISTRIBUTION							
	Example Average data Washing Machine 5 kg model [57]	**WM 1 Semi-professional washing machine & washer extractor**	**WM 2 Professional washer extractor, small <40kg**	**WM 3 Professional washer extractor, large >40kg**	**WM. 4 Professional Wash Dryer**	**WM 5 Professional Barrier washer**	**WM 6 Washing tunnel machines**
Energy (kWh)							
Electricity	28.98						
Heat	14.79						
Water (m3)	0.59						
Other materials (g)	92						
Volume of packaged final product (m3)	0.36						
Transport average (km)	160						

END OF LIFE							
	Example Average data Washing Machine 5 kg model[57]	**WM 1 Semi-profess. washing machine and washer extractor**	**WM 2 Professional washer extractor, small <40kg**	**WM 3 Professional washer extractor, large >40kg**	**WM. 4 Professional Wash Dryer**	**WM 5 Professional Barrier washer**	**WM 6 Washing tunnel machines**
		in %	in %	in %	in %	in %	in %
Landfill (fraction of products not recovered)		5	5	5	1	1	
Recycling of plastics							
Re-use, closed loop recycling	27	25	25	25	10	10	
Materials Recycling	70	70	70	70	80	80	
Thermal Recycling (%)	3	5	5	5	10	10	
Total	**100**	**100**	**100**	**100**	**100**	**100**	

EuP Lot 24: Professional washing machines, dryers and dishwashers

Task 4 – Technical Analysis of Existing Products – Part on Professional Dryers

The data should be valid for a "typical" device of each category.
We know that within each washing machine and dryer category there is a certain degree of variation. Please specify the appliance for which the data is valid in more detail if necessary (e.g. regarding capacity etc.).

The data is used to determine the environmental profile and impact analysis of the identified product categories with the "EuP-EcoReport" tool for:

1. Production Phase
2. Assembling / Distribution Phase
3. Use Phase*
4. End of Life Phase

* data collection included in seperate working paper on use phase, including user behaviour

PRODUCTION (including packaging material)									
Main Materials Category type	**Material (EuP EcoReport)**	Example Average data household **air vented dryer** [g][58]	Example Average data household **condenser dryer** [g][58]	**D 1 Semi-professional dryer, condenser [g]**	**D 2 Semi-professional dryer, air vented [g]**	**D 3 Professional tumble dryer <40kg [g]**	**D 4 Professional tumble dryer >40kg [g]**	**D 5 Cabinet Dryer [g]**	**D 6 Heavy duty Pass-trough (transfer) Tumble dryer [g]**
Bulk Plastics	Low-density polyethylene (LDPE)								
	High-density polyethylene (HDPE)	29	86						
	linear low density polyethylenes (LLDPE)								
	Polypropylene (PP)	4 157	7 715						
	Plystyrene (PS)	364	378						
	Styropor expandable polystyrene (EPS)								

[58] load size 6kg (data from Lot 16)

PRODUCTION (including packaging material)									
Main Materials Category type	**Material (EuP EcoReport)**	Example Average data household **air vented dryer** [g][58]	Example Average data household **condenser dryer** [g][58]	**D 1 Semi-professional dryer, condenser [g]**	**D 2 Semi-professional dryer, air vented [g]**	**D 3 Professional tumble dryer <40kg [g]**	**D 4 Professional tumble dryer >40kg [g]**	**D 5 Cabinet Dryer [g]**	**D 6 Heavy duty Pass-trough (transfer) Tumble dryer [g]**
	High Impact Polystyrene (HI-PS)								
	Polyvinylchlorid (PVC)	100	115						
	Styrol-Acrylnitril (SAN)								
	Acrylonitrile Butadiene Styrene (ABS)	1 307	2 117						
Bulk Plastics		***5 957***	***10 411***	***0***	***0***	***0***	***0***	***0***	***0***
TecPlastics	Polyamide (PA)	99	198						
	Plolycarbonate (PC)	4	23						
	Polymethylmetacrylate (PMMA)	30	30						
	Epoxy								
	Rigid-Pur		330						
	Flex - Pur								
	Talcum filler								
	E-glass fibre								
	Aramid fibre								
TecPlastics		***133***	***581***	***0***	***0***	***0***	***0***	***0***	***0***
Ferrous metals	Steel Sheet galvanized	2 856	2 515						
	Steel tube/profile								
	Cast Iron								
	Ferrite								
	Stainless 18/8 coil	19 722	17 616						
Ferrous metals		***22 578***	***20 131***	***0***	***0***	***0***	***0***	***0***	***0***

PRODUCTION (including packaging material)									
Main Materials Category type	**Material (EuP EcoReport)**	Example Average data household **air vented dryer** [g][58]	Example Average data household **condenser dryer** [g][58]	**D 1 Semi-professional dryer, condenser [g]**	**D 2 Semi-professional dryer, air vented [g]**	**D 3 Professional tumble dryer <40kg [g]**	**D 4 Professional tumble dryer >40kg [g]**	**D 5 Cabinet Dryer [g]**	**D 6 Heavy duty Pass-trough (transfer) Tumble dryer [g]**
Non ferrous metals	Al sheet/extrusion	611	653						
	Al diecast								
	Cu winding wire	231	710						
	Cu wire								
	Cu tube/sheet								
	CuZn38 cast								
	ZnAl4 cast								
	MgZn5 cast								
Non ferrous metals		***842***	***1 363***	***0***	***0***	***0***	***0***	***0***	***0***
Coating	pre-coating coil								
	powder coating								
	Cu/ni/Cr plating								
	Au/Pt/Pd								
Coating		***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Electronics	LCD per m² scrn								
	CRT per m² scrn								
	big caps & coils								
	slots / ext. Ports								
	IC´s avg., 5% Si, Au								
	IC´s avg., 1% Si								
	SMD/LED´s avg.								
	PWB 1/2 lay 3.75kg/m²								
	PWB 6 lay 4.5kg/m²								

PRODUCTION (including packaging material)									
Main Materials Category type	**Material (EuP EcoReport)**	Example Average data household **air vented dryer** [g][58]	Example Average data household **condenser dryer** [g][58]	**D 1 Semi-professional dryer, condenser [g]**	**D 2 Semi-professional dryer, air vented [g]**	**D 3 Professional tumble dryer <40kg [g]**	**D 4 Professional tumble dryer >40kg [g]**	**D 5 Cabinet Dryer [g]**	**D 6 Heavy duty Pass-trough (transfer) Tumble dryer [g]**
	PWB 6 lay 2kg/m²								
	Solder SnAg4Cu0.5								
	controller board								
Electronics		***1 556***	***1 987***	***0***	***0***	***0***	***0***	***0***	***0***
Miscellaneous	Glass for Lamps								
	Bitumen								
	Cardboard								
	Office Paper								
	Concrete								
Miscellaneous		***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
OUT of Scope EUP **	others	1 778	1 856						
	Resins								
	thermostat								
	Cotton								
	Cotton+Resins noise absorbers								
	adhesive								
	PBT polybutylene terephthalate								
	Plastics, others	1 337	2 475						
	wood								
	PU Foam - Insulation								
	Cr								
OUT of Scope EUP		***3 115***	***4 331***	***0***	***0***	***0***	***0***	***0***	***0***
TOTAL		**34 181**	**38 804**						

** For some materials no correspondance with EuP EcoReport is possible, in that case please allocated the materials in the main category "out of scope"

ASSEMBLING / DISTRIBUTION								
	Example Average data household **air venture dryer**[58]	Example Average data household **condenser dryer**[58]	**D 1 Semi-professional dryer, condenser**	**D 2 Semi-professional dryer, air vented**	**D 3 Professional tumble dryer <40kg**	**D 4 Professional tumble dryer >40kg**	**D 5 Cabinet Dryer**	**D 6 Heavy duty pass-trough (transfer) Tumble dryer**
Energy (kWh)								
Electricity								
Heat								
Water (m3)								
Other materials (g)								
Volume of packaged final product (m3)	0.4	0.4						
Transport average (km)	160	160						

END OF LIFE								
	Example Average data household air vent**ure dryer**[58] [%]	Example Average data household **condenser dryer**[58] [%]	**D 1 Semi- profess. dryer, condenser** [%]	**D 2 Semi-professional dryer, air vented** [%]	**D 3 Professional tumble dryer <40kg** [%]	**D 4 Professional tumble dryer >40kg** [%]	**D 5 Cabinet Dryer** [%]	**D 6 Heavy duty pass-trough (transfer) tumble dryer** [%]
Landfill[59]	5	5	5	5	5	1	1	1
Plastics recycl.								
Re-use, closed loop recycling	0	0	0	0	0	0	0	0
Materials Recycling	67	67	67	67	80	80	90	90
Thermal Recyc.	28	28	28	28	20	20	10	10
Total			**95**	**95**	**100**	**100**	**100**	**100**

[59] fraction of products not recovered

5.4 Additional questions on production, distribution and end-of-life phase

Attached you find an excel-file, where we kindly ask your members to fill in the following data:

1. Production:

Material composition of the defined product categories (incl. packaging material)

The data should be valid for electrically heated washing machines and dryers (as we assume this as standard). If possible, we would like to ask you to specify the additional materials required for other heating possibilities (steam / hot water and gas heating respectively, therefore 3 columns there). Either possible as percentage or in absolute values.

The data should be valid for a "typical" washing machine and dryer of each category. We know that especially in case of transport washing machine and dryer there are quite big differences.

2. Assembling, Distribution:

Energy, water and other material demand for the manufacturing process at the manufacturer. It is obvious, that this can be only rough values, perhaps not differentiated per category, as it is difficult to allocate them to specific products.

Volume of packaged final product

Transport average (manufacturer - user)

3. End of life

Fraction of products not recovered ("landfill" in any sense)

Fraction of plastics that (1) is re-used, (2) goes to material recycling or (3) goes to thermal recycling (you find an assumption in the excel-file already)

Additionally we would like to ask the following questions:

Which percentage of the used sheetmetal is made of scrap metal?

Are the PWB (printed wiring boards) easy to disassemble?

Do the products contain refrigerants? If yes, which and how much? We assume that this is the case, if the waste steam condensation takes place with a heat pump, which, however we assume not as "standard" but rather as BAT.

How is the refrigerant of the heat pumps being disposed of in the end-of-life phase? Which fraction of it is retained?

Do the products contain mercury? If yes, how much and for which purpose? Which fraction is retained in the end-of-life phase?

5.5 Explanations to data collections (Task 4)

The data should be valid for a "typical" device of each category. We know that within each washing machine and dryer category there is a certain degree of variation. Please specify the appliance for which the data is valid in more detail if necessary (e.g. regarding capacity etc.).

1. Production

Material composition of the defined product categories (incl. packaging material)

2. Assembling, Distribution

- Energy (Electricity, and heat energy), water and other material demand for the manufacturing process at the manufacturers'. It is obvious, that these can be only rough values, perhaps not differentiated per category, as it is difficult to allocate them to specific products.
- Volume of packaged final product
- Transport average (manufacturer – user)

3. End of life

- Fraction of products not recovered ("landfill" in any sense)
- Fraction of plastics that 1. is re-used, 2. goes to material recycling or 3. goes to thermal recycling (you find an assumption in the excel-file already)

Additionally we would like to ask the following questions:

- Are the PWB (printed wiring boards) easy to disassemble?
- Which percentage of the used sheetmetal is made of scrap metal?
- Do the products contain refrigerants? If yes, which and how much? (We assume that this could be the case, if there is a heat pump in the appliance, which, however we assume not as "standard" but rather as BAT.) How is the refrigerant being disposed of in the end-of-life phase? Which fraction of it is retained?
- Do the products contain mercury? If yes, how much and for which purpose? Which fraction is retained in the end-of-life phase?

You will find in both Excel-files the data for a washing machine from Lot 14 and from Lot 16 the dryer data.

In general we assume that production, distribution and end-of-life have a rather small share at the overall environmental impacts over the entire product life cycle. Therefore the data can be reasonably rough.

The data is only going to be published on an aggregated basis that does not allow tracing back to data of single manufacturers. It is also possible that you or your member associations deliver already aggregated data to us. We also prepared a non-disclosure agreement (NDA), if necessary.

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

Lot 24: Professional Dishwashers, Washing Machines and Dryers

Tender No. TREN/D3/91-2007

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Final Report,
Part: Washing Machines and Dryers

Task 5: Definition of Base Case

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

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

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

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective of Task 5

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

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

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

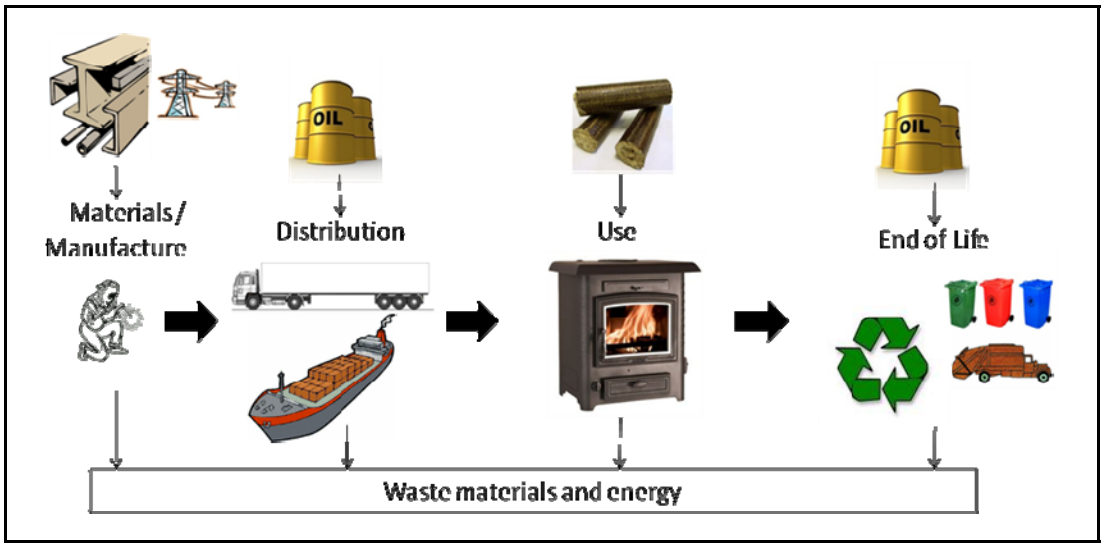


Figure 1 Simplified material flow diagram for LCA

These material and energy flows are then aggregated over the lifetime of the product to compute total environmental impacts. These environmental impacts can be expressed in many different ways, but are expressed in this study with 17 environmental indicators that

were predefined for all Eco-design studies. These indicators will be described in more detail later in the report. As the results are presented through several indicators of environmental impact, LCA is a multi-criteria approach.

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

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

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

2 Product-specific inputs

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

[1] Necessary input into EuP EcoReport.

2.1 Definition of base cases

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

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

Table 1 Description of the professional washing machines BCs

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

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

Table 2 Description of the professional laundry dryers BCs

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

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

2.2 Inputs in the production phase

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

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

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

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

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

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

All professional washing machines base cases, except WM1, have at least 70% of ferrous materials in their BOMs. For the case of professional laundry dryers, this ferrous material

share is at least 60%. It is expected that the impacts of the production and manufacturing phases will be mainly due to this category of materials.

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

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

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

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

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

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

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

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

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

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

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

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

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

2.3 Inputs in the distribution phase

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

Table 7 Volume of packaged product for washing machines base cases

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

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

[4] All materials from EcoInvent 2.0 database.

Table 8 Volume of packaged product for dryers base cases

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

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

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

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

2.4 Inputs in the use phase

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

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

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

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

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

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

The EcoReport Tool enables energy consumption to be split between electricity and heat input. However, a single energy source (gas, oil, wood pellets, etc.) has to be selected for the heat input, along with single process efficiency. Consequently, for simplicity reasons, the options internal heating with gas, internal heating with steam and external heating will be modelled together in the case of washing machines, by a gas heating process (atmospheric) with an efficiency of 90% (Lower Heating Value). This was determined as an average EU situation with the support of experts of Lot 24, part: dishwasher, in the case of warm water supply (the external boiler used to heat externally the water is estimated to be an

atmospheric gas boiler). As customers from professional dishwashers and laundry appliances belong to similar market segments (e.g. hotels and catering sector), the same assumption will be used for the washing machines and dryers. The internal gas heating may be a bit more efficient than the internal steam heating (which necessitates firstly the external heating of the steam) or the warm water supply options, as these options are subject to additional energy losses during the transport of the warm water or the steam through pipes. However, the efficiency difference between these three options is estimated much less important than the difference between their "average" model efficiency (90%, gas atmospheric) and the efficiency of electric heating. For dryers, the same reasoning applies and internal gas and internal steam heating will be modelled together.

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

Table 11 Modelling of the water heating for washing machines BCs

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

Table 12 Modelling of the air heating for dryers BCs

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

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

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

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

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

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

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

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

[5] Source: From manufacturers' responses to questionnaire.

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

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

Table 15 Example of energy split calculation considering base case WM1

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

2.4.1 Energy consumption

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

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

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

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

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

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

2.4.2 Water consumption

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

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

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

2.4.3 Detergent and laundry aid consumption

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

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

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

2.4.4 Travelling distance for maintenance and repair over the product life

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

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

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

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

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

2.5 Inputs in the end-of-life phase

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

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

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

[6] www.bfr.bund.de

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

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

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

2.6 Economic inputs

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

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

Table 22 Professional washing machines and dryers lifetimes (years)

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

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

** hours*

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

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

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

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

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

Table 24 EcoReport economic inputs of the professional dryer base cases

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

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

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

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

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

Table 26 Energy rates, by professional dryer base case

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

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

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

According to the industry, the energy and water consumption has decreased around 65% when comparing the top class current model with the average ten-year old model. The water

consumption over the past 25 years has decreased around 75%. However, comparing top of the range machines, the improvement has been 15%. This overall improvement ratio is considered for all base cases.

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

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

3 Base case environmental impact assessment

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

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

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

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

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

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

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

3.1 Base case WM1: Semi-professional washer extractor

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

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

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

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

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

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

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

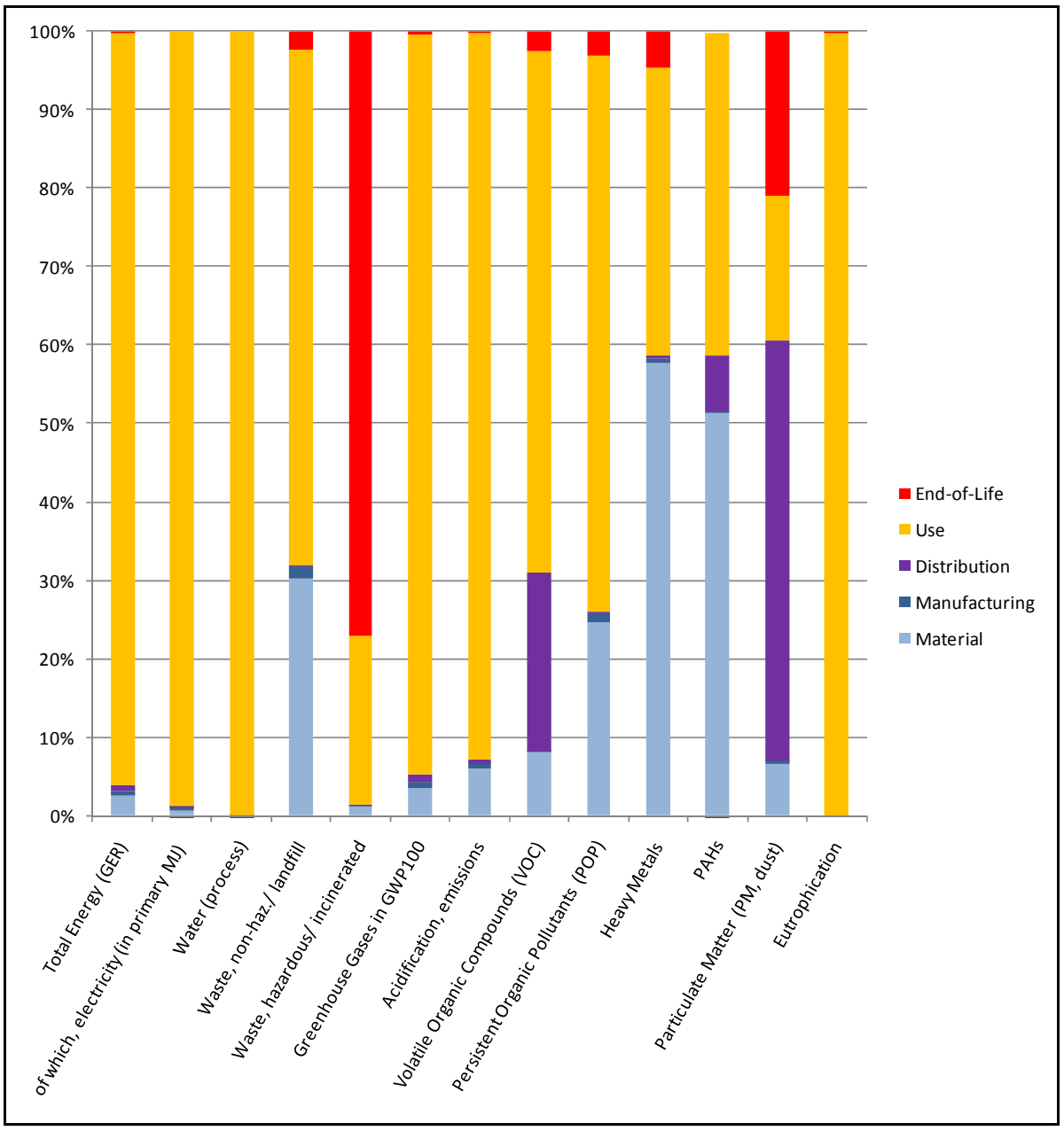


Figure 2 Distribution of environmental impacts of BC WM1 per life cycle phase

3.2 Base case WM2: Professional washer extractor <15 kg

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

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

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

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

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

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

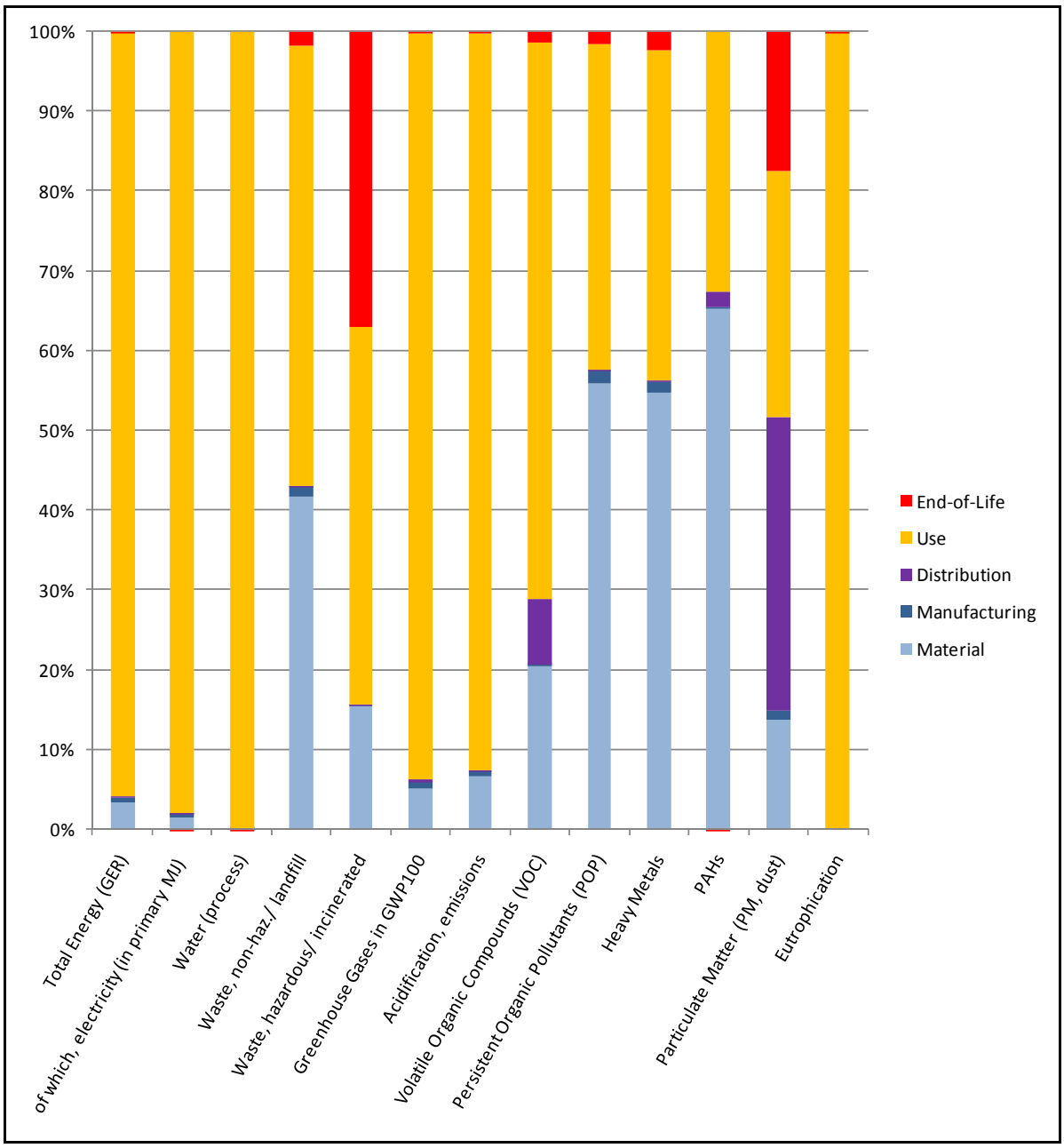


Figure 3 Distribution of environmental impacts of BC WM2 per life cycle phase

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

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

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

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

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

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

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

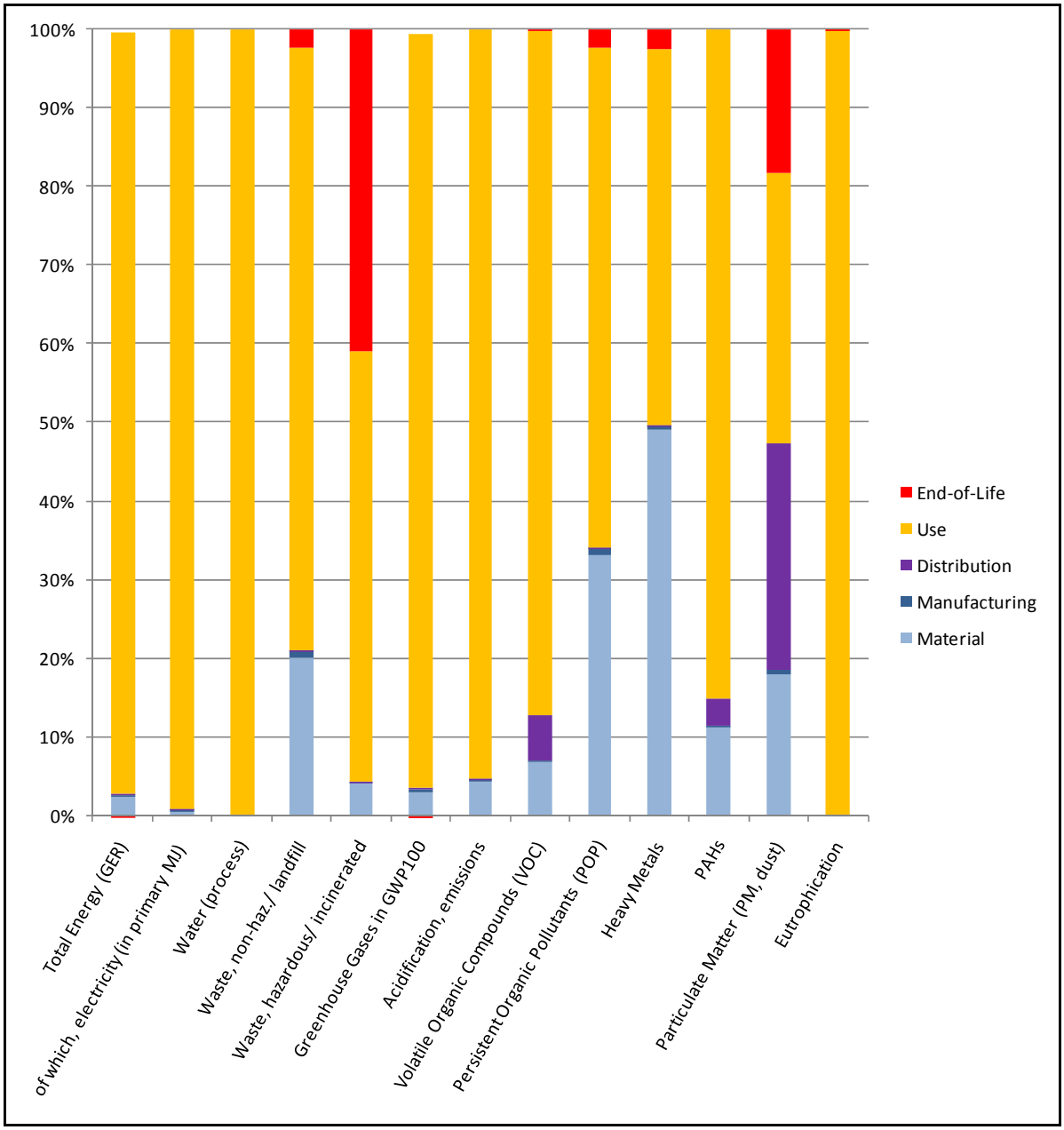


Figure 4 Distribution of environmental impacts of BC WM3 per life cycle phase

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

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

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

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

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

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

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

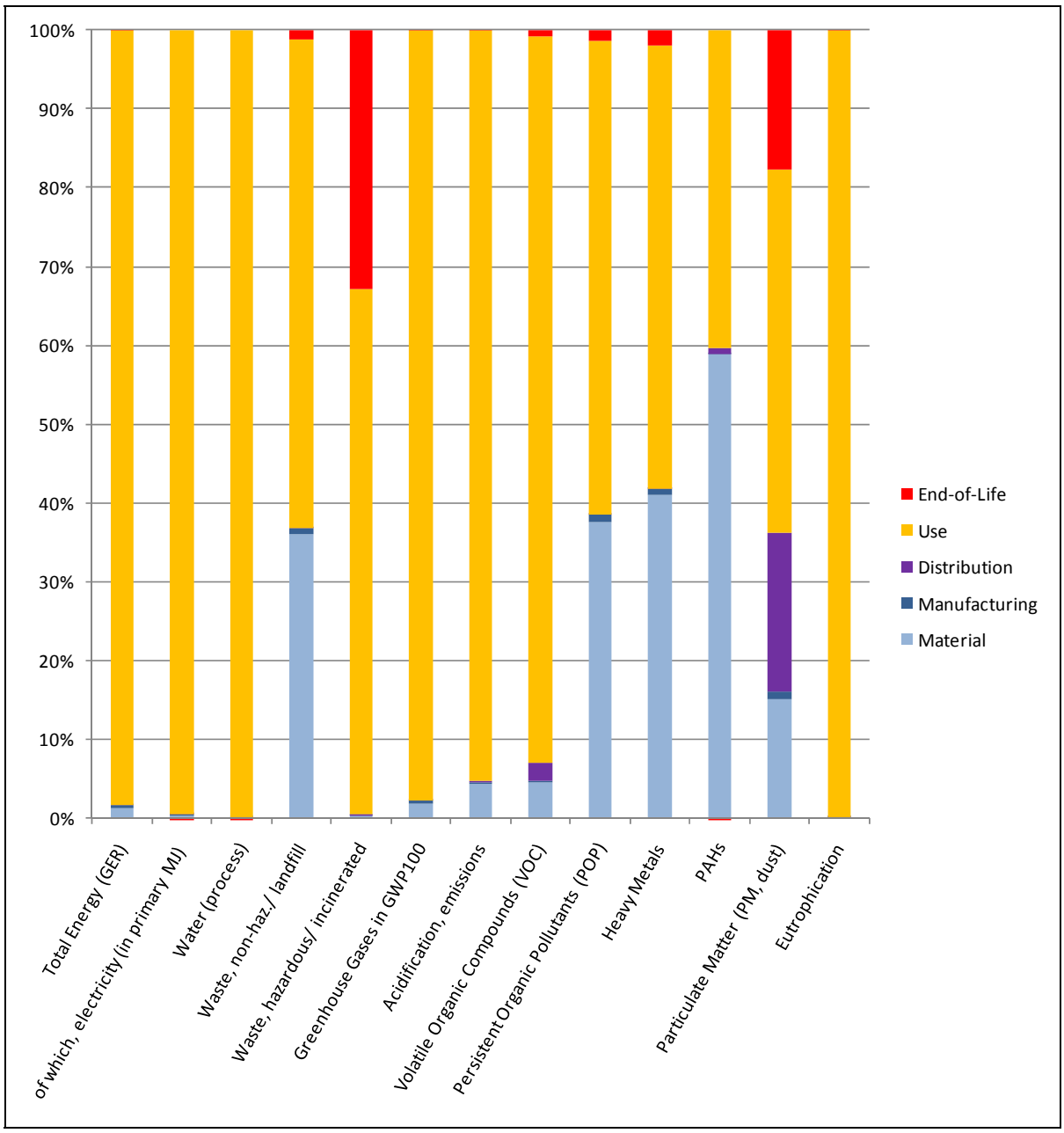


Figure 5 Distribution of environmental impacts of BC WM4 per life cycle phase

3.5 Base case WM5: Professional washer dryer

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

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

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

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

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

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

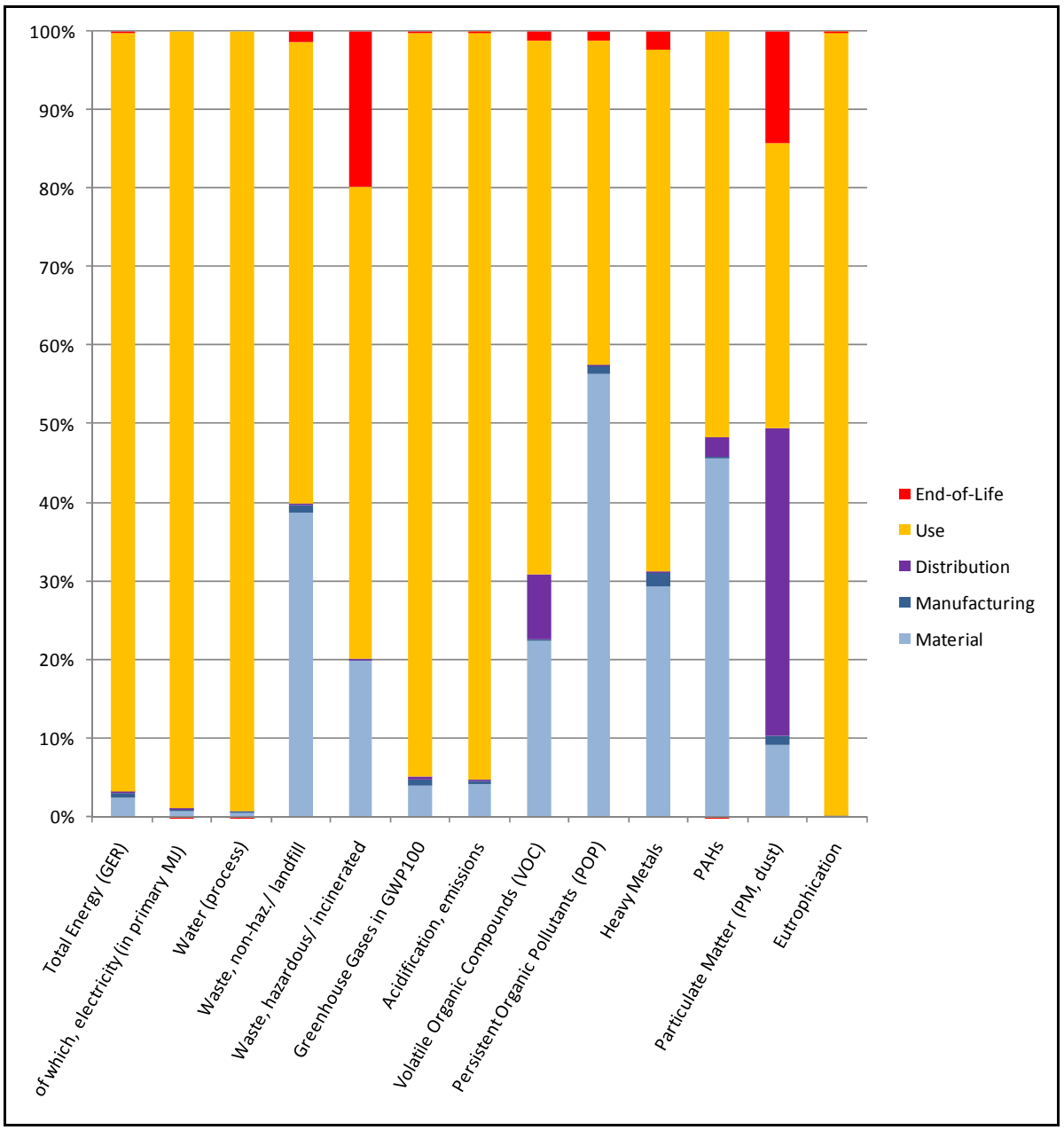


Figure 6 Distribution of environmental impacts of BC WM5 per life cycle phase

3.6 Base case WM6: Professional barrier washer

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

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

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

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

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

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

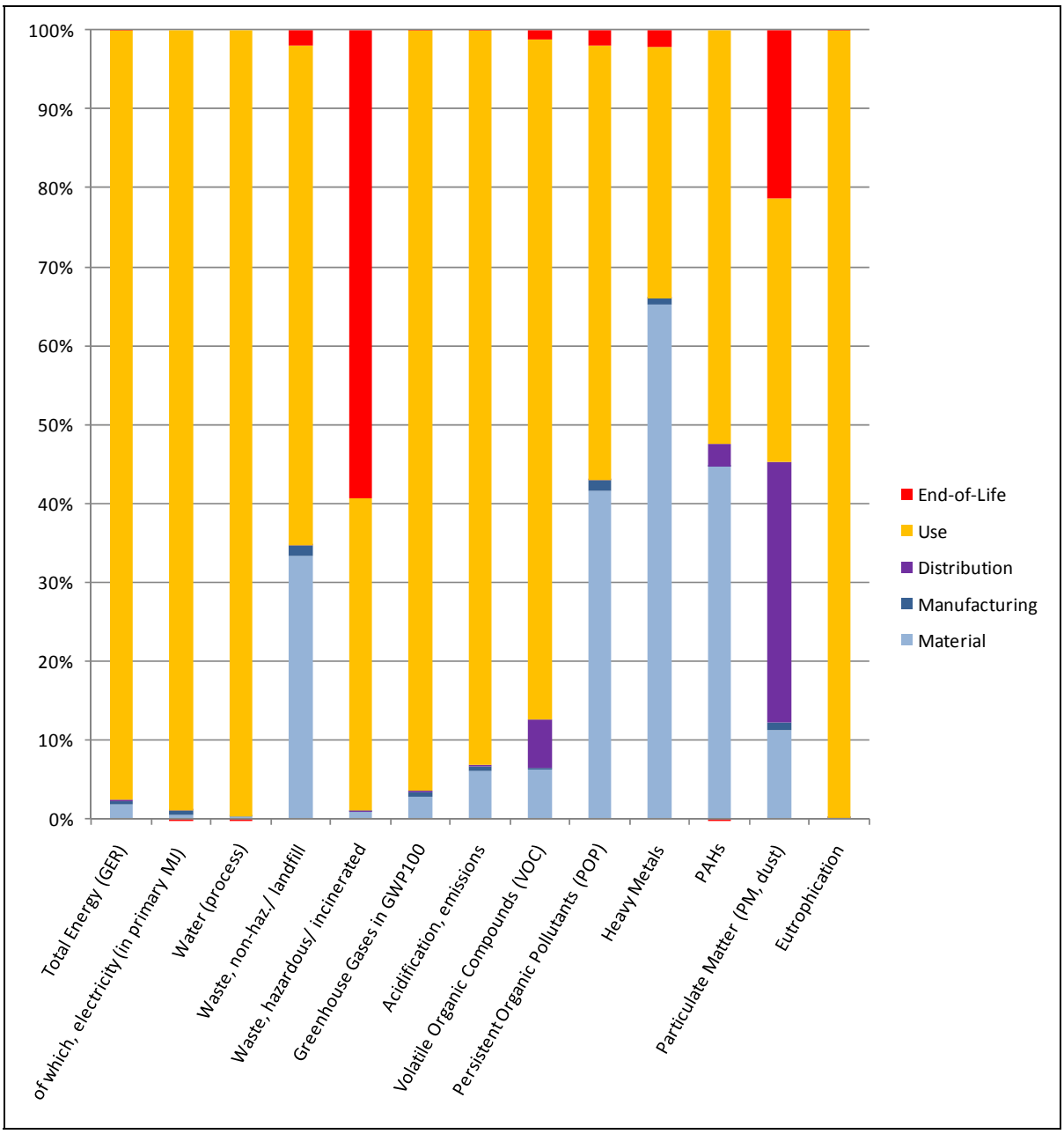


Figure 7 Distribution of environmental impacts of BC WM6 per life cycle phase

3.7 Base case WM7: Washing tunnel machine

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

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

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

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

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

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

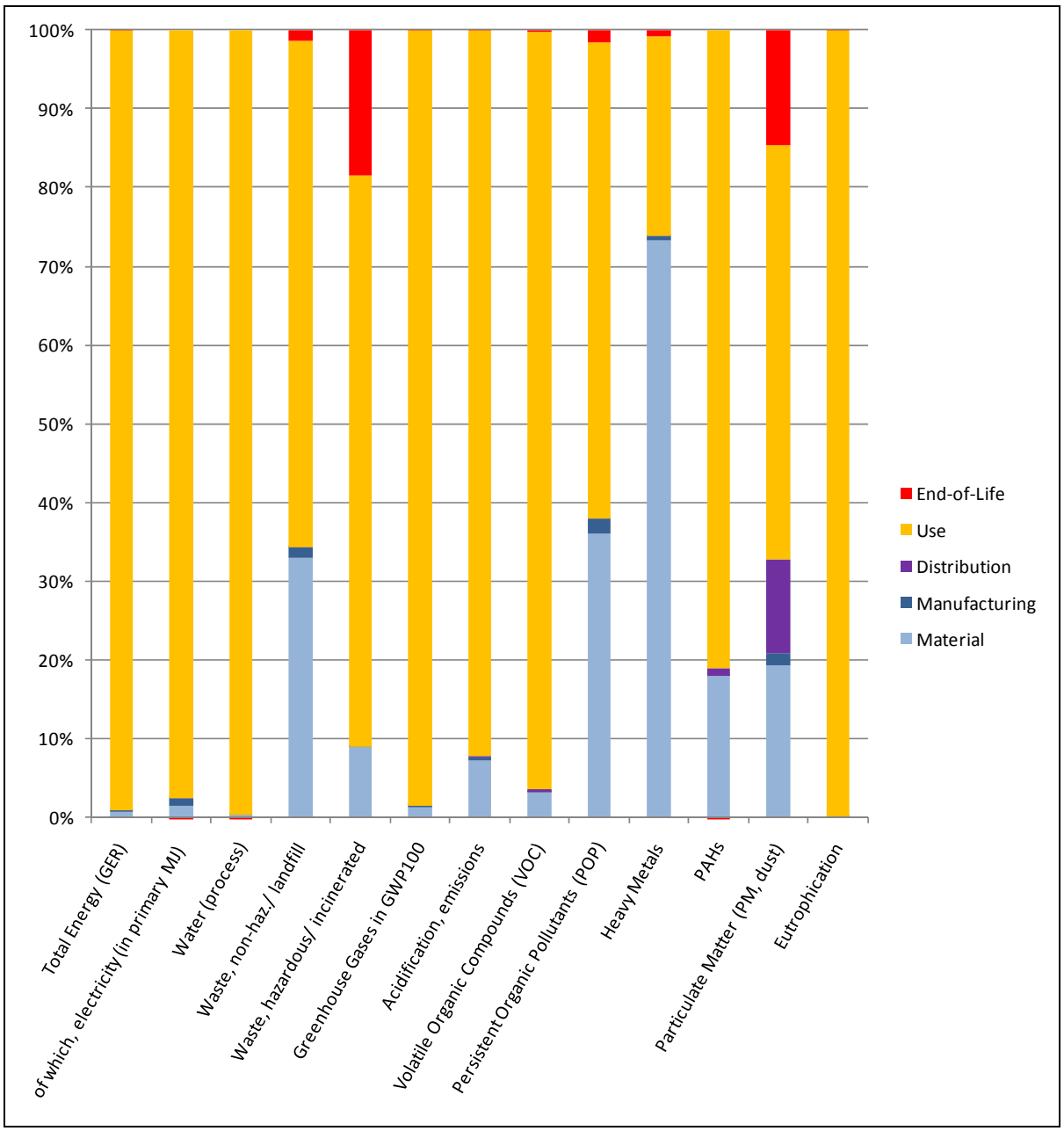


Figure 8 Distribution of environmental impacts of BC WM7 per life cycle phase

3.8 Base case D1: Semi-professional dryer, condenser

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

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

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

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

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

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

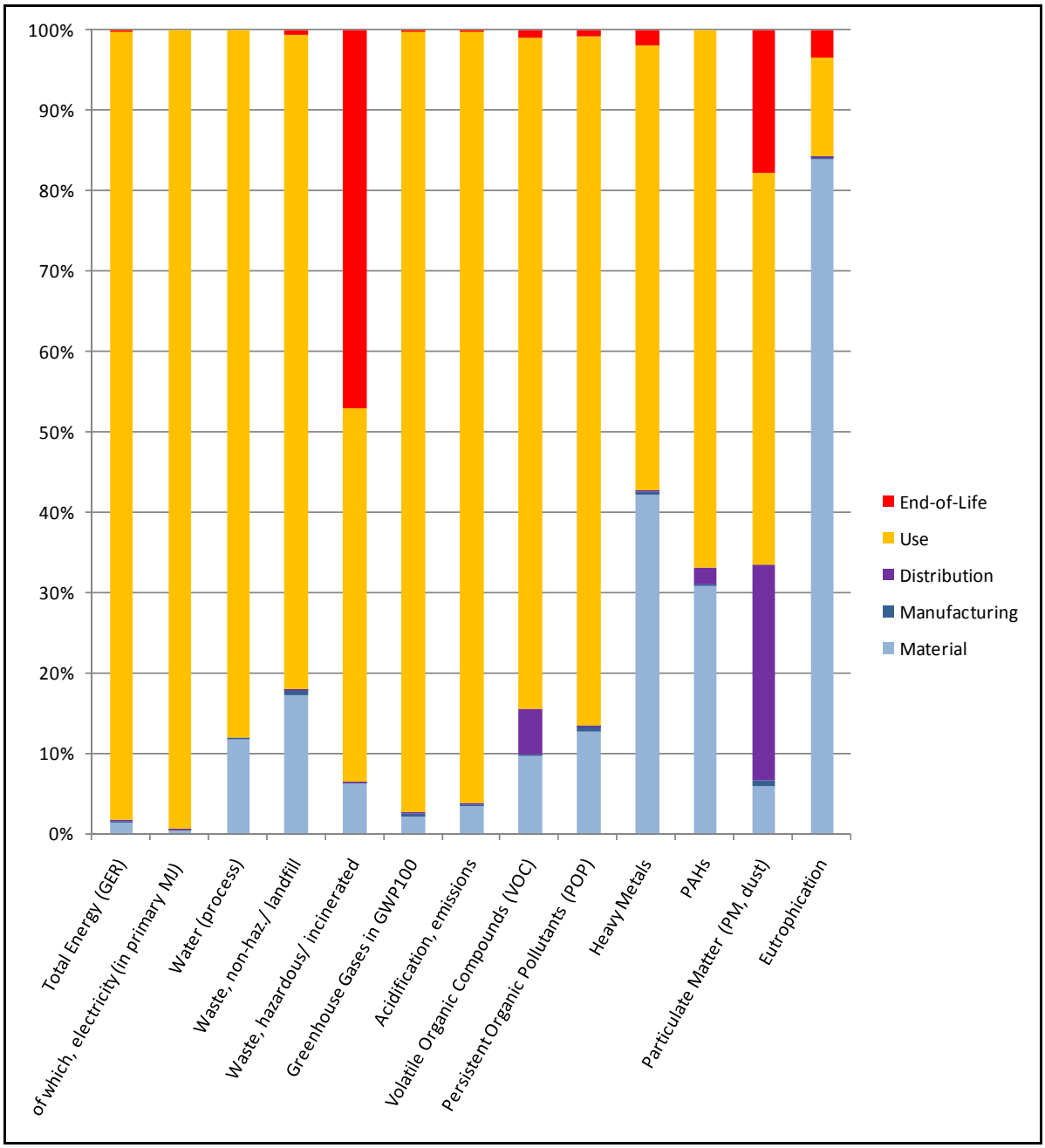


Figure 9 Distribution of environmental impacts of BC D1 per life cycle phase

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

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

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

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

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

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

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

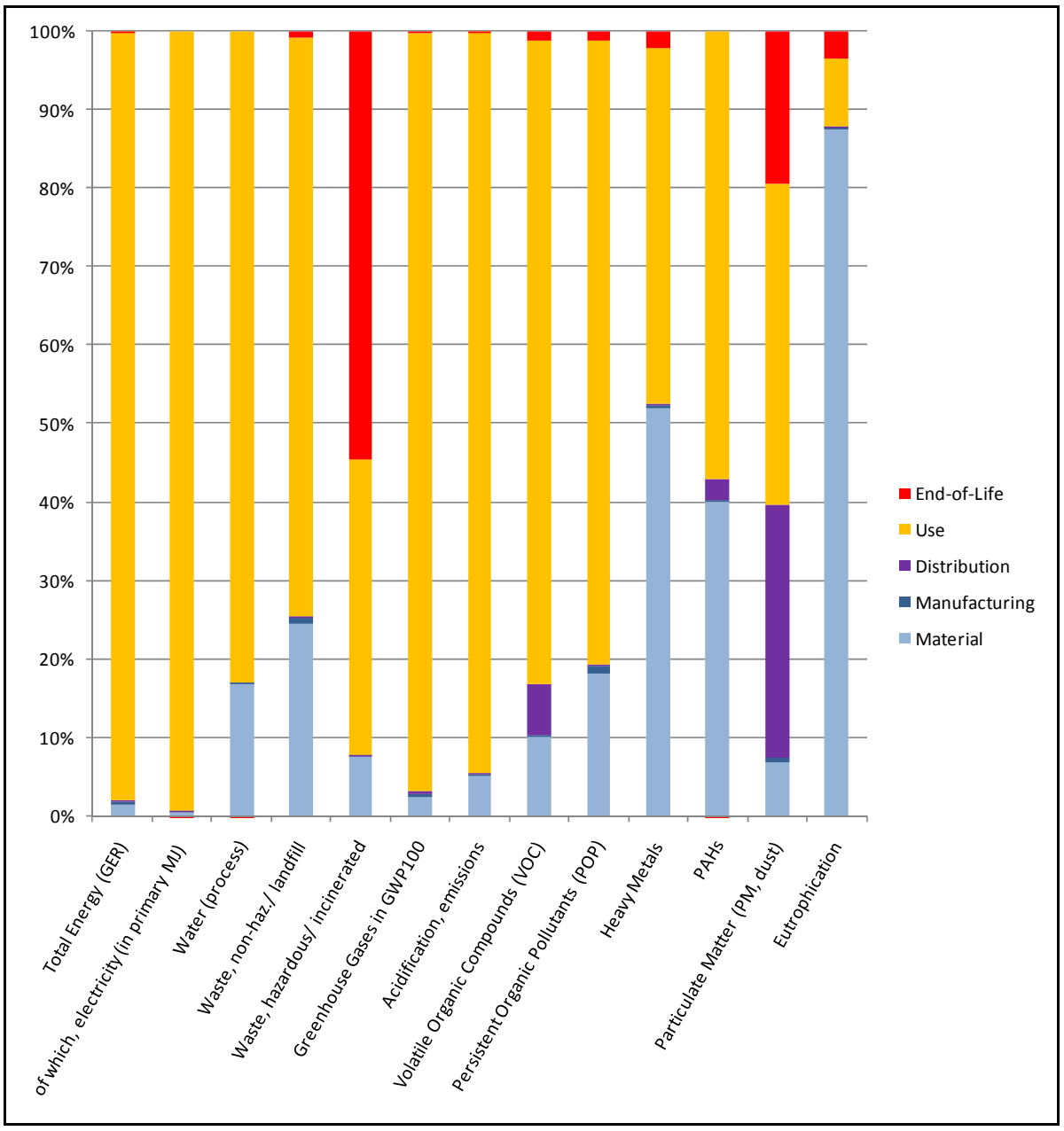


Figure 10 Distribution of environmental impacts of BC D2 per life cycle phase

3.10 Base case D3: Professional cabinet dryer

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

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

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

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

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

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

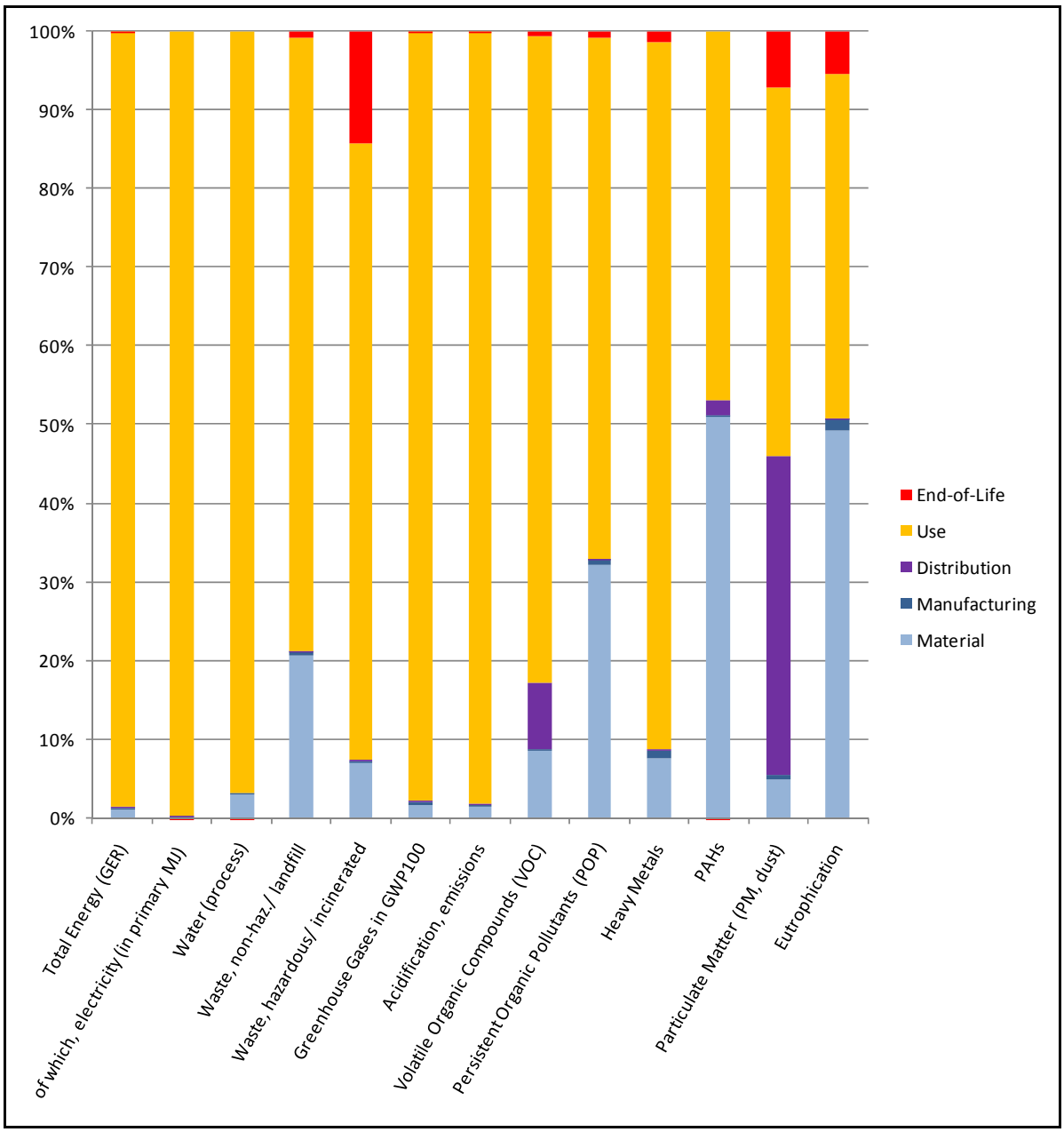


Figure 11 Distribution of environmental impacts of BC D3 per life cycle phase

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

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

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

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

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

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

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

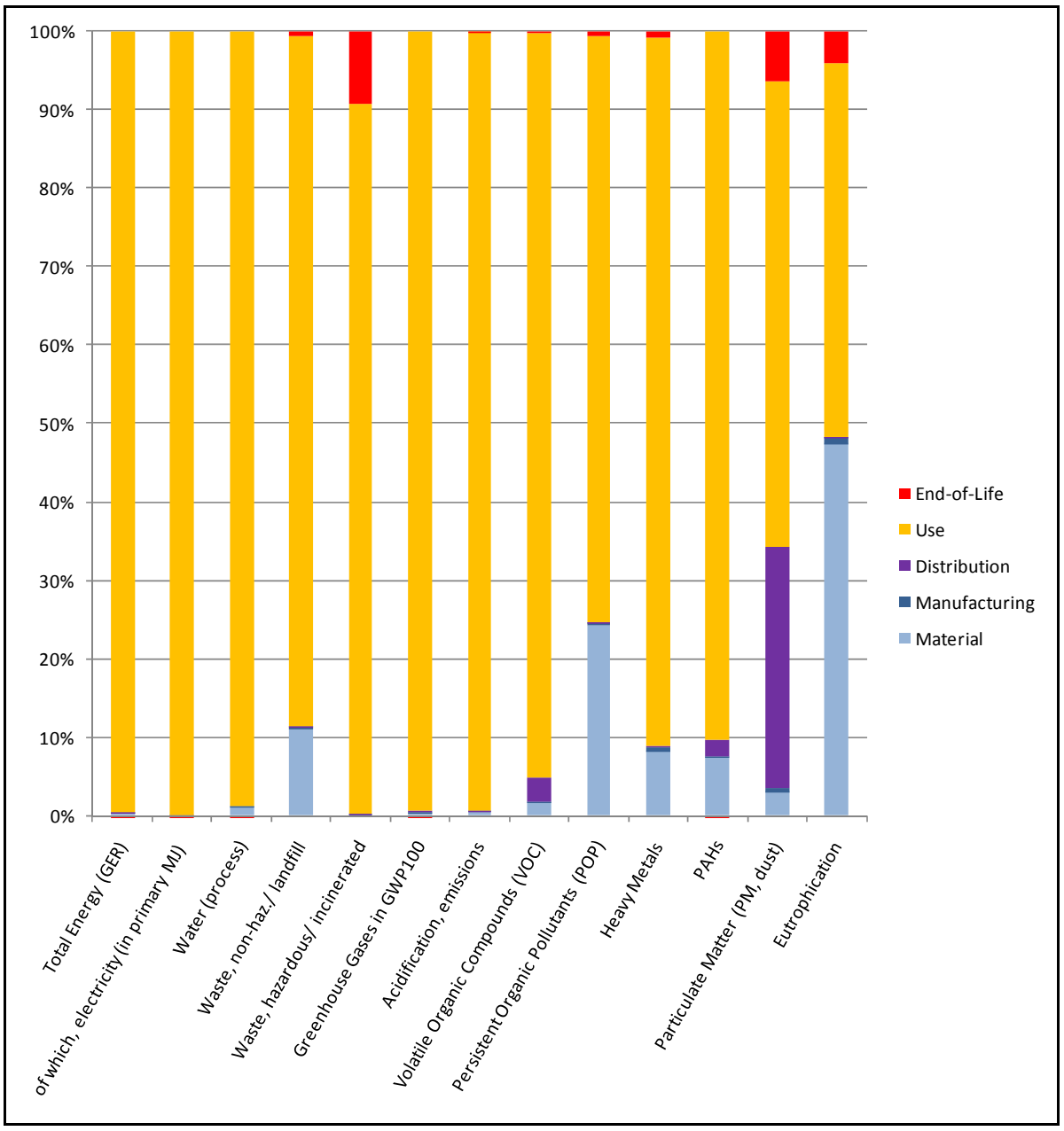


Figure 12 Distribution of environmental impacts of BC D4 per life cycle phase

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

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

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

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

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

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

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

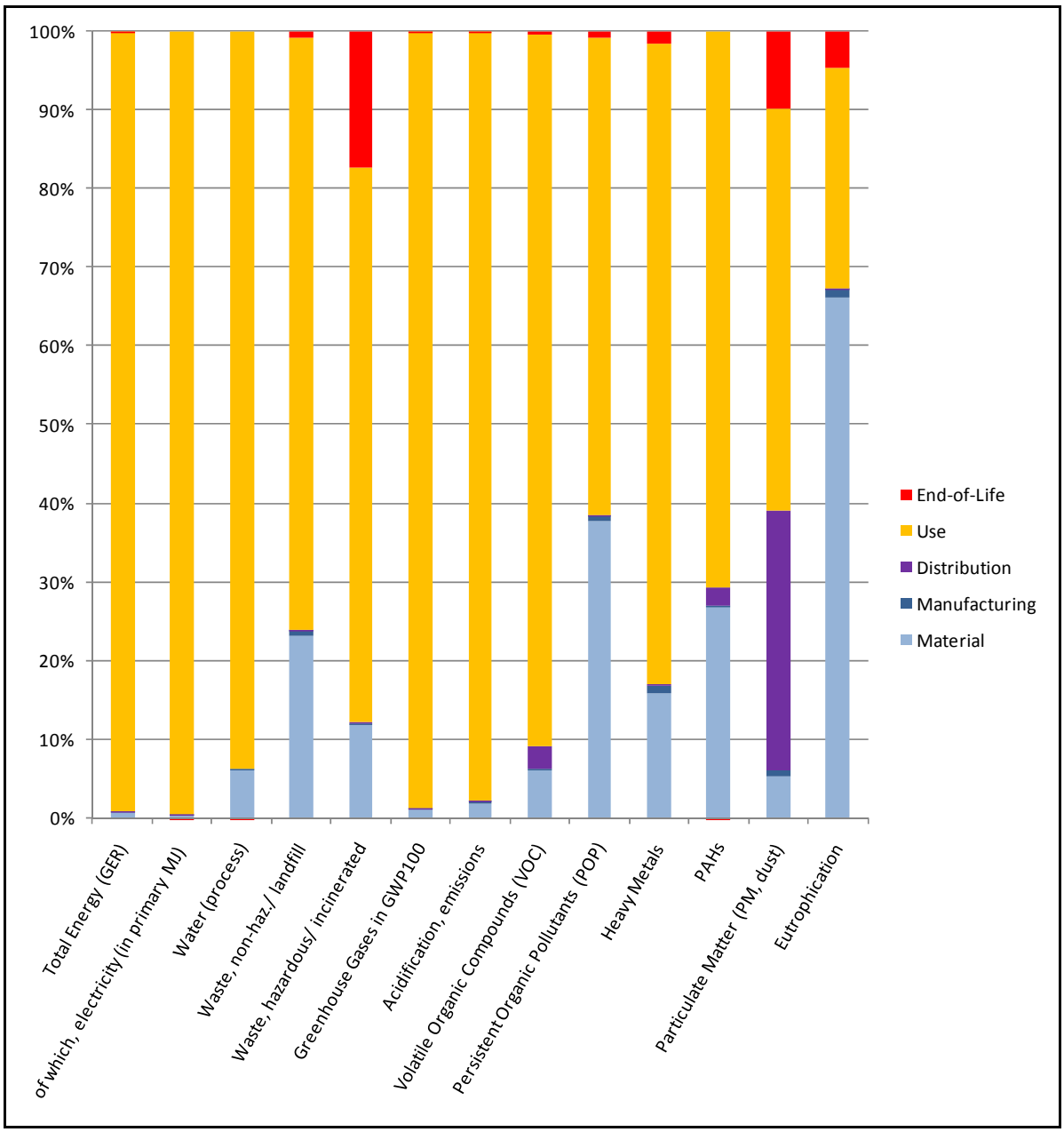


Figure 13 Distribution of environmental impacts of BC D5 per life cycle phase

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

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

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

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

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

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

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

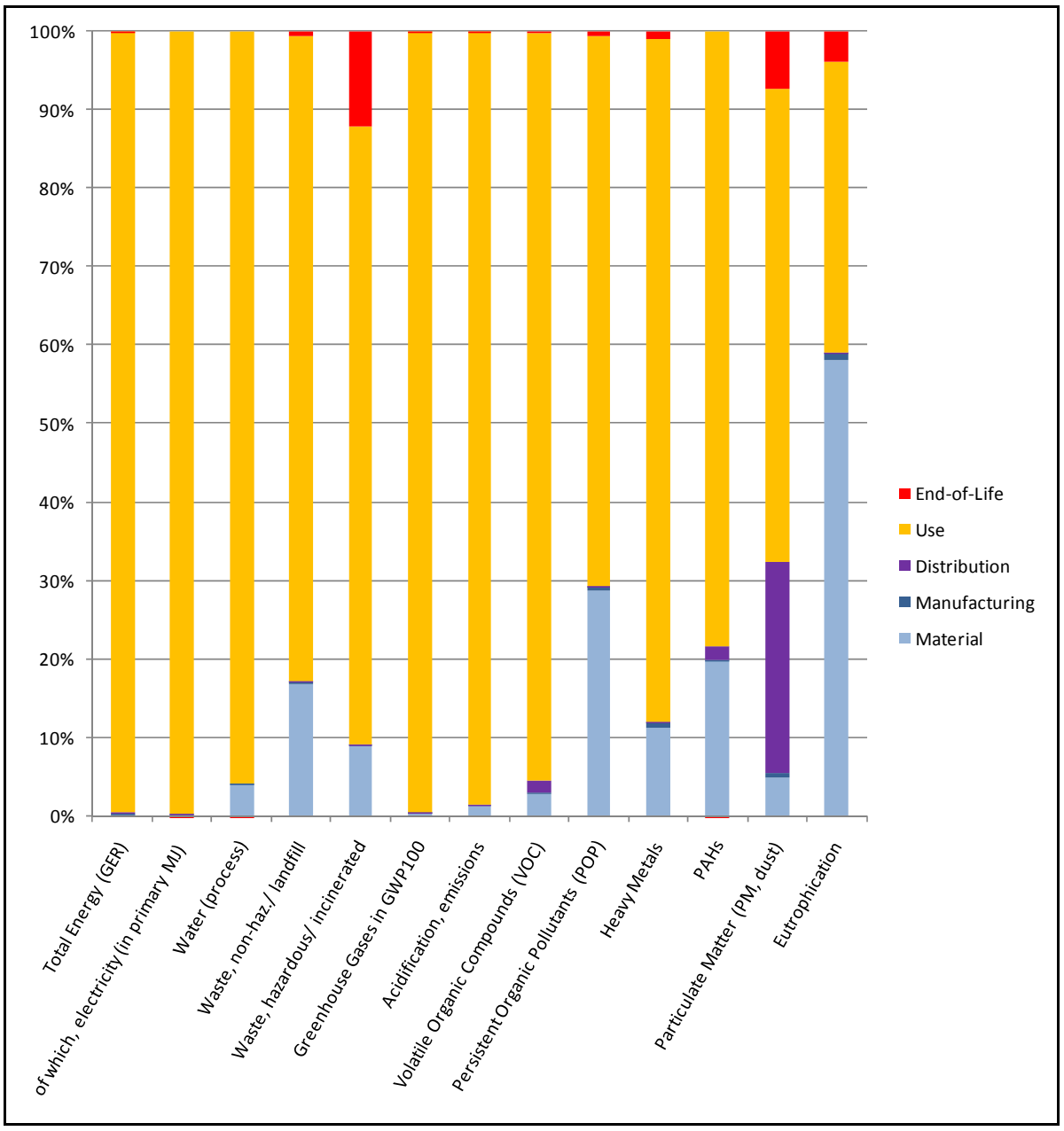


Figure 14 Distribution of environmental impacts of BC D6 per life cycle phase

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

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

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

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

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

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

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

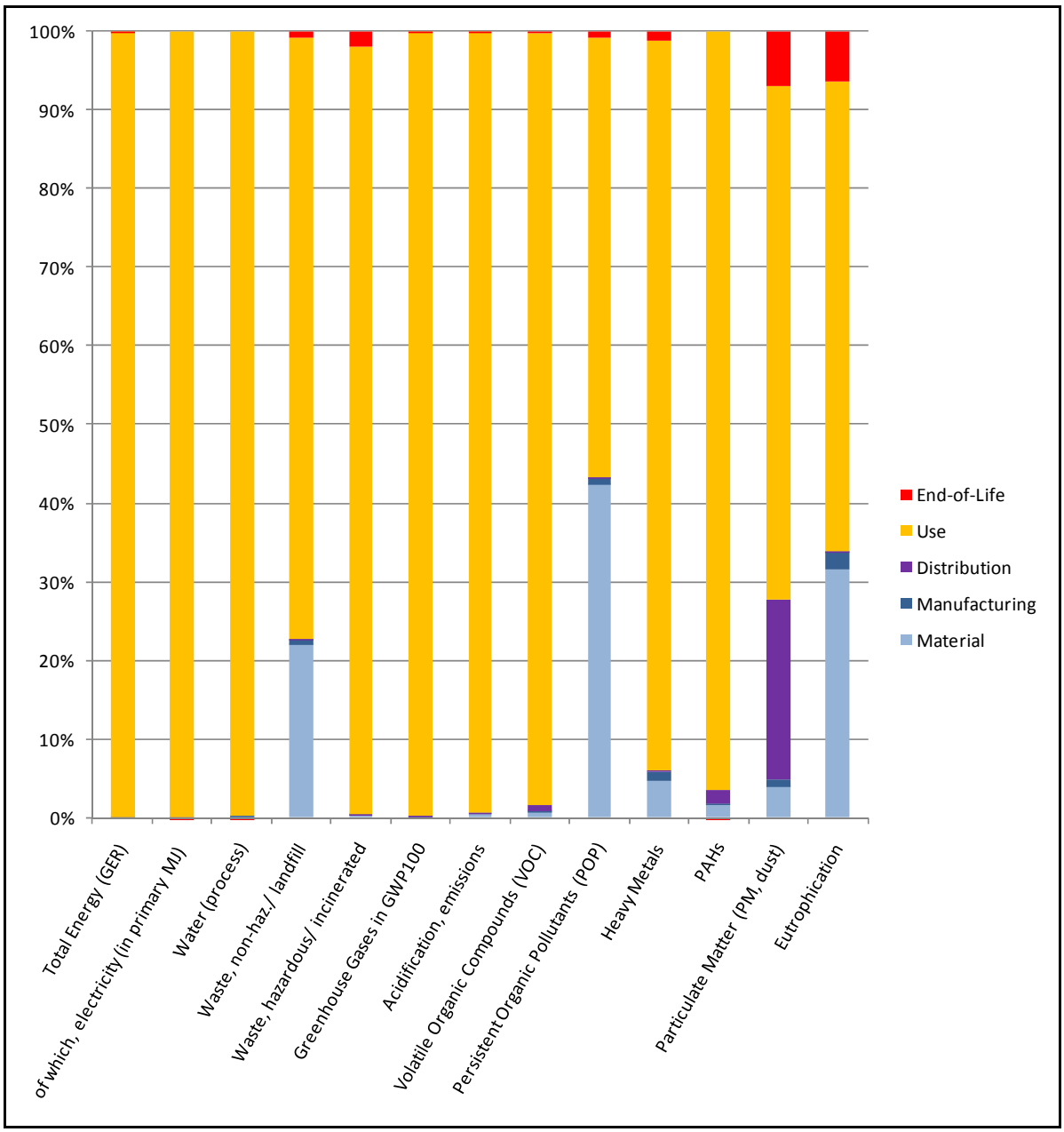


Figure 15 Distribution of environmental impacts of BC D7 per life cycle phase

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

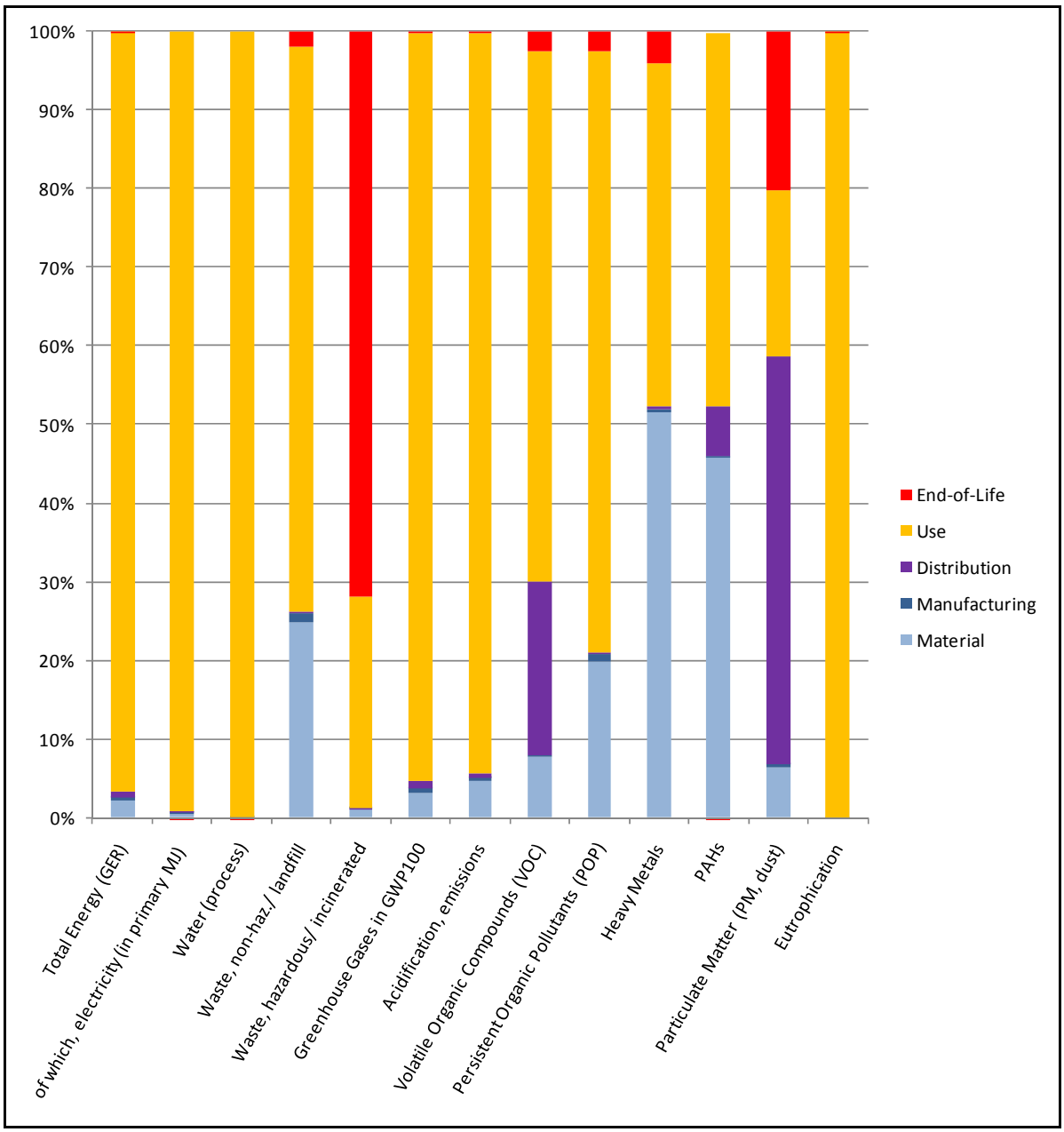


Figure 16 Distribution of environmental impacts of WM1 using only electricity for water heating, per life cycle phase

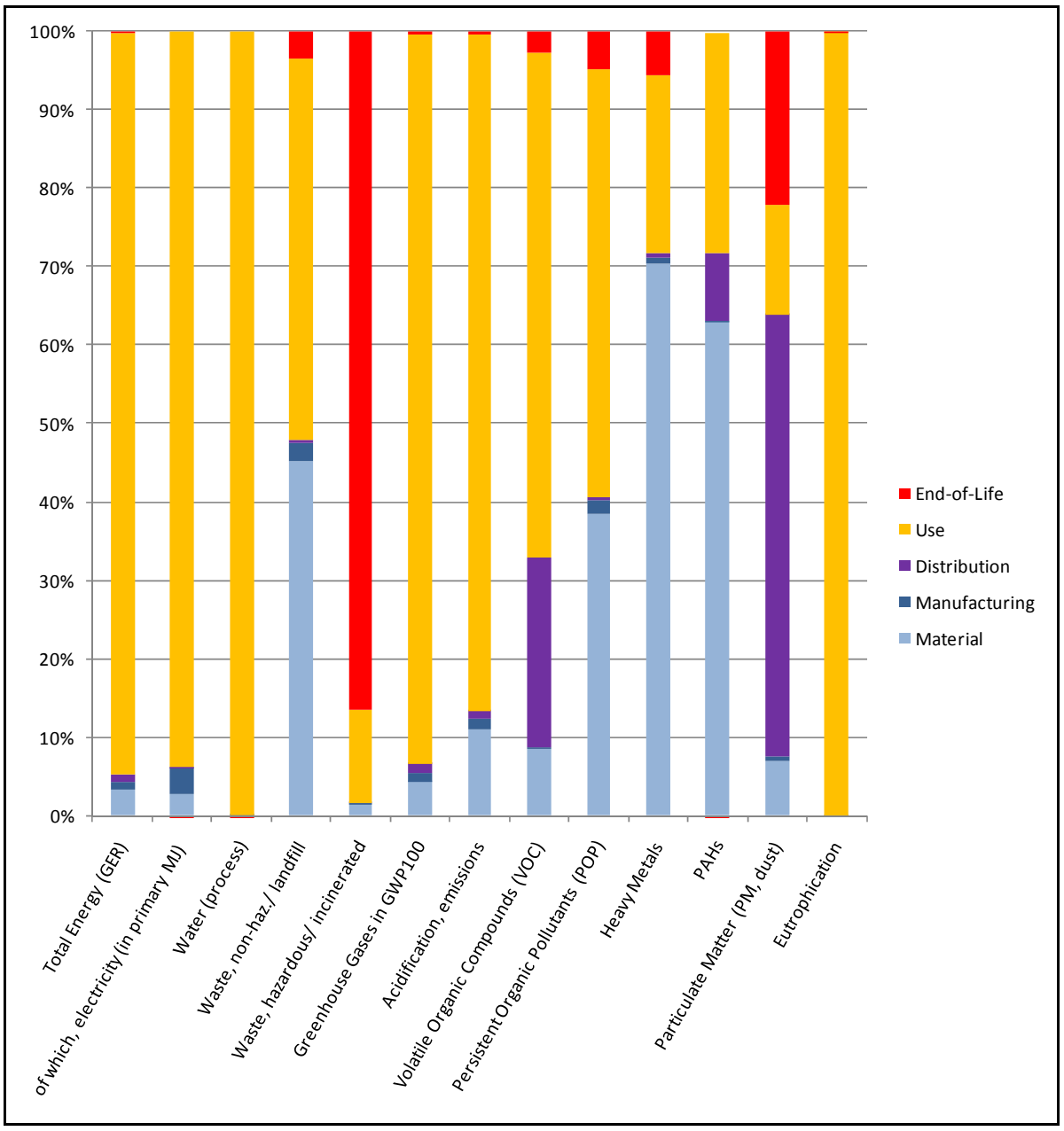


Figure 17 Distribution of environmental impacts of WM1 using only alternative energy source for water heating, per life cycle phase

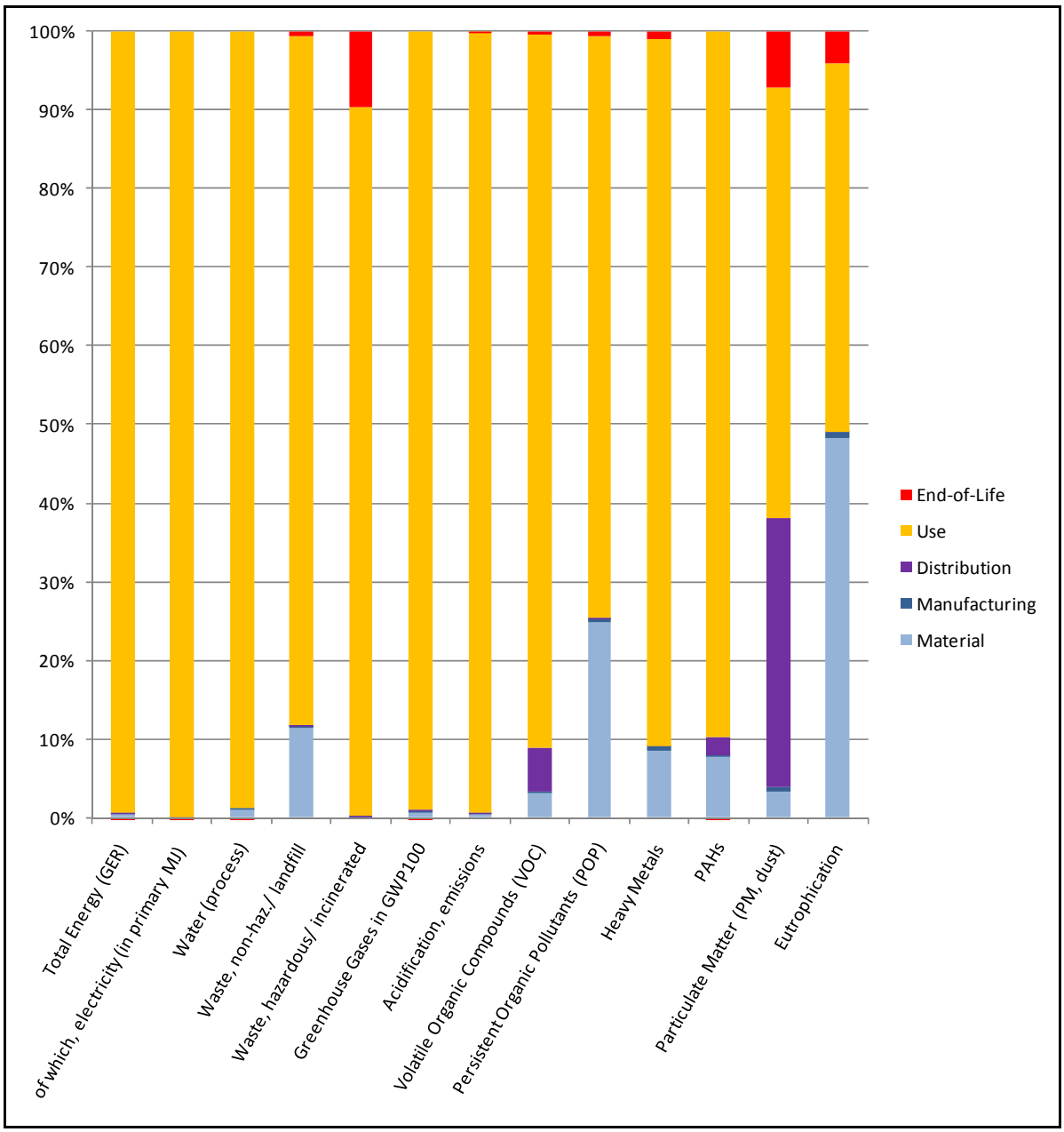


Figure 18 Distribution of environmental impacts of D4 using only electricity for water heating, per life cycle phase

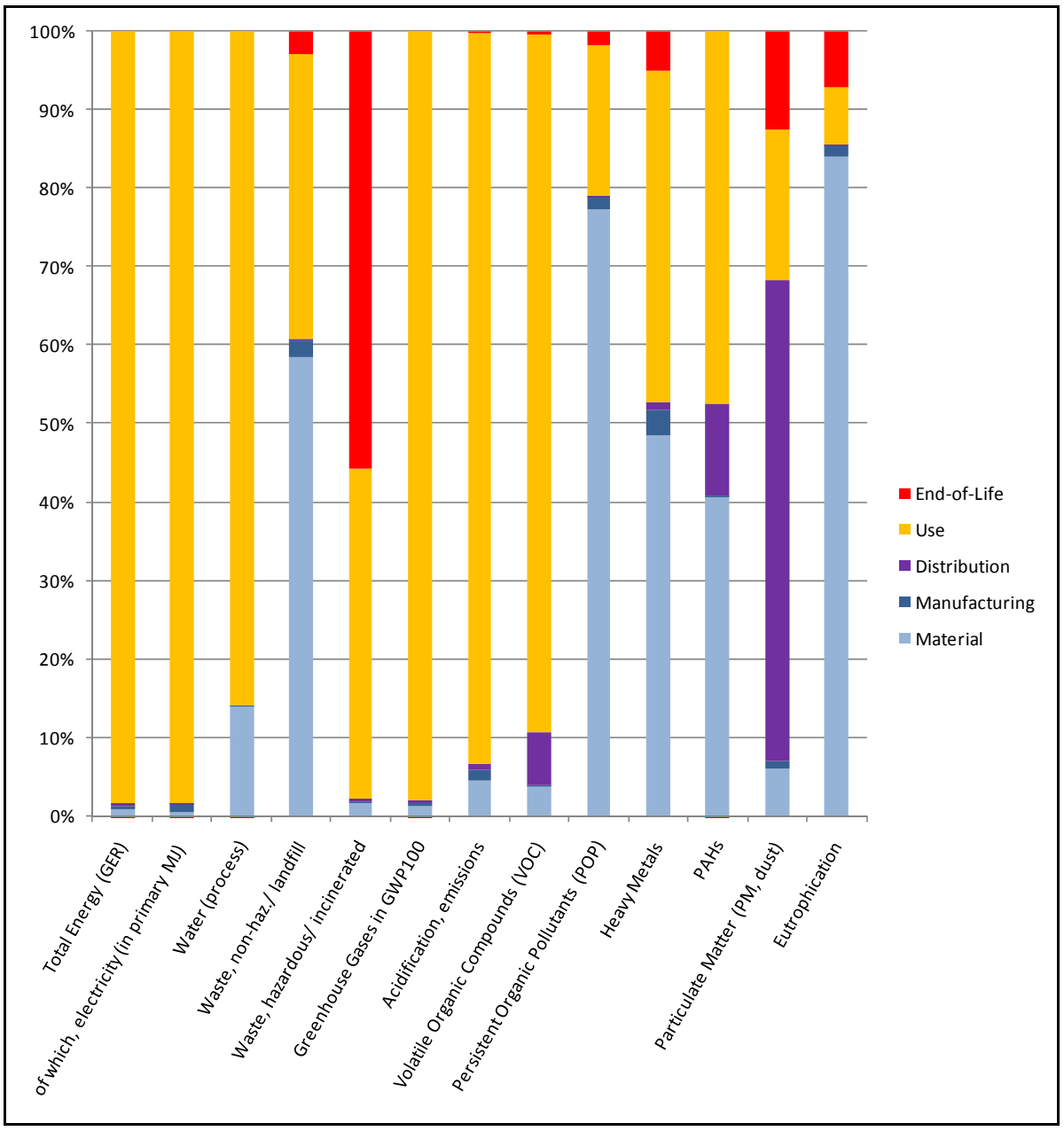


Figure 19 Distribution of environmental impacts of D4 using only alternative energy source for water heating, per life cycle phase

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

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

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

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

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

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

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

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

3.16 Summary by kg of laundry processed

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

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

Table 50 Impact of professional washing machines per kilogram of laundry

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

Table 51 Impact of professional dryers per kilogram of laundry

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

3.17 Conclusions

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

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

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

use phase. The differences in the results of these studies concern the total of energy and emissions generated. Professional machines consume more overall due to the intensity of use and therefore produce more emissions.

4 Base case life cycle costs

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

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

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

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

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

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

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

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

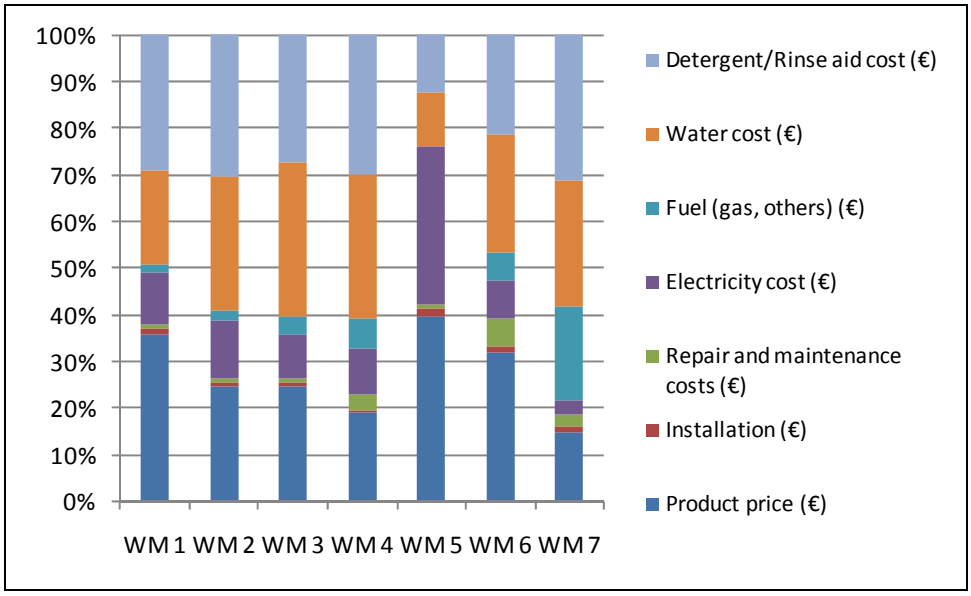


Figure 20 Breakdown of professional washing machines base cases' LCC

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

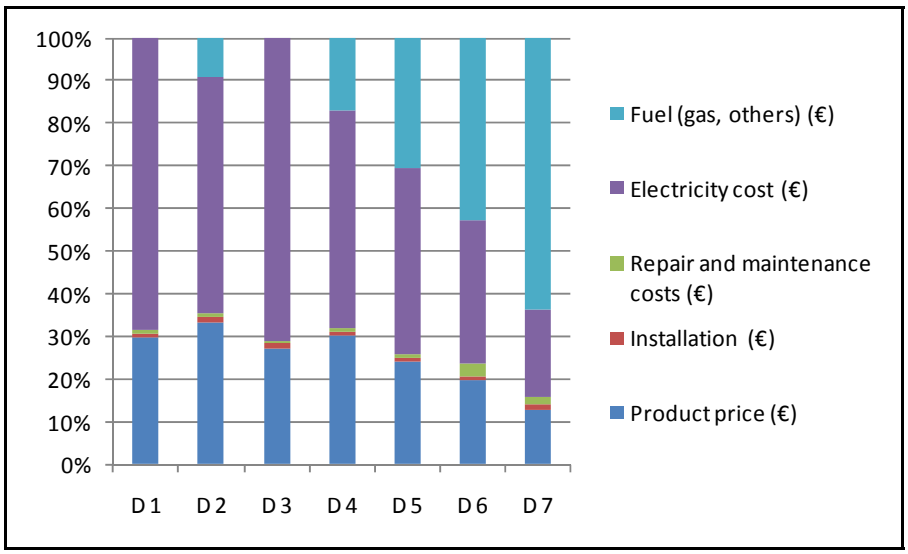


Figure 21 Breakdown of professional laundry dryer base cases' LCC

Table 54 Expenditure cost proportion for professional washing machines

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

Table 55 Expenditure cost proportion for professional dryers

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

5 EU totals

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

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

5.1 Market data

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

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

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

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

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

5.2 Life cycle environmental impacts

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

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

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

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

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

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

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

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

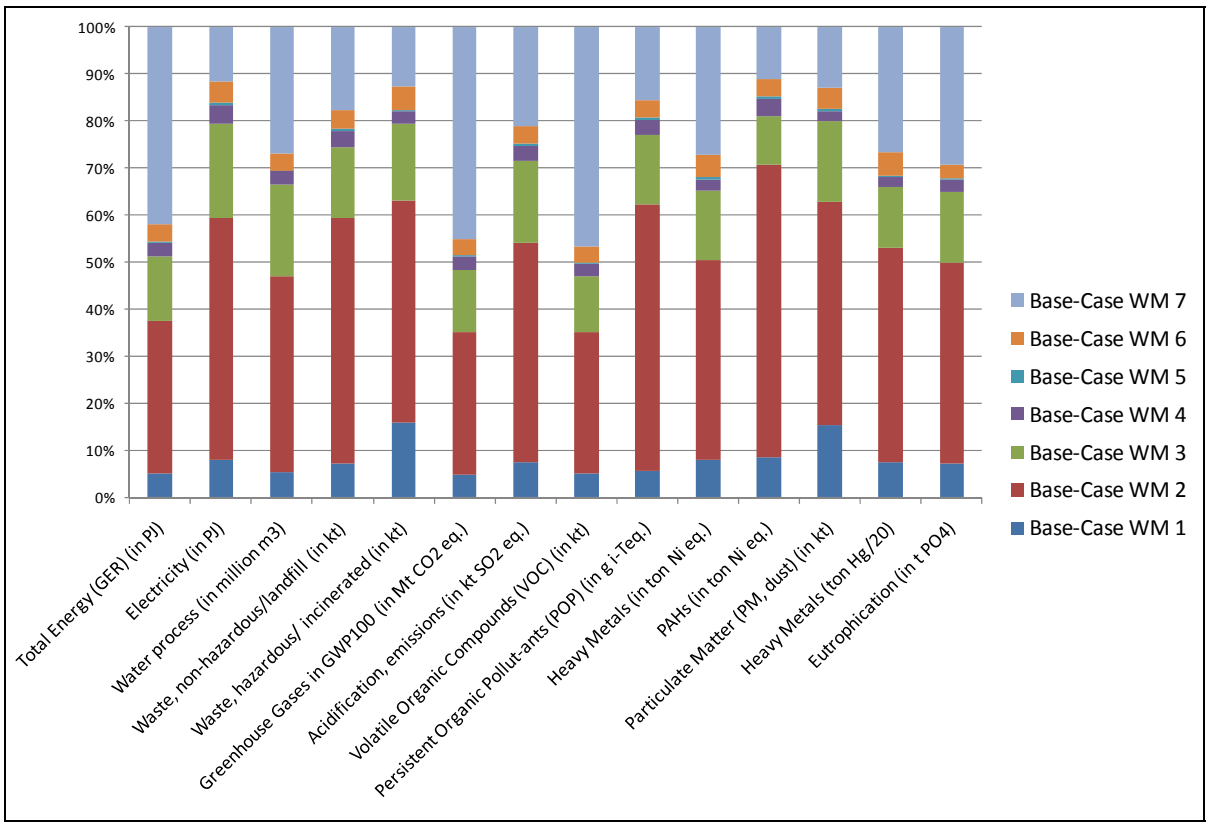


Figure 22 Professional washing machine base cases' share of the environmental impacts of the 2009 stock

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

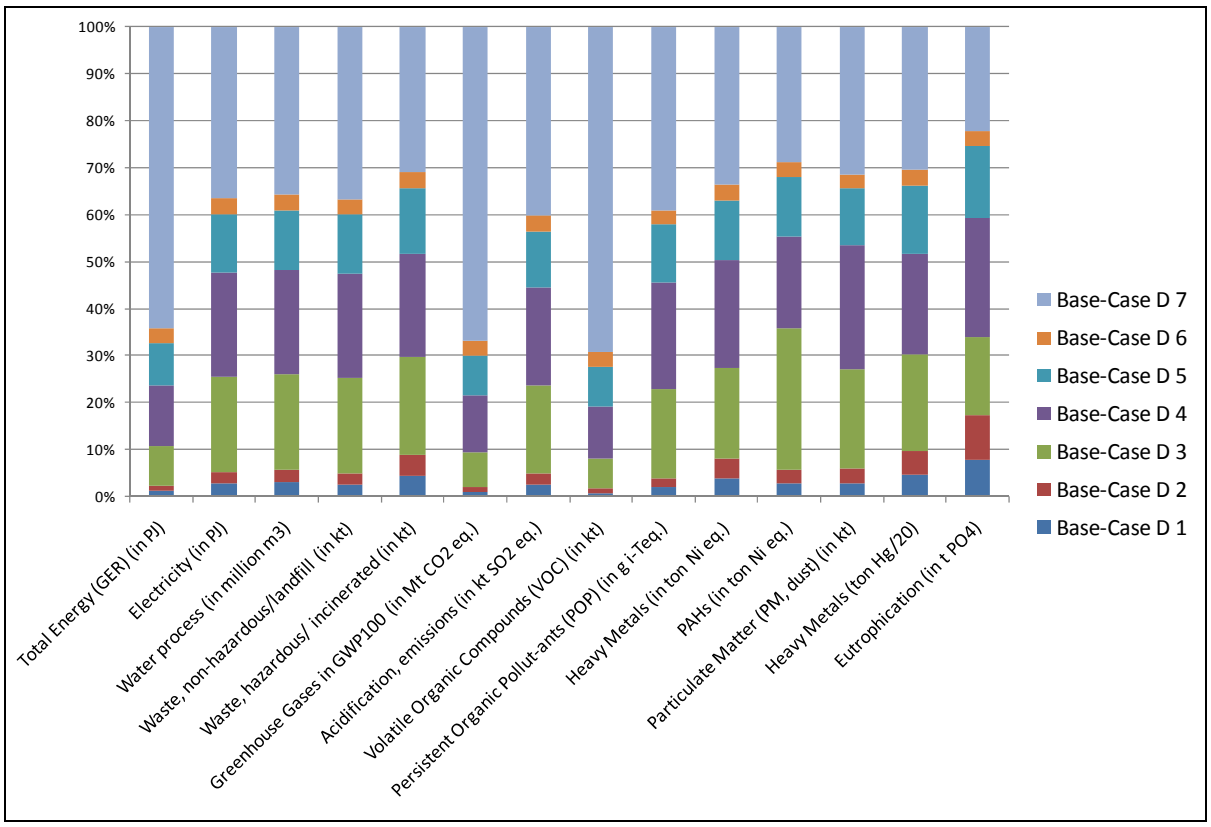


Figure 23 Professional dryer base cases' share of the environmental impacts of the 2009 stock

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

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

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

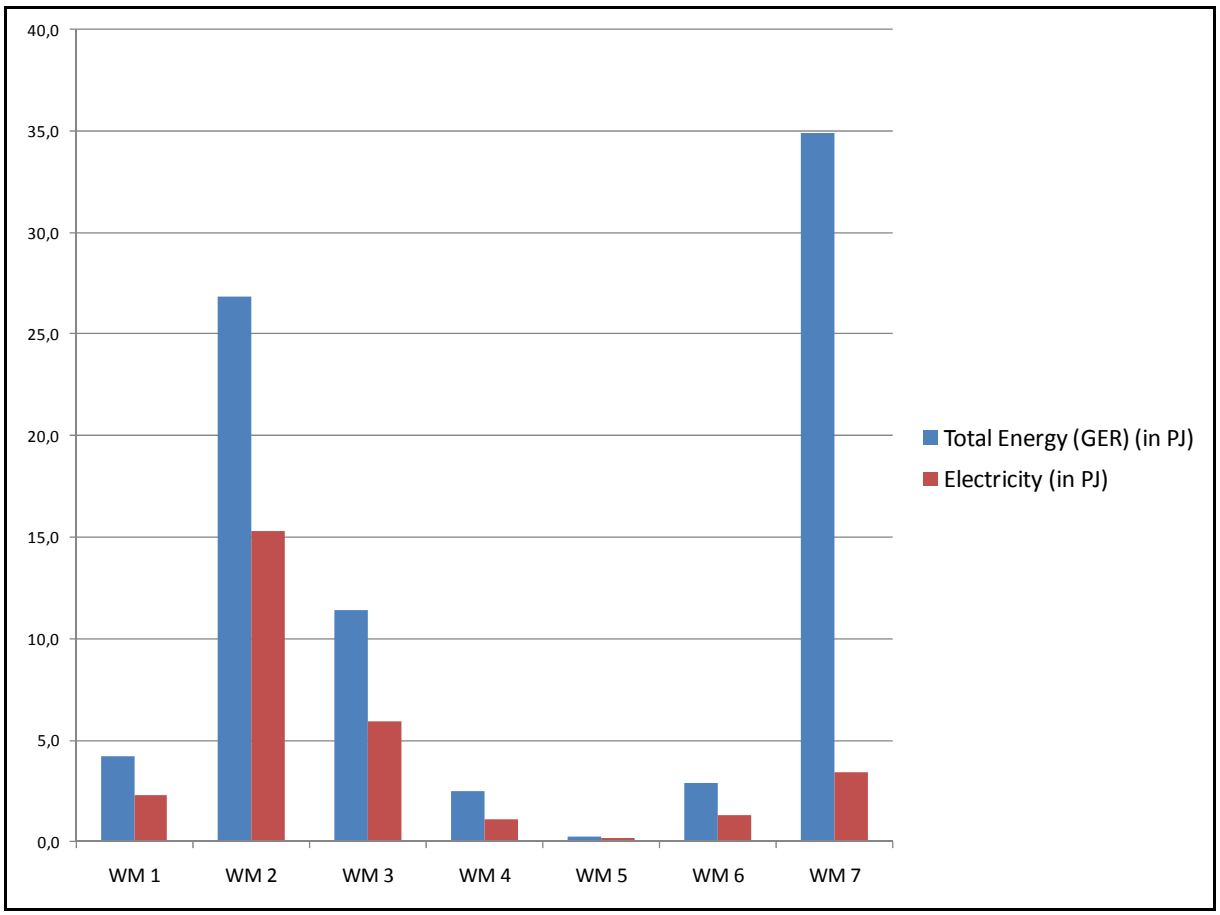


Figure 24 Energy/electricity consumption of the 2009 stock, per washing machine base case

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

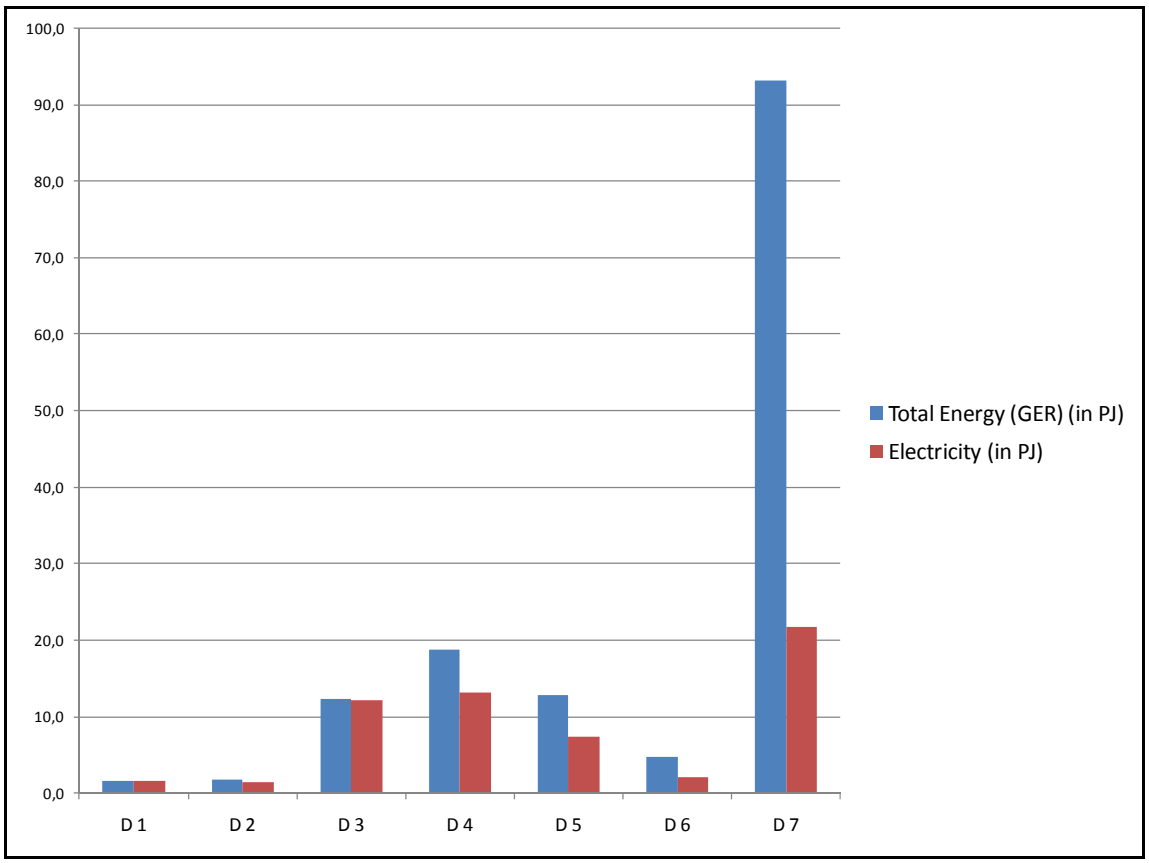


Figure 25 Energy/electricity consumption of the 2009 stock, by dryer base case

5.3 Life cycle costs

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

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

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

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

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

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

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

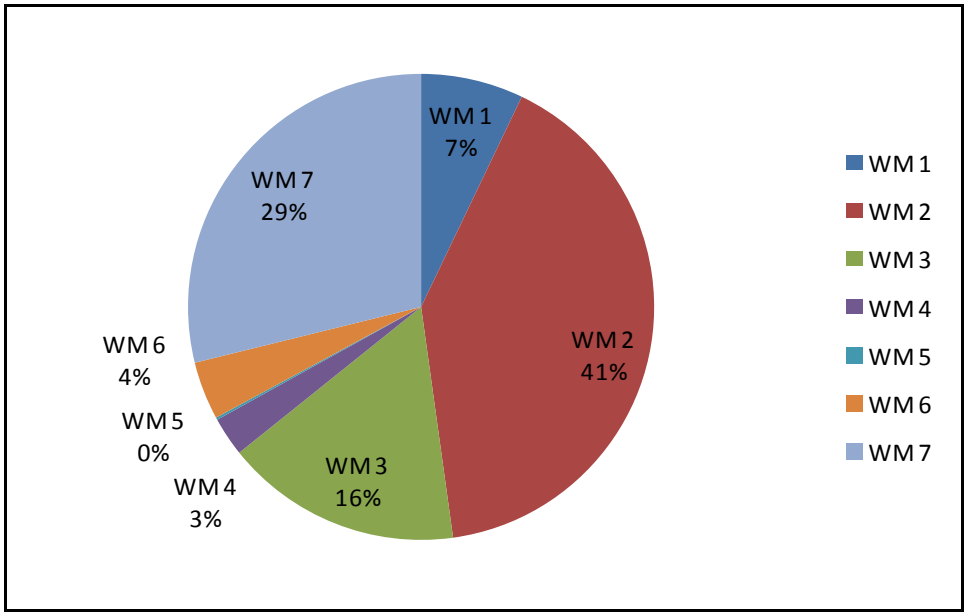


Figure 26 Base cases' share of the total consumer expenditure for professional washing machines in 2009

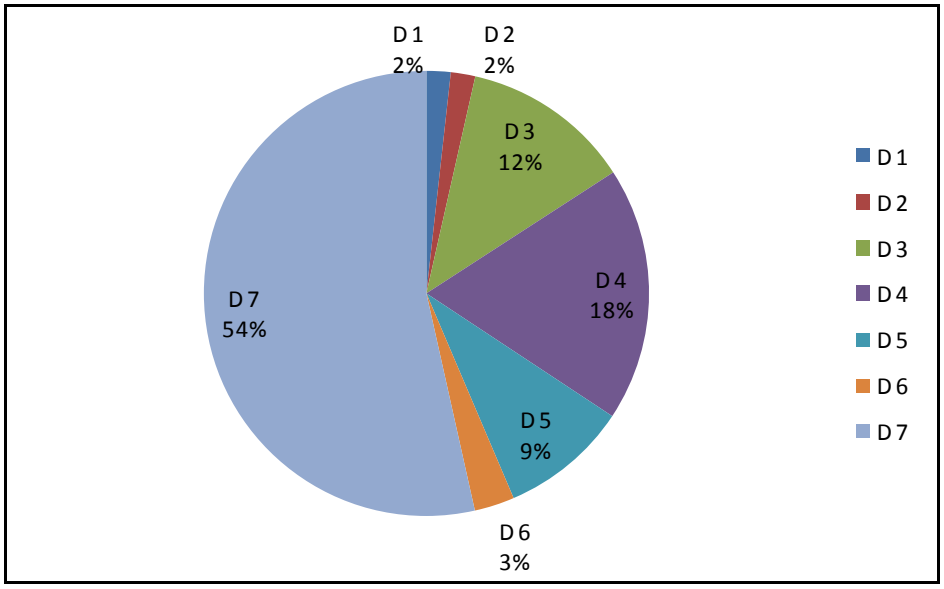


Figure 27 Base cases' share of the total consumer expenditure for professional dryers in 2009

6 EU-27 total system impact

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

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

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

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

7 Conclusions

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

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

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

8 Annex

8.1 Detailed bills of materials of the base cases

Bill of material of Base case WM1

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Stainless Steel	20606.0	3-Ferro	**25-Stainless 18/8 coil**
2	Steel Sheet galvanized	564.0	3-Ferro	**21-St sheet galv.**
3	Cast Iron	11192.0	3-Ferro	**23-Cast iron**
4	Polypropylen (PP)	8021.0	1-BlkPlastics	**4-PP**
5	Polyamid (PA)	94.0	2-TecPlastics	**11-PA 6**
6	Polycarbonate	190.0	2-TecPlastics	**12-PC**
7	Epoxy	260.0	2-TecPlastics	**14-Epoxy**
8	Acrylonitrile Butadiene Styrene (ABS)	1145.0	1-BlkPlastics	**10-ABS**
9	Plystyrene (PS)	678.0	1-BlkPlastics	**5-PS**
10	Polybutylene Terephthalate (PBT)	8.0	1-BlkPlastics	
11	Polyvinylchlorid (PVC)	221.0	1-BlkPlastics	**8-PVC**
12	EPDM-rubber	1752.0	1-BlkPlastics	**1-LDPE**
13	Plastics others	1101.0	1-BlkPlastics	**2-HDPE**
14	Aluminium	2233.0	4-Non-ferro	**26-Al sheet/extrusion**
15	Cu wire	1305.0	4-Non-ferro	**29-Cu wire**
16	CuZn38 cast	99.0	4-Non-ferro	**31-CuZn38 cast**
17	Chrom	176.0	4-Non-ferro	
18	Bitumen	38.0	7-Misc.	**55-Bitumen**
19	Concrete	18205.0	7-Misc.	**58-Concrete**
20	Glass	1773.0	7-Misc.	**54-Glass for lamps**
21	Wood	2452.0	7-Misc.	**56-Cardboard**
22	Electronics (control)	165.0	6-Electronics	**98-controller board**

Bill of material of Base case WM2

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

Bill of material of Base case WM3

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

Bill of material of Base case WM4

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

Bill of material of Base case WM5

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

Bill of material of Base case WM6

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

Bill of material of Base case WM7

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

Bill of material of Base case D1

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

Bill of material of Base case D2

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

Bill of material of Base case D3

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

Bill of material of Base case D4

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

Bill of material of Base case D5

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

Bill of material of Base case D6

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

Bill of material of Base case D7

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

8.2 Additional questionnaire to stakeholders

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

EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

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Final Report, Part:
Washing Machines and Dryers

Task 6: Technical Analysis
Best Available Technologies

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For reasons of better readability, two Task 6 reports were prepared.

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

The Task 6 report on *professional dishwashers*
is published separately.

For the benefit of the environment, this document has been optimised for **double-sided printing**.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective of Task 6

Task 6 entails a technical analysis not of current products on the market but on currently available technology, expected to be introduced at product level within 2 to 3 years. It provides input for the identification of the improvement potential (Task 7), i.e. especially relating to the best available technology. Therefore, objective of Task 6 is to describe the principal design options for improving the efficiency and environmental performance of professional washing machines and dryers. The technical analysis carried out in Task 4 serves as an input for this purpose.

1.2 Methodology and assessment of data quality

The information used in this report was gathered from a number of different sources. Based on a questionnaire (see Annex 5.1) important inputs were provided by major European manufacturers (see also Task 3). Other sources as data sheets and research studies were also analysed. These sources permit a detailed insight into the current state of the art in professional laundry equipment technology. Stakeholders also contributed to the assessment of not yet available technology due to their own research and development efforts.

We start the technical analysis of best available technologies with a general overview over the energy flows and losses of professional washing machines and dryers (see Sections 2.1 and 3.1). This analysis provides an initial insight into the environmentally most important areas and improvement potentials.

In Sections 2.2 and 3.2, several design options are described at component and product level leading to a reduction in water and energy demand during the use phase.[1] Additionally, state-of-the-art product technology outside the EU has been analysed. In order to analyse possible trade-offs through additional environmental impacts in the production, distribution or end-of-life phase, the differences in material composition between a standard product and a product with integrated design option(s) are presented for each design option. Further, we provide a rough estimation of the proportion of the respective BAT options already being implemented. These best available technologies in the areas identified for improvement as well as indicative quantitative data were derived from manufacturers' brochures supplemented by personal communication with and input from manufacturers based on a questionnaire.

[1] As the detergent consumption is related to the water consumption, a reduction in water consumption thus also leads to a decreased detergent consumption.

In Sections 2.3 and 3.3, we describe which combinations of different best available technologies are possible and which design options are actually applicable to the different washing machine and dryer types (as many, but not all of the listed improvement options can be used within every category).

Moreover, we looked for best not yet available Technologies (BNAT) which are currently not introduced in the market but under development (e.g. in a prototype stage).

After these more general analyses of several possible design options, in Sections 2.4 and 3.4 we asked manufacturers to describe the components of currently best available products on the market for each washing machine and dryer category.

Important note: Assessment of data quality throughout Task 6 report

It is important to note that all information with regard to the saving potential of improvement options should be seen in the following context:

- There are no commonly applicable European standard measurement methods for quantifying the energy and water consumption of **professional washing machines and dryers**, and there are likewise no eco-design or efficiency minimum requirements or a labelling scheme requiring manufacturers to define the measurement procedure for potential savings (see Task 1).
- Energy, water and detergent (the latter only for washing machines) savings depend on many different factors such as: ambient air temperature and humidity, water temperature, type of laundry textile, condition of soiling, type of machine, customer segment, type of energy heating and, last but not least, the base case or reference case to which savings are compared.
- Little or no systematic independent research is carried out on the potential saving impacts of improvement options.
- Manufacturers use varied terms for their improvement options and assess their innovative systems to their competitors in different ways.
- The figures in sales brochures are usually used for marketing purposes and therefore might over-estimate the actual savings.
- Quantitative data provided by manufacturers with regard to the savings potentials are only rough estimations.
- Due to the above reasons, estimations and quantitative data of the different manufacturers to some extent diverge considerably. Therefore, the data presented in the Task report at hand are average values of the responses and inquiries.

2 Professional washing machines

2.1 Main areas of environmental improvement potentials

The factors influencing the energy consumption of professional washing machines can be mainly subdivided into energy for heating the water, and energy for mechanical action and the functioning of other electronic components. Approximately 90% of the energy consumed can be allocated to the heating of the water (compared to around 10% electricity used for the motor and electronic components).[2] The energy necessary for mechanical action depends on the total washing time. The energy necessary for heating the water is influenced by the amount of water, the wash load, and the temperature difference between the cold water inlet and the washing temperature to be reached. The entire washing cycle can be divided into the following phases:

1. Water (+ detergent) intake;
2. Heating (to the set water temperature);
3. Pre-wash phase (temperature depending on the kind of soiling);
4. Main wash phase (temperature depending on the kind of soiling and the temperature of the pre-wash phase: For instance, the test cycles defined in ISO 9398-4:2003(E) require temperatures between 60 - 85°C);[3]
5. Rinsing phase (with cold water);
6. Neutralisation (reduction of textile pH-value for the purpose of preventing a yellowing effect during the drying or ironing process by addition of laundry aids like e.g. starch, textile softener, acid);
7. Final spinning phase (extraction of water from the laundry).

Water acts as heating medium, transport medium and solvent for the detergents and soil, and as wetting agent for the textiles.[4] It is a main component of the washing process and is used for the pre-wash, main wash and rinsing phase. For the washing process, only the pre- and main wash phases operate with warm or hot water. Although the rinsing phase needs the highest amount of fresh water, this phase is using cold water. Contrary to professional dishwashers, where the final rinse of the washware requires the highest temperature (usually between 80 and 85°C) to accelerate the following drying period for the items.

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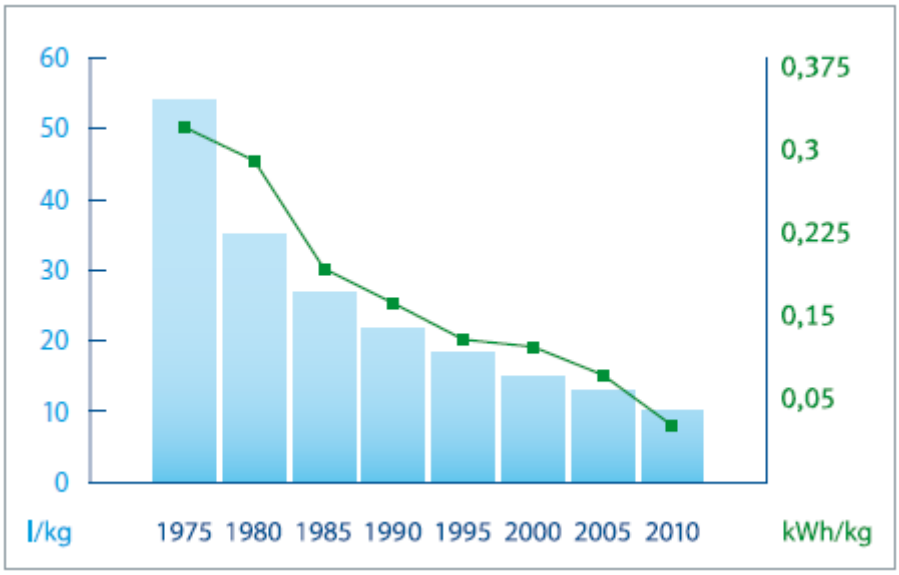
2 For details, see Task 4, section ratio of energy use.

3 This temperature is not fixed for the categories WM4, WM5 and WM7; however, a thermal disinfection requires a temperature > 85°C

4 http://www.laundry-sustainability.eu/en/html/module_1__water.html

During the washing process, the energy used to heat the water also flows to other parts of the machine, for example to the steel drum or the glass door. The major part of this energy, however, is lost to the environment. These heat losses depend, for example, on the temperature of the heated water, the insulation of the machine, and the ambient temperature. In contrast to professional dishwashers, where energy losses due to absorption of heat by the wash ware play a significant role, this fact is negligible for washing machines with regard to heat absorption by the washed laundry. Consequently, the greatest improvement potential for professional washing machines lies in the reduction of energy for heating the water in the pre- and main wash phases.

Figure 1 shows the development of the water and energy consumption of professional washing machines over the past decades; it reflects that a major reduction has already been realised. For example, professional appliances of Schulthess[5] that used more than 50 litres per kg laundry around 30 years ago, now only use about 10 litres or even less per kg laundry (see Figure 1 further information in Task 2) mainly achieved by solutions for the re-use of rinsing water. Compared to current appliances in the stock, manufacturers expect further possible reductions of the overall water consumption in the coming years (cf. Task 2).



(Source: Schulthess)

Figure 1 Development of the water and energy consumption of commercial appliances from the Swiss manufacturer Schulthess (this figure is comparable to categories WM2 and WM3)

There are no specific options listed with regard to the reduction of the detergent consumption. From the perspective of laundry operators, a sole reduction of the detergent consumption is not reasonable as optimal *concentration* of the detergent is needed to reach the desired cleaning result. The detergent concentration depends on the overall amount of water

5 http://www.schulthess.ch/de/produkte/gewerbe-industrie.html

used for the cleaning process. Thus, the detergent consumption is correlated to the water consumption, and the consumption of detergents will decrease if the overall water consumption can be reduced. Furthermore, according to A.I.S.E,[6] there are some market trends promoting a reduced consumption of detergents:

- Suppliers of detergents for professional applications place emphasis on the improvement of formulae and avoidance of components with a high environmental impact. To keep the use of raw materials in the washing process to a minimum, a great variety of detergent products is offered, by adjusting the components of each product to the individual requirements of the various types of laundry. The mixture of different detergent components can be tailored to fit the customer's needs, thus avoiding chemical waste and unnecessary disposal into the environment.
- The institutional laundry detergent segment has developed towards a higher acceptance of concentrated detergents, both for granular and liquid detergents. This development has moved forward faster in the last few years and is expected to continue.
- The industrial laundry market uses mostly concentrated granular detergents and liquids. 'Paste-type' products or anhydrous liquids can also be found. The use of concentrates reduces the amount of packaging and of chemicals (mainly bulking agents) and therefore the total environmental impact of a product (cf. Task 4). However, highly concentrated products necessitate adapted dosage behaviour, as the dosage units (volume, weight) differ compared to conventional detergents.
- Finally, there is a trend towards lower wash temperatures and a shorter cycle duration. At lower temperatures, a special composition of detergents is needed to be applied for the same high level of cleaning and to guarantee hygiene.
- Enzyme applications have increased in recent years since research developments have allowed their use for very diverse applications. The largest reduction in environmental impact that enzymes have contributed to, is the lowering of wash temperatures with corresponding energy savings. In order to tailor the use of chemicals to the specific needs of commercial and industrial applications, enzymes are mainly used as boosters. Enzymes are needed in order to carry out high chemical reactions under mild conditions (temperature, pH).

The following description of technological improvement options is structured according to the following categories:

- Design options considered best available technology (BAT),
- Improvement options outside EU,
- Best not yet available technologies (BNAT).

[6] International Association for Soaps, Detergents and Maintenance Products

2.2 Best available technologies at component and product level

In this section, first the state of the art at component level will be described. The best available technologies in the areas identified for improvement as well as indicative quantitative data were derived from manufacturers' brochures supplemented by personal communication with input from manufacturers based on a working paper (see Annex 5.1).

2.2.1 Design options

In general, the market has changed towards professional washing machines with reduced energy and water use in recent years (cf. Task 2 – market trends). These reductions in energy and water are caused by several technological features like optimal mechanical action or innovations such as new control or management systems for improving the efficiency and environmental performance. The most relevant technological options are described below.

2.2.1.1 Description of the design options

M 1.1 Increased motor efficiency

An option to reduce the energy consumption of the professional washing machine is to enhance the efficiency of the motor. Consistent with other appliances, washing machine manufacturers are continuously looking for methods to improve the operational efficiency while simultaneously reducing costs. In the past, various types of motors have been used in washing machines whereas nowadays nearly all machines use a three phase alternating current (AC). According to stakeholders, especially for the larger washing machine categories (WM4 and WM7), a three-phase system is more economical compared to a single- or two-phase system or a direct current motor (being more efficient for household washing machines) at the same voltage.[7] Although the heavier machines of WM4 and WM7 require more power for starting the filled drum, the three-phase motor is more efficient due to the fact that it requires less conductor material to transmit the electric power. According to the stakeholders, no further saving potential could be realised with another motor technology.

Another option to optimise the motor would be to use less amount of construction material. Although this has no direct impact on the energy or water consumption of the washing machine, it reduces the overall material composition of the machine and the costs for manufacturers and customers. Furthermore, an optimised motor can lead to a reduction of machine vibrations and noise emissions.

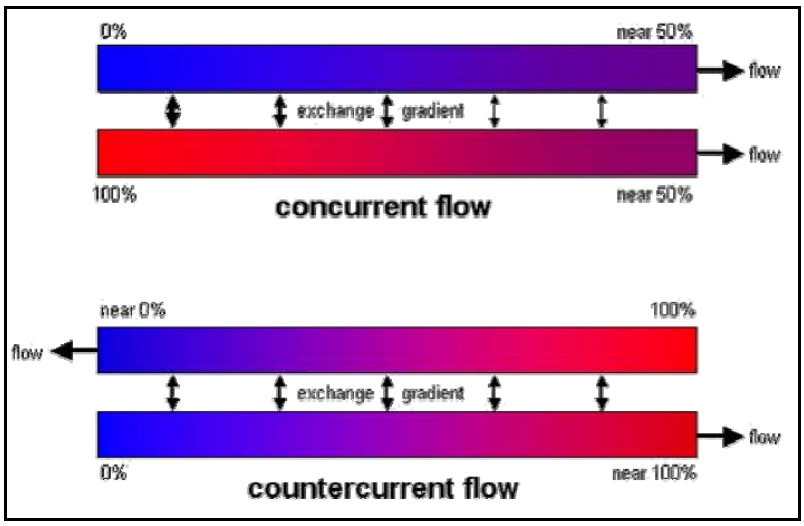
[7] http://www.allaboutcircuits.com/vol_2/chpt_10/2.html

The European Commission has recently taken steps to further regulate the energy performance of electric motors;[8] however, these requirements currently do not apply to professional washing machines. The Regulation No. 640/2009/EC is not applicable to motors completely integrated into a product (for example gear, pump, fan or compressor) and whose energy performance cannot be tested independently from the product.

M 1.2 Heat exchanger

Depending on the pre-wash temperature, approximately 10-40% of the energy can be recovered by using a heat exchanger. Two different alternatives of the flow can be distinguished: "concurrent flow" and "counter current flow". As for a concurrent flow system, warm and cold liquids flow along the heat exchange surface in the same direction. In the counter current heat exchanger, hot and cold liquids flow along the separation wall in opposite direction. The energy loss of the counter current heat exchanger is significantly lower compared to that of a concurrent heat exchanger, as a larger proportion of the heat of the warmer liquid is transmitted to the colder liquid.

The principle of a heat exchanger is illustrated in Figure 2.



(Source: Laundry Sustainability)

Figure 2 Concurrent and counter current flow in heat exchangers

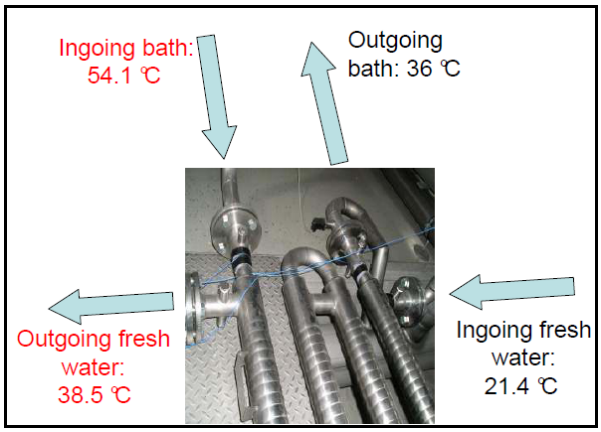
The different flow characteristics depend on the flow speed, the flow rates and the viscosity of the liquid (expressed in the so called Reynolds number[9]). As flow speed and flow rates are limited, turbulences.might occur in the heat exchanger leading to a reduced heat transfer.

[8] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:191:0026:0034:EN:PDF

[9] The Reynolds number is a dimensionless number a measure of the ratio of inertial forces to viscous forces

On the market, there is a variety of heat exchanger types with different technical and economic advantages and drawbacks. The following construction types of heat exchangers are mainly used in laundry equipment:

- Shell and tube heat exchanger;
- Corrugated pipe heat exchanger (see Figure 3);
- Plate heat exchanger;
- Rotating discs heat exchanger;
- Panel heat exchanger.



(Source: Laundry Sustainability)

Figure 3 Corrugated pipe heat exchanger of Kannegiesser

M 1.3 Water recovery systems

Washing machines with a water recycling system collect the wash water from all previous rinse cycles for a re-use in the next prewash and main wash cycle, thus decreasing the amount of fresh water required.

This system consists of a filter unit cleaning the water of coarse impurities. The water filtrate is then heated to operating temperature ready for the use in the prewash and main wash cycle. Fresh water is only needed for the rinse cycle.

Figure 4 shows a water recovery module that can be installed optionally on the washing machine.



(Source: Miele)

Figure 4 Washer extractor with an additional water recovery module

Figure 5 presents a similar system with several recirculation tanks for washer extractors.

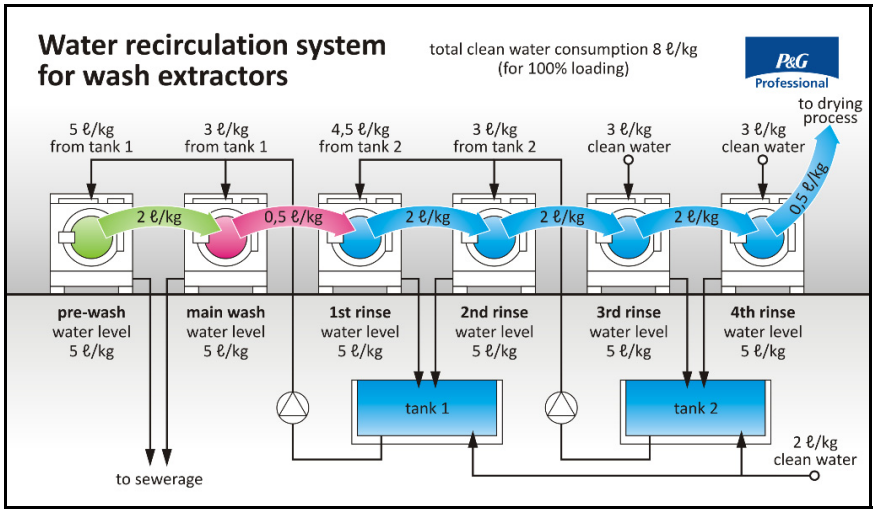


Figure 5 Various washer extractors in a water recirculation system [10]

This design option is often used in washing tunnel machines (WM7). Through a “balanced water management system” wash water is recycled and reused from previous wash cycles to decrease the amount of new required (hot) water. The water quality from the extraction process (i.e. press machine or centrifugal machine) is sufficient for rinsing the laundry, and the water quality from rinsing is sufficient for the pre- and main wash.

[10] http://www.pgprof.info/Water-and-energy-saving.html

M 1.4 Load control

Partial load of washing machines causes additional energy, water, and detergent consumption (cf. Task 3) when evaluated on the basis of a per kg laundry.[11] Sensor technologies (e.g. through an automatic weighing-machine or an algorithm based on the motor speed) can be implemented to evaluate the real load weight and consequently adapt the amount of water, detergent and time. For example, according to A.I.S.E., the most advanced washer extractors are equipped with load cells which weigh each batch of wash ware and automatically adjust the water level and dosage of detergent/chemicals to that weight.

This design option may result in a reduction of water consumption and energy as less water has to be heated. The absolute saving potential depends on the difference between the machines' capacity size and real-life workload. Note that for cleaning half load, the relative water reduction is far less than 50%, thus even with load control sensors the washing process is not as effective as washing at full load.

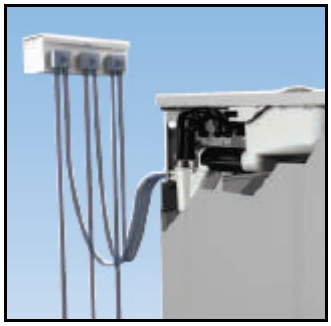
M 1.5 Further control systems

In terms of detergents, control systems are tailored as closely as possible to the specific requirements of individual users to minimise the generation of waste. Over-dosage directly increases the environmental impacts while under-dosage may lead to a non satisfactory result with regard to the cleaning performance, resulting in an additional washing cycle (which also leads to additional water, energy and detergent consumption). To reduce maloperation which depends on the respective consumer behaviour (e.g. in Coin & Card laundries, cf. Task 3), detailed dosage instructions might be given.

From the technical point of view, there is a broad variety of dispensers in the market to dose liquids, powders, pastes and even solids automatically. According to A.I.S.E[12], increasing use is made of sensors, which measure the amount of product actually dispensed, so that a central control unit is able to stop the dosing equipment as soon as the required detergent concentration is reached in the machine. The semi-automatic dosing devices of the 1970s and early 1980s in laundry equipment were based on flushing chambers or stock solutions, filled by hand and started by card systems in the washing machines. Card systems were simple mechanical readers that had to be changed and corrected by hand whenever changes to the washing process, used in the machine, were necessary.

[11] On average, the real-life workload – depending on the washing machine category – is assumed to be between 60 to 85%, resulting in additional consumption (energy: +10%; water and detergent: +20%; cf. Task 3).

[12] A.I.S.E. "Industrial and Institutional Sector – Environmental dossier on professional laundry" (2000)



(Source: Electrolux)

Figure 6 Automatic detergent dosing feature

Sensors to measure and regulate the dispensed amounts of detergents are not yet used everywhere. The quantity dispensed is still most commonly measured by the running time of the dosing equipment. For this it is necessary that the dosing unit delivers a constant amount of product per time unit. A variation in the quantity dispensed leads to over- or under-dosage. The sensors measure the amount dispensed and then send that information to a control unit.

A modern controlling system offers a number of additional functions that might also be able to contribute to the careful use of resources, e.g. pH- and conductivity-controlled dosage. Modern automatic control units are also able to dispense the required product quantity per litre of fresh water used. This is an important aspect, e.g. with regard to disinfection of the laundry or partial load of the machine, as in the case of conventional dosage, which is usually indicated for one kg of textiles, a suitable concentration of washing liquor might not be achieved. Further, most large industrial laundries have a central water softening system integrated in their infrastructure reducing the water hardness and therefore the requirement of "builders"[13] in the detergent formulation and/or the overall detergent dosage which is usually indicated for a certain hardness of water.

M 1.6 Ozone technology

Ozone works as bleaching agent (it kills bacteria 3 200 times faster than chlorine bleach[14]) at low temperatures and furthermore shortens wash time cycles so that potential energy and detergent savings are possible.

When using ozone technology in commercial laundering system, ozone must be dissolved into the wash water where the ozone breaks down by oxidation of $2O_3$ to $3O_2$. Thus, the main technical difference between a conventional washing machine and an ozone washing machine is the addition of a pump and piping loop. Water from the washer drum is circulated through this loop. Ozone laundry systems use an ozone generator and compressed air is forced through a high voltage electrical arc, which results in the conversion of oxygen

[13] Association Internationale de la Savonnerie, de la Détergence et des Produits d'Entretien (2000), Professional laundry and the environment

[14] http://www.schiff-consulting.com/Ozone_in_laundry_washing.html

molecules into ozone. The ozone is then dissolved in cold laundry wash water where it exerts its cleaning action. Ozone reacts with fatty and other soils attached to clothing, destroying them rapidly. Ozone is capable of degrading organic soil into compounds such as carbon dioxide and water.

There is a variety of ozone using solutions on the market as well as different methods for dissolving ozone into the wash water. The most common technologies are[15]

- Direct Water Injection – Ozone is directly dissolved into the cold water supply line by injection.
- Air Injection – Ozone gas is injected directly into the integrated drip pan of the washing machine. This approach could be applied also to a single ozone air injection system. Being a gas in solution, ozone penetrates and opens individual garment fibres, allowing faster cleaning and bleaching of garments with the use of fewer chemicals.
- Recirculation Injection – The rinse water is continually cycled back to the ozone system (generator) for re-oxidation of the rinse water and a predetermined amount of dissolved ozone is sent back to washer for sanitizing of the laundry.

The installation of ozone technology inside laundries requires particular water and steam quality to protect the material of the machines as well as special health and safety management aspects to protect workers potentially exposed to ozone[16] (e.g. sensors and detectors continually monitoring the exposure levels of ozone within the laundry room).

The generation of ozone itself requires energy[17] and causes additional costs; heating of the wash water is still required although washing is possible at lower temperatures; and there is a greater risk of damaging the textiles[25]. According to one stakeholder, due to lower washing temperatures increasing the ratio of suspended solids in the washing solvent, the ozone gas might not reach the textiles anymore. Especially in open systems as tunnel washing machines, the use of the highly volatile ozone is questionable as it can easily escape through the inner drum.

In the North American market, ozone technology is commonly applied in laundries, whereas according to stakeholders in Europe this technology is currently not so prevalent except for UK. Unfortunately, we did not receive any detailed information on the washing effects, savings potential and additional material composition of ozone-based technology.

M 1.7 Drum construction

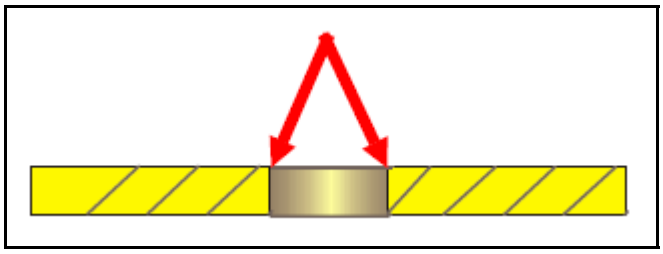
In recent years, the drums of washing machines had cylindrical perforations resulting in an inter-fibre friction caused by the rough edges (see Figure 7).

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15 http://www.cwtozone.com/index.php?page=ozone-in-the-laundry-industry---practical-experiences-in-the-uk

16 Due to the strongly oxidizing properties of ozone, ozone is a primary irritant, affecting especially the eyes and respiratory systems and can be hazardous at even low concentrations

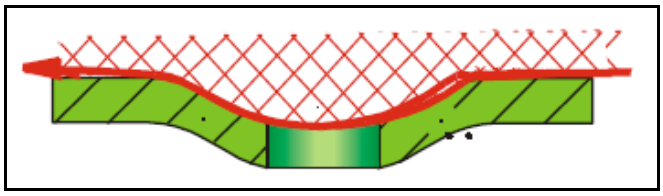
17 Due to its instability, ozone can not be stored for long periods or used as other industrial gases are purchased in ozone cylinders. Prior to his commercial application it must be produced on the premises.



(Source: Laundry Sustainability[18])

Figure 7 Cylindrical perforation of washing machines' inner drums

Funnel perforation, shown in Figure 8, is gentler on the fibres.



(Source: Laundry Sustainability[19])

Figure 8 Funnel perforation of inner drum surface

One manufacturer offers a patented honeycomb drum, in which the laundry glides on a thin film of water caused by a hexagonal relief pattern. This drum design particularly preserves delicate textile fibres.

This design option might not be relevant with regard to energy, water or detergents savings (improvement options cf. Task 7), but rather in terms of protective treatment of fabrics.

M 1.8 Wash process with lower temperature

If users of household appliances wash their clothes at 30°C instead of 40°C, the savings of energy consumption could reach about 12%. For the semi-professional appliances (WM1), lowering the used washing temperature could also be more efficient than increasing the washing machine's performance.[20]

The use of lower temperatures during the washing cycles, however, might promote the development of bio-films within the machines (bacteria and fungi), resulting in the need for regular routine services at higher temperatures to provide necessary hygienic cleaning

[18] http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-2_Washer_Extractors.PDF, sighted on 12.11.2010

[19] http://www.laundry-sustainability.eu/en/Microsoft_PowerPoint_-_Module_2-2_Washer_Extractors.PDF, sighted on 12.11.2010

[20] BIO Intelligence Service / Giraffe / Intertek (2009), "Reducing the environmental impacts of clothes cleaning", for DEFRA

results. Therefore, some end users (especially in the medical sector) may require even compulsory high temperature washing in their activity area (e.g. health care market).

According to A.I.S.E, the large majority of professional washing processes take place at 80°C to 90°C or 60°C to 70°C. This washing temperature is critically important for cleaning performance and hygiene claims. Professional users need to be sure about the washing hygiene because of the claims they promised to their customers (the situation for professional use might be different compared to the household use due to specific cleaning requirements of the different kinds of stains, e.g. oil in the industrial and blood in the medical customer segments). At temperatures lower than 55°C, adequate reformulation of detergents may be needed to guarantee hygiene.[21]

Finally, washing with lower temperatures might result in a longer washing time to achieve the same required cleaning performance (cf. Task 3, principle of Sinner's Circle). As, in contrast to household applications, shorter wash cycles play a major role in professional laundry processes, washing at lower temperatures might be a limited solution in the professional context.

2.2.1.2 Material composition

The improvement options M1.1 to M1.8 described above may lead to a reduction in water and energy demand during the use phase. In order to analyse possible trade-offs through additional environmental impacts in the production, distribution or end-of-life phase, differences in material composition and between a basic product and a product with integrated design options were investigated (see following table). Furthermore, the implementation of certain design options might require another material composition or a change in (the proportion of) the constituent parts of the appliance possibly inducing a better durability or a reduction of noise emissions.

[21] A significant germ reduction is achieved at temperatures higher than 40°C; at temperatures higher than 55°C most germs are killed off. To achieve a comparable result at lower washing temperatures, other factors like cycle time or composition of the detergent have to be adapted (cf. Principle of Sinner's Circle, Task 3). (Source: http://www.forum-waschen.de/doc/files/16199/WagnerNachhalitgesWaschen.pdf)

Table 1 Differences in material composition through implementation of the design options described

Design Option / Material category	M 1.1 Increased motor efficiency [g]	M 1.2 Heat ex-changer [g]	M 1.3 Water recovery [g]	M 1.4 Load control [g]	M 1.5 Further control systems [g]	M 1.6 Ozone techno-logy[22] [g]	M 1.7 Drum con-struc-tion [g]	M 1.8 Wash process with lower temp [g]
Bulk plastics								
PP					+ 200			
Ferrous metals								
stainless steel	- 100	+ 8 000	+ 15 000		+ 2 500		- 200	
Non-ferrous metals								
copper wire								
Al diecast		+ 3 000			+ 750			
Electronics				+ 200	+ 250			+ 100
Misc.					+ 100			

Note: empty fields = not applicable or no response by manufacturers

Stakeholders only provided information on a change in material composition with regard to the improvement options "heat exchanger" and "water recovery". The material composition of the further design options is an own estimate. Anyhow, the additional material consumption of the options described would not play a significant role due to the following reasons:

- The input of all material has only a minor influence on the energy-consumption and the total environmental impact. Within Task 5 we concluded that the environmental impact resulting from the production (including material), distribution and disposal of the devices is negligible compared to that during the use period: For example the global warming potential (GWP) caused by the use phase accounts for 93 to 99% of the total GWP over the lifetime of professional washing machines.
- The material with the highest influence is stainless steel for the containment and frame of the washing machines (50 to 80% depending on category). Even if stainless steal would be substituted by another material with no environmental impact, the influence on total environmental impact over lifetime of the washing machine would be lower than 3 %. Nevertheless, there is no alternative for stainless steel for now.
- Due to the absence of a commonly applied standard measurement method at EU level and reliable results from other analyses the range of uncertainty of the consumption data is significantly higher than the influence of all materials.

[22] No input from stakeholders available, no own estimations possible

2.2.1.3 Market penetration

The above described technological options result in saving potentials in the following fields:

- Water consumption;
- Detergent consumption;
- Energy consumption;
- Program efficiency and cycle time.

The expected energy saving potential and the estimated additional costs for the users are further elaborated in Task 7. The following table shows the current (year 2010) market share of the BAT options, their economic and practical advantages as well as the drawbacks of all the design options are listed.

Please note, that the values regarding the market share are not differentiated with regard to the different product categories or the respective key customer segments. A thorough analysis will be undertaken in Task 7.

Table 2 Design options for professional washing machines

Design options for professional washing machines		Application to the market in %[23]	Details or Comments	
			Advantages	Drawbacks
M 1.1	Increased motor efficiency	~30-80	Process flexibility, better motor efficiency	Electromagnetic compatibility; more components
M 1.2	Heat exchanger	5-60	Reduced energy consumption	Customized solutions, high costs
M 1.3	Water recovery	5-80	Saves water and energy	hygiene risk, bioaccumulation in system, high costs
M 1.4	Load control	30-80	Reduced energy, water, detergent consumption, faster wash time	n.a.
M 1.5	Further control systems	20-50	Better dosing, selection of right programme	n.a.
M 1.6	Ozone technology	n.a.	Reduced energy, water, detergent consumption	Additional costs, health & safety risk; higher ratio of suspended solids in the washing solvent
M 1.7	Drum construction	20-40	Better clemency of the textile fibres.	n.a.
M 1.8	Wash process with lower temperature	35-50	Reduced energy consumption	Lower wash performance, hygiene risk, bio accumulation within machine, longer cycles

n.a. = no information available (Source: manufacturers' feedback)

[23] Depending on the different customer segment and washing machine category

2.2.2 Improvement options outside the EU

According to the stakeholders no further improvement options for professional washing machines outside EU are known.

2.2.3 Best not yet available technologies (BNAT)

In this section, best not yet available technologies shall be provided. To obtain an overview of future developments and long-term saving potentials in the professional washing machines sector, stakeholders were asked to name further technologies (see questionnaire Annex 5.1) which are currently not yet available on the market but expected to be introduced in the coming years (BNAT).

Unfortunately, we did not receive comprehensive information from manufacturers. It should be noted that, for competition reasons, manufacturers are rather reluctant to talk about inventions, ideas and strategies which are not yet available on the market. Competition between the manufacturers is quite fierce and the circle of leading manufacturers is rather small. Nevertheless, we found one BNAT option based on own literature research and subsequent personal communication with the manufacturer.

Polymer beads

The following Figure 9 shows the general process of cleaning with polymer beads.[24] By contact and friction of the polymer beads with the laundry, the stains are more easily removed; the stains are transported to the beads, and afterwards absorbed by and diffused into the beads.

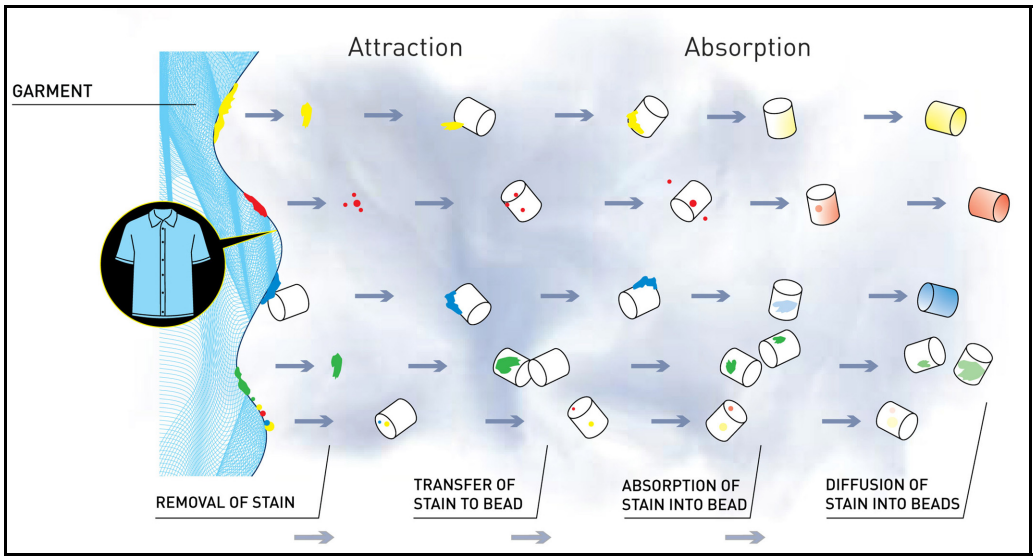


Figure 9 Polymer cleaning

[24] http://www.xerosltd.com/nylon-polymer-technology.htm

Whereas conventional washing processes use a dip wash which needs a high level of water, the polymer bead process only needs to wet the wash load by spraying water into the drum. According to the manufacturer, the estimated savings during the main wash phase represent about 60% for energy, water and detergents compared to the consumption of conventional washing machines. Further, with the reduced level of detergents less rinse water is needed. The technology could be combined with additional recycling of the rinse water.
The bead system is not applicable in conventional washing machine technology: new designs or modifications of existing designs are needed before a polymer bead system can be introduced.[25] The polymer bead technology is currently under development and expected to be introduced in the market in 2011/2012.

2.3 Possible implementation and combinations

From a technical point of view, i.e. not taking into account economic feasibility, in principle nearly all improvement options could be implemented in every washing machine category. Only few exceptions exist which cannot be combined with other options:

- Heat recovery systems are not applicable in washing processes with lower temperatures as a certain temperature difference between outgoing and incoming water is required.
- Improvement options helping to reduce the overall water consumption are reasonably not combinable to water recovery systems.
- The implementation of some improvement options requires space. For instance, in the case of semi-professional machines, it would be difficult to integrate a water recovery system or a heat exchanger due to the compact nature of these washing machines.

2.4 Best available washing machine products on the market

In Sections 2.1 and 2.2 we provided a more general technical description of possible design options and – if available – a first rough quantification of the improvement potentials by manufacturers. In Section 2.3 we narrowed the spectrum due to certain constraints with regard to implementation and combination possibilities. For this section, we asked manufacturers to specify those components or technologies being currently implemented in best available products on the market. From this inquiry, an impression of most important design options and combinations thereof for each washing machine category shall be derived.

[25] BIO Intelligence Service / Giraffe / Intertek (2009), “Reducing the environmental impacts of clothes cleaning”, for DEFRA.

Table 3 Technologies built into currently best available products on the market

Washing machine categories, base cases	Most efficient energy source to heat up the water	Contained improvement options
WM1 Semi-professional washer extractor	Alternative heating (mainly external heating through warm water input)	electronic stop controls, high extraction, drum construction, water and temperature sensors
WM2 Professional washer extractor, <15 kg	Alternative heating (mainly external heating through warm water input)	electronic stop controls, drum construction, water and temperature sensors
WM3 Professional washer extractor, 15-40 kg	Alternative heating (mainly steam heating)	electronic stop controls, drum construction, automatic weighing system, water and temperature sensors
WM4 Professional washer extractor, >40 kg	Alternative heating (mainly steam heating)	electronic stop controls, drum construction, load control, intelligent water and temperature sensors, high extraction, control system (with an industrial programmable logistic controller for the whole laundry process)
WM5 Professional washer dryer	Electric heating	electronic stop controls, drum construction, load control
WM6 Professional barrier washer	Alternative heating (mainly steam heating)	electronic stop controls, drum construction, load control
WM7 Washing tunnel machine	Alternative heating (mainly steam heating)	Control system (with an industrial programmable logistic controller for the whole laundry process),

(Source: feedback from manufacturers and own research)

However, the best available products currently on the market have not implemented all possible design options as marginal savings are decreasing and therefore additional investments do not pay off. Nevertheless, from a purely technological point of view, it would of course be possible to implement most options in professional washing machines.

3 Professional dryers

3.1 Main areas of environmental improvement potentials

The drying process needs hot air which is usually generated by an electrical heating system and blown to the wet laundry, thus taking up humidity from laundry and drying it. The humid air is then either vented to the ambient air or condensed by cooling it down in a heat exchanger. The energy demand of the drying process inter alia depends on the residual moisture of the laundered wash ware. The wet laundry with a designated residual moisture coming from a washing process is loaded into the tumble dryer (manual or automatically) and

affects the operation of the tumble dryer. The more water is removed by mechanical treatment (usually through spinning in the washing machine) the less thermal energy is required for the subsequent drying.

Another factor influencing the energy consumption is the duration of the drying process. In case the drying process is too short the laundry is still wet and an extra drying step would be necessary increasing the energy consumption. Whereas in the case the drying process is too long the textiles could be over-dried with a higher energy demand than necessary and a possible damage to the linen.

The whole drying process needs energy. Typical heat losses occur through exhaust air (process air), evaporation of the water and radiation losses (see Figure 10 for condenser dryers). Air vented tumble dryers need additional energy as the warm and humid air is blown outside and is replaced by cold air that has to be heated up by the space heating system. In a typical drying cycle of an air dryer the heating of the air represents approximately 90% (cf. more detailed for each category in Task 4) of the energy demand, about 10% is used for the electric motor and electronic controls, as shown in Figure 11. Therefore, the most effective approach for improving energy efficiency would be to focus on the aim to decrease the amount of heat input per kg of laundry.

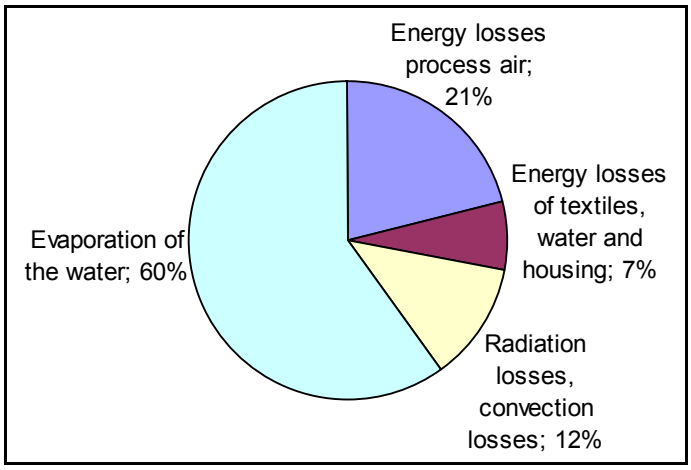


Figure 10 Energy use for a typical professional condenser dryer [26]

[26] Own illustration according to following sources: Universität Bonn / Haushaltstechnik and Electrolux/AEG

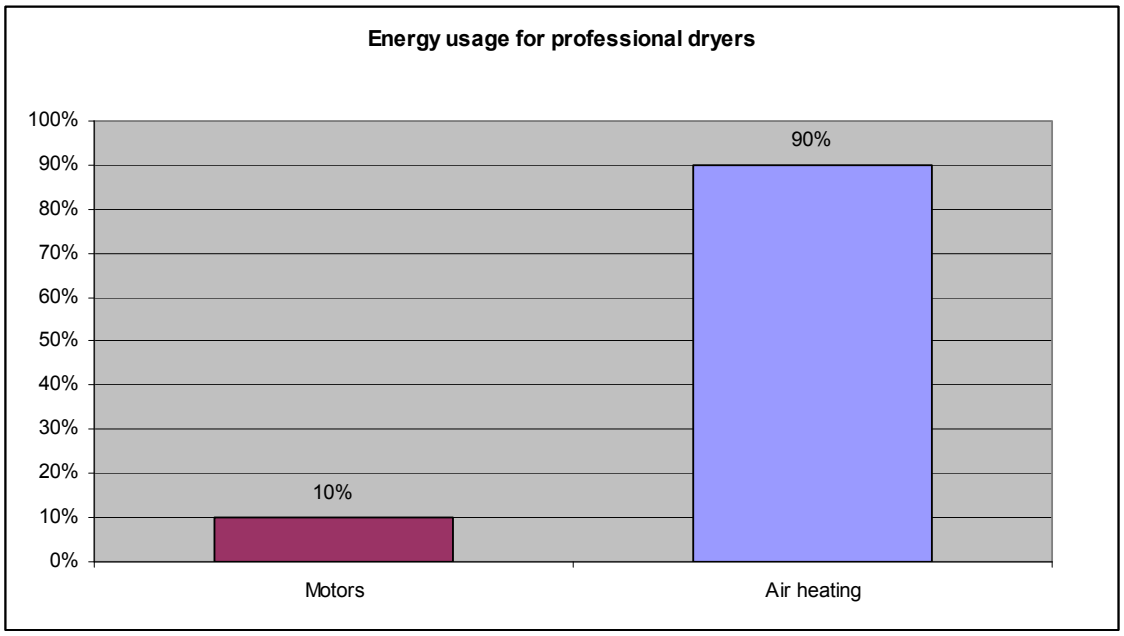


Figure 11 Energy use for a typical professional air dryer cycle[27]

The following sections describe various energy saving technologies for professional dryers. The description of improvement options is structured according to the following categories:

- Design options considered best available technology (BAT),
- Improvement options outside EU,
- Best not yet available technologies (BNAT).

3.2 Best available technologies at component and product level

In this section, first the state of the art at product and component level is described. These best available technologies (BAT) as well as indicative quantitative data were derived from manufacturers' brochures supplemented by personal communication with input from manufacturers based on a questionnaire (see Annex 5.1). A couple of design options applicable to domestic appliances were also identified for (semi-)professional dryers.

3.2.1 Technological options

The reductions in energy could be achieved by several technological features offered by manufacturers. The most relevant technological options are described below.

[27] Own illustration according to: DOE 2008 laundry equipment report, page 265

3.2.1.1 Description of the design options

M 2.1 Increased motor efficiency

The efficiency of the motors can be optimised. Electric energy is preliminary needed for the functioning of the dryer's drum that provides the mechanical agitation of the laundry to be dried: depending on the type of dryer, electric energy is also needed for the air flow and pumping out of the water (condenser dryer). Most of the dryers' categories use a three phase alternating current (AC) motor. Most gas heated dryers especially in the range up to 20 kg[28] are working with single phase motor systems. Optimizing the motor control strategy (adaptive acceleration, speed, positional control, and rotation patterns) would provide possible decrease of the energy consumption, the uniformity of drying and a gentler treatment of the laundry. Also material savings would be possible.

The European Commission has recently taken steps to further regulate the energy performance of electric motors;[29] however, the requirements currently do not apply to professional dryers. The Regulation No. 640/2009/EC is not applicable to motors completely integrated into a product (for example gear, pump, fan or compressor) and whose energy performance cannot be tested independently from the product.

M 2.2 Heat pump

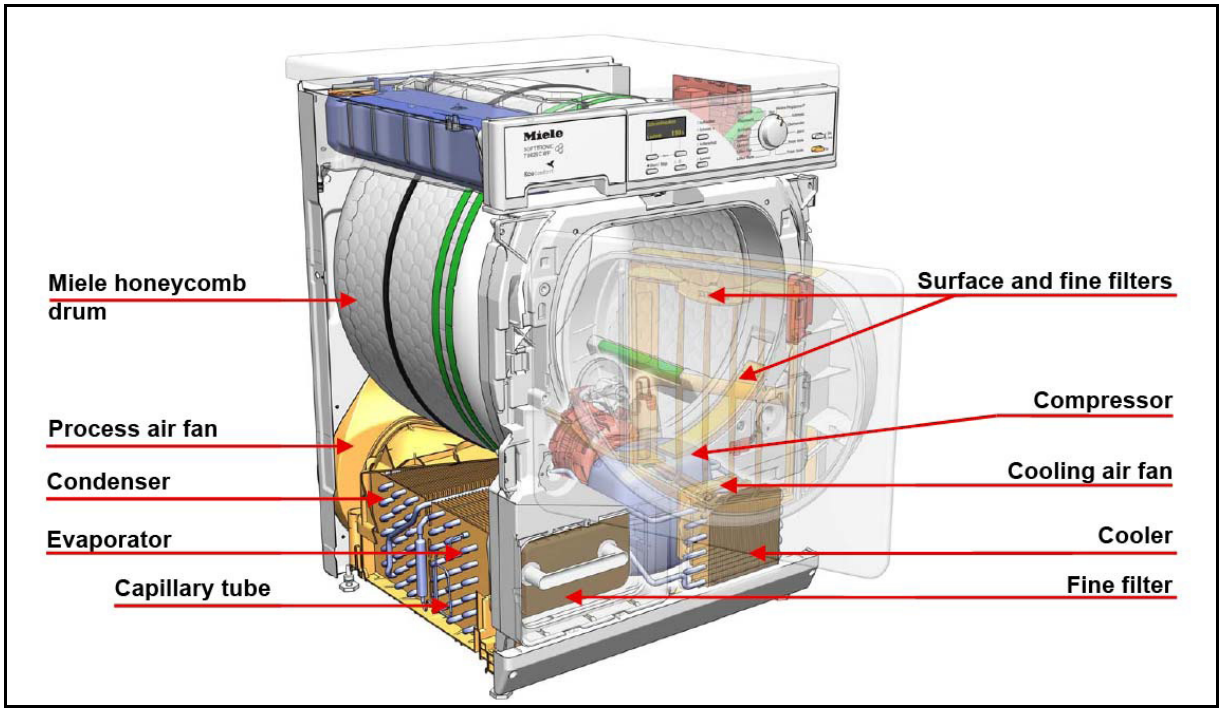
The heat pump consists of a refrigeration loop containing a refrigerant steam compressor, an evaporator heat exchanger, a condensing heat exchanger, and an expansion valve.

Hot, dry processed air enters the rear of the drum and interacts with the laundry. Inside the dryer, the residual moisture of the laundry evaporates into the hot, dry air, thereby generating warm moist air which exits the drum. In the evaporator, heat from this air is transferred to the refrigerant inside the evaporator coils. This decreases the temperature of the warm moist air and causes the moisture in the air to condense. The condensate is drained from the dryer. The cool dry air flows from the evaporator back to the condenser heat exchanger where the heat is transferred from the high-temperature refrigerant to the cool dry air. The resulting hot dry air enters the drum and the cycle is completed.

The design of a heat-pump dryer is shown in Figure 12.

[28] Source: Personal information by Miele

[29] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:191:0026:0034:EN:PDF



(Source Miele: http://www.miele.com.au/media/haushalt/VG_AUS/T_8627_WP_information.pdf*)*

Figure 12 Design of a heat pump dryer

Heat pump driers use refrigerants in their vapour compression cycles. Refrigerants as well as the heat pump units are not designed and manufactured by the manufacturers. Typical refrigerants used are R-134a (tetrafluorodichlorethene), R-407C[30] (a hydrofluorocarbon blend of R-32, R-125, and R-134a) and others with an average filling of 1 to 3 kg depending on the dryer categories.

The electricity consumption of a dryer with heat pump can be reduced by approximately up to 60% compared to a conventional condenser dryer. Besides the energy saving potential heat pump tumble dryers provide further advantages compared to conventional condensing dryers:[31]

- Waste heat dissipation into the operation room is about 50% lower as the heat is regained for the drying process and the outgoing exhaust air has temperatures of about only 18-22°C (conventional dryers: heated exhaust air). This is advantageous especially in summer as extending the possible operation hours of the appliances in hot periods (as conventional condensing dryers only limited operate at temperatures

[30] Source Electrolux data sheet: http://skalbimas.com/pdf_files/ts4180.pdf

[31] Jürg Nipkow, Eric Bush: Promotion of energy-efficient heat pump dryers. Swiss Agency for Efficient Energy Use (S.A.F.E.), Topten International Group; http://www.topten.info/uploads/File/Efficient%20Heat%20Pump%20Dryers%20-%20EEDAL%2009.pdf

above 30°C) and reducing the additional energy demand for cooling the operating facility.

- Compared to conventional air vented dryers, there is no smelling and steaming exhaust air.
- Vented dryers blow the warm exhaust air outside the building being compensated by cold incoming air which has to be heated. For heat pump dryers, this cooling down of the operating room in winter is of no relevance, as the exhaust air is not blown outside but recycled within the heat exchanger.

On the other hand, there are also some disadvantages by implementing a heat pump[32]:

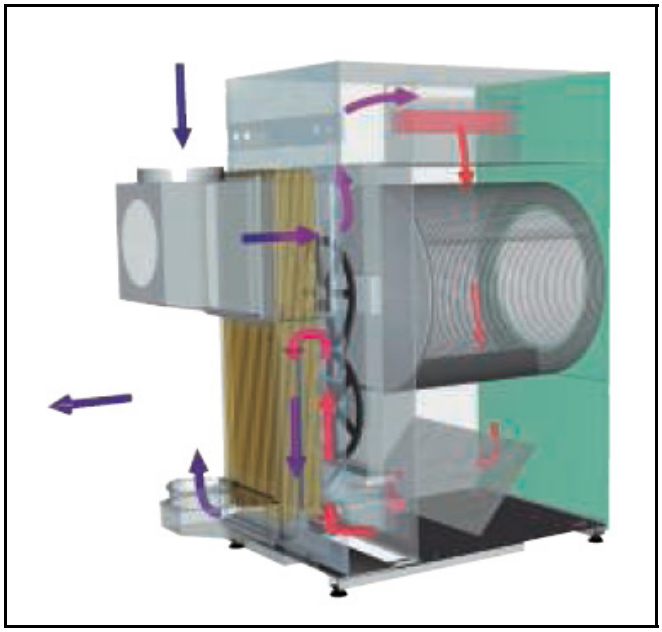
- additional costs are significant for the components and process integration;
- heat pumps need additional inspections to control whether or not the refrigerant circuit is leaking; thus it will cause additional maintenance costs.

M 2.3 Heat recovery systems

In general the same aspects described for the heat pump apply to heat recovery systems.

Heat recovery systems are usually based on a heat exchange that uses the warm exhaust air produced by the tumble dryer to preheat the cold inlet air. This system leads to energy savings, especially when the cold incoming air to be preheated is not exceeding 24°C. Furthermore, the drying time can be shortened, as less time is needed for preheating the incoming air. In a launderette (Coin & Card Laundry), for each dryer heat recovery units can be installed, or a number of tumble dryers can be connected to a central heat recovery unit.

32 http://www-cep.ensmp.fr/francais/innov/pdf/ICR0143SLV%20_IIR_IIF%20Conf.pdf



(Source: Electrolux[33])

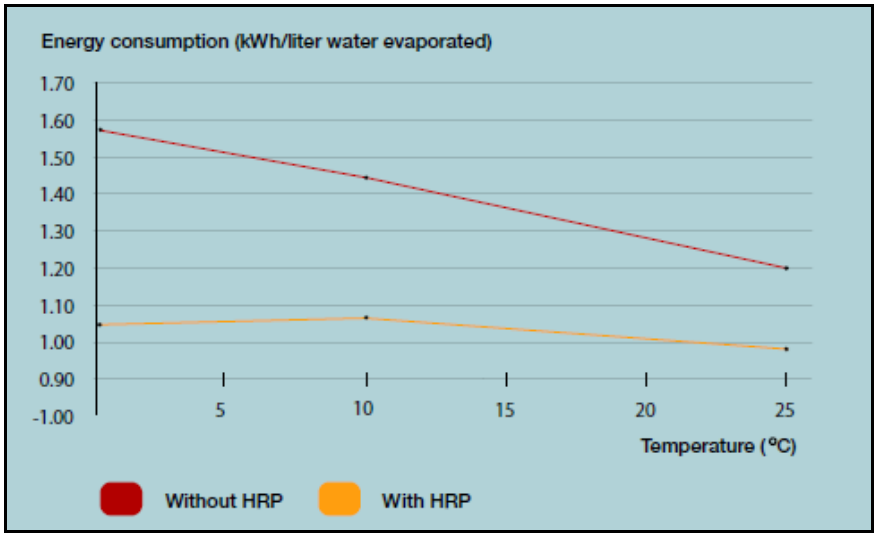
Figure 13 Air flow of the heat recovery system

Laundry dryers normally exhaust large amounts of warm, moist air. After having been circulated through the clothes, the air is exhausted along with moisture and heat. This can be avoided by installing a heat recovery system. In order to recover the exhausted heat, an air-to-air heat exchanger is installed, the incoming air thus being preheated by the hot exhaust air. The thermal contact surface of the heat exchanger should be optimized in order to guarantee the best transport of thermal energy from the hot to the cool side, thereby allowing vapour to condensate without inducing excessive heat transfers.

Since the hot process medium is humid air coming from the drum which is filled with laundry, it sometimes happens that lint covers the surface and makes the heat exchange less efficient. To avoid this effect, user-accessible air filters are in place, which have to be cleaned time and again to ensure optimal operation.

Figure 14 illustrates the energy consumption of a tumble dryer, with and without a heat recovery system.

[33] http://www.laundrysystems.electrolux.com/Files/Pdf_files2/Ljungby/Brochures/Heat_recovery_pipes_GB.pdf, sighted on 06.12.2010)

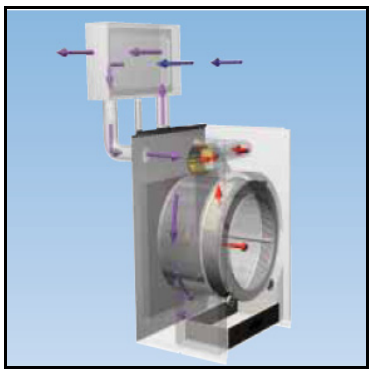


(Source Electrolux:

http://www.laundrysystems.electrolux.com/Files/Pdf_files2/Ljungby/Brochures/Heat_recovery_pipes_GB.pdf *)*

Figure 14 Energy consumption with and without heat recovery pipes (HRP)

A further possibility is an air preheat condensing unit with an effective heat exchanger. A condensing unit (see Figure 15) is required for installations where a normal dryer exhaust connection to the outside is not possible. The condensing unit is connected to the dryer air exhaust and the air inlet. The warm moist exhaust air passes through the condensing unit. The condensing unit condenses the humidity of the exhaust air by using the ambient room air for cooling. The condensed water is led to the drain. For optimal performance the room temperature should not exceed 25°C.



(Source: *http://www.waeschereitechnik-horstbalk.de/Waschetrockner.pdf* / Electrolux)

Figure 15 Condensing unit

Another manufacturer developed a plate heat exchanger which preheats the incoming air of the dryer by extracting heat from the hot exhaust air. The heat exchanger increases the heat

of the air entering the dryer by about 30 to 35°C. If the ambient temperature is 15°C, the air transferred to the dryer is typically at 45 to 50°C.[34]

M 2.4 Improved air flow systems

Tumble dryers can be equipped with different air flow systems (axial, radial, mixed or others). With axial systems, the air flows through the drum from rear to front, rather than from top to bottom (see Figure 16). This means all the air passes through the load and increases the speed of the drying process. With radial airflow, the air flows from the bottom to the top (see Figure 17). In contrast to the axial airflow, part of the air does not come into contact with the linen but passes alongside the drum.

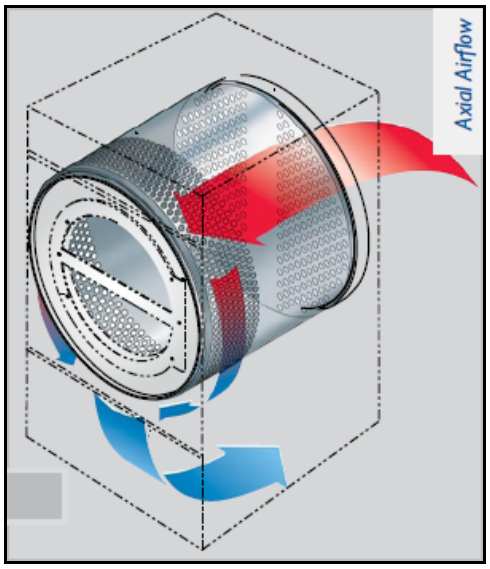


Figure 16 Axial airflow

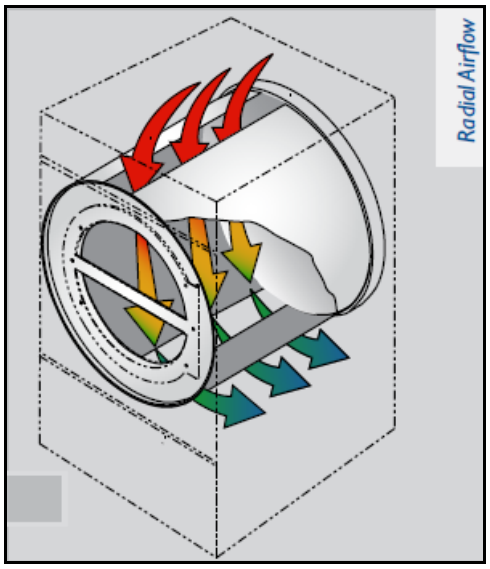


Figure 17 Radial airflow

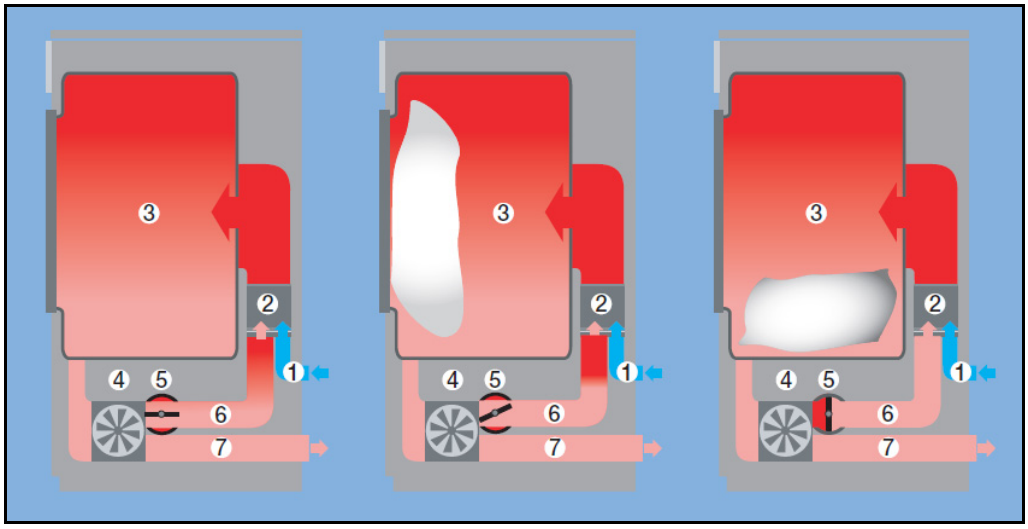
(Source: Girbau[35])

In order to achieve an improved drying temperature, an alternative solution might be to use an air system as specified in Figure 18). A special air shutter controls the intake of the air via a fan. If the temperature inside the drum rises, this air shutter reduces the intake of hot air into the drum. Air-resistant fabrics can cover the perforations in the interior of the drum next to the door, creating an under pressure which causes the temperature inside the drum to rise. With a reduction of the air intake the laundry falls to the bottom of the drum, exposing the perforation and enabling the air/pressure balance to equalise.

These air and temperature controls result in shorter drying times, and therefore a better energy efficiency.

[34] http://www.resourcesmart.vic.gov.au/documents/BP_ProcessHeating_Case_Study.pdf

[35] http://www.girbau.co.uk/shopimages/products/extras/Pro_Series_II.pdf, sighted on 06.12.2010



(Source: Miele, http://www.miele-ebrochures.co.uk/professional/files/PT7801_Tumble_Dryer_2006.pdf, sighted on 06.12.2010)

Figure 18 Air control system

M 2.5 Load control

Weight sensors directly measure the weight of the load and could adapt the drying process in case of partial load. Dryers with integrated weight sensors sending a signal.to users that their dryer is only partially loaded, may influence their behaviour (optimizing the load and thus improving the energy efficiency).

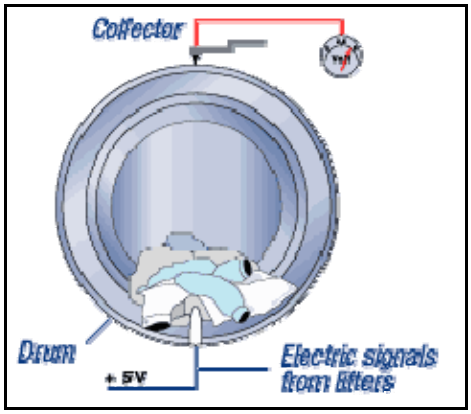
M 2.6 Residual moisture control – RMC

The residual moisture control system allows an optimal drying cycle end-point determination to avoid both still wet laundry as a result of too short drying and over-drying by extended drying. Is the drying too short the laundry is still wet and an extra drying phase is necessary which, in turn, leads to an increased energy consumption. When, however, the drying process is too long the textiles could be over-dried resulting in higher energy demand as necessary which might damage the linen.

Several end point determination methods are available on the market:

- Fixed drying time per article,
- Methods based on air temperature control, and
- Infrared sensors which measure the temperature of the linen.

Moisture-controlled dryers stop the drying process as soon as the preset residual moisture level is reached. Time-controlled dryers stop after a certain period of time set by the user. Usually the time-controlled dryers run longer than necessary resulting in higher energy consumption in comparison to moisture-controlled appliances.



(Source: http://www.wascomat.net/docs/sect03/inst_rmc.jsp)

Figure 19 RMC provides a direct electronic and accurate measurement of moisture content in the dryer load

M 2.7 Improved insulation

A further design option to reduce heat losses is to ensure optimal thermal insulation. Improved geometry and materials for the casing, drum, tubing, etc. ensure that a lower amount of heat is lost to the surroundings.

3.2.1.2 Material composition

The improvement options M 2.1 to M 2.7 described above lead to a reduction in energy and time demand during the use phase of professional dryers. In order to analyse possible trade-offs through additional environmental impacts in the production, distribution or end-of-life phase, differences in material composition between a basic product and a product with integrated design options were investigated (see questionnaire in Annex 5.1).

Table 4 Differences in material composition through implementation of design options

Design Option / Material category	M 2.1	M 2.2	M 2.3	M 2.4	M 2.5	M 2.6	M 2.7
	Increased motor efficiency	Heat pump	Heat recovery from exhaust air	Improved air flow system	Load control	Residual moisture control – RMC	Improved insulation
	[g]	[%][36]	[g]	[g]	[g]	[g]	[g]
Bulk plastics		+ 1,5%	+ 1 400				+ 200
PP				+ 500			
Ferrous metals							
stainless steel	- 200	+75%	+ 21 000	+ 500			
Non-ferrous metals							
copper wire		+ 4,5%	+ 850	+ 1 500			
Al diecast		+17%	+4 700	+ 500			
Electronics		+ 1,2%		+ 100			
Misc.					+ 200	+ 100	
refrigerant		+ 0,8%					

Note: empty fields = not applicable or no response by manufacturers

Unfortunately, stakeholders only provided information on a change in material composition with regard to the improvement options "heat pump" and "heat recovery system". Thus, the material composition of the other design options are own estimations. Anyhow, the additional material consumption of the options described would not play a significant role due to the following reasons:

- The input of all material has only a minor influence on the energy-consumption and the total environmental impact. In Task 5 Report we concluded that the environmental impact resulting from the manufacture (including material), distribution and disposal of the appliances is negligible compared to the impact of the use phase: For example the global warming potential (GWP) caused by the use phase accounts for 97% to 99% of the total GWP over the lifetime of professional dryers.
- The material with the highest influence is stainless steel for the containment and frame of the dryers (more than 60%, depending on the product category). Even if stainless steal would be substituted through another material with no environmental impact, the influence on total environmental impact over lifetime of the dryers would be lower than 2%. But there is no alternative to stainless steel for now.

[36] Size and additional material of heat pumps depend on the size of respective dryer category. Thus, additional material consumption of the heat pump is given as proportional to the material composition of the different base cases. The weight of the heat pump unit includes the cabinet, tubes, base etc (detailed calculations: see Task 7)

- Due to the missing standard measurement method and other reliable results the uncertainty of the consumption data is significantly higher than the influence of all materials.

3.2.1.3 Market penetration

The expected energy saving potential and the estimated additional costs for the users are further elaborated in Task 7. The following table shows the current (year 2010) market share of the BAT options, their economic and practical advantages as well as the drawbacks of all the design options are listed.

Please note that the values regarding the market share are not differentiated with regard to the different product categories or the respective key customer segments. A thorough analysis will be undertaken in Task 7.

Table 5 Design options for professional dryers

Design options for professional dryers		Application to the market %	Advantages	Drawbacks
M 2.1	Increased motor concept	30	Slightly better energy performance	n.a.
M 2.2	Heat pump	3–5	Saves a lot of energy	Longer drying time
M 2.3	Heat recovery	10	Saves energy more in cold climates	Maintenance, more difficult to clean
M 2.4	Improved air flow system	40–60	Saves energy Optimisation for different loads	More complexity Requires more front space
M 2.5	Load control	0–5	Can detect part loads	Complexity
M 2.6	Residual moisture control – RMC	30–90	Less energy consumption Better laundry economy.	Cost
M 2.7	Improved insulation	20	Saves energy	Cost

n.a. = no information available (Source: manufacturers' feedback)

3.2.2 Improvement options outside the EU

It was stated by all manufacturers that the most advanced dryer technologies and the most efficient professional dryers are produced in the European Union. According the stakeholders the state of the art is very similar all over the world. Thus no further improvement options for professional dryers from outside EU are known.

3.2.3 Best not yet available technologies (BNAT)

In this section, best not yet available technologies are provided. To obtain an overview of future developments and long-term saving potentials in the professional dryers sector,

stakeholders were asked to identify further technologies (see questionnaire Annex 5.1) which are currently not yet available on the market but are expected to be introduced in the coming years (BNAT).

Unfortunately, we did not receive any information on BNAT from manufacturers; they stated that especially for the components used in dryers considered BNAT are still subject to research and development. It should be noted that, for competition reasons, manufacturers are rather reluctant to talk about inventions, ideas and strategies which are not yet available on the market. Competition between the manufacturers is quite fierce and the circle of leading manufacturers is rather small.

The following BNAT technologies were derived from Lot 16 (dryers for household use); it is expected that they could be applicable for semi-professional dryer categories as well. However, there is no indication that professional laundries are currently working on these technologies in Europe.

Modulating Gas Dryers

Most gas dryers on the market today operate with a single burner at fixed input rate and fixed airflow rate. The burner typically operates in an on/off mode as determined by the cycle chosen. One strategy for saving energy in a gas dryer is to modulate[37] the heat input rate to the moisture level of the load. This saves energy because the dryer requires less heat towards the end of the cycle. Modulating gas dryers have the ability to detect when the clothes are becoming dry, and to reduce the heat input rate accordingly as the clothes are approaching their dry state.

Microwave dryer

Microwave dryers employ electromagnetic waves in order to directly heat the water. The water vapour is removed by a stream of air and blown out to the atmosphere. Energy is transferred through the material electro-magnetically, not as a thermal heat flux. Therefore, the rate of heating is only limited by the power for the generation of microwaves; the uniformity of heat distribution is rather improved. Heating times can be reduced to less than one percent of those required using conventional techniques.

Because volumetric heating is not dependent on heat transfer by conduction or convection, it is possible to use microwave heating for applications where conventional heat transfer is inadequate. One example is in heterogeneous fluids where the identical heating of solids and

[37] U.S. Department of Energy Energy Efficiency and Renewable Energy Building Technologies Program. Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances, Navigant Consulting, Inc. December 21, 2009

liquids is required to minimize over-processing. Another application is to obtain very low final moisture levels for products without over-drying.

A disadvantage is the depth of penetration achievable using microwave energy. This is a function of microwave frequency, the dielectric properties of the material being heated and its temperature. As a general rule, the higher the frequency, the lower is the depth of penetration.

Vacuum dryer

A vacuum dryer uses vacuum condensation technology to dry laundry at lower temperatures. As the air pressure inside the drum is reduced (vacuum), water evaporates at temperatures lower than 100°C. This results in energy savings because less energy is needed to create a vacuum than to heat the laundry up to 100°C. Vacuum dryers have a completely different design compared to existing dryers and they need a complex structural design raising high research and development costs.

3.3 Possible implementation and combinations

From a technical point of view, i.e. not taking into account economic feasibility, in principle nearly all improvement options could be implemented in every dryer category except for the following restrictions:

- The air-flow design options cannot be implemented in condenser dryers (category D1).
- Heat pump technology is only applicable to condenser type dryers, but not to air vented dryers.
- An improved condensing unit can not be combined with an additional heat pump and also not within gas or steam operated machines.
- The implementation of some improvement options requires additional space. Thus, for example, for semi-professional dryers D1 and D2 as well as for the smaller tumble dryers it would be difficult to integrate a heat pump due to the compact nature of these appliances.

3.4 Best available dryer products on the market

In Sections 3.1 and 3.2 we provided a more general technical description of possible design options and – if available – a first rough quantification of the improvement potentials estimated by manufacturers. In Section 3.3 we narrowed the spectrum due to certain constraints with regard to implementation and combination possibilities. For this section, we asked manufacturers to specify those components or technologies being currently implemented in best available products on the market. From this inquiry, an impression of

most important design options and combinations thereof for each dryer category can be derived.

Table 6 Technologies built into the best available products on the market (feedback from manufacturers)

Dryer categories, base cases	Current best available energy source for the air heating	Contained Improvement options
D1 Semi-professional dryer, condenser	Electricity heating	Control system,
D2 Semi-professional dryer, air vented	Electricity heating	Control system, improved air flow system
D3 Professional cabinet dryer	Electricity heating	Heat pump, control system (adjustable)
D4 Professional tumble dryer, <15 kg	Alternative heating (mainly gas heating)	Heat pump, exhaust duct not needed, RMC, improved air flow system
D5 Professional tumble dryer, 15-40 kg	Alternative heating (mainly gas heating)	RMC, improved air flow system
D6 Professional tumble dryer, >40 kg	Alternative heating (mainly gas heating)	Control systems, (with an industrial programmable logistic controller for the hole laundry process)
D7 Pass-through (transfer) tumble dryer	Alternative heating (mainly gas heating)	Infrared control, control system (with an industrial programmable logistic controller for the hole laundry process), heat recovery system

The best available products currently on the market have not implemented all possible design options as marginal savings are decreasing and therefore additional investments do not pay off. Nevertheless, from a purely technological point of view, it would of course be possible to implement most options in professional dryers.

4 Infrastructure options and laundry system solutions

4.1 Infrastructure options

Apart from powering the motor and electronic controls, laundry equipment requires most energy for heating the water of washing machines and the air of dryers. Different heating options can be used depending on the existing local infrastructure: electricity, gas and steam (or thermo oil). Washing machines can also be heated by using externally heated water. Tunnel washing machines (category WM7) are mostly (more than 90%) operated by steam heating (see Task 3).

The existing infrastructure influences the choice of the heating source and accordingly the difference in environmental impacts. It is a general rule that only one method of heating supply is used. In order to achieve economies of scale, it would not make sense to install multiple heating systems like steam heating, thermo-oil or natural gas in parallel. Improve-

ments by changing the heating source could be realised for example in case of new investments or re-planning of a laundry or a launderette.[38]

In the following sections, the further heating options besides electricity heating are described.

4.1.1 External heating with warm (hot) water

Heating with warm water might result in energy savings if heating the water outside of the washing machine (e.g. existing central or district heating system of the regarded customer segment) is more efficient compared to electric water heating within the machine. Next to the direct efficiency of the heat generation this mainly depends on the primary energy sources used for the energy supply.

To prevent reduced washing performance, for some laundry (some stains like e.g. blood require a lower initial temperature) the initial temperature of the hot-fill has to be limited to a starting temperature just below 40°C. To allow alternatively both hot-fill or lower initial temperatures, two valves (for each hot and cold water) are necessary and currently mostly implemented in the machinery.[39]

In general, warm or hot water connection leads to shorter programme times and lower energy consumption of the washing machine itself. However, the overall environmental and economic advantage of the connection to warm water supply strongly depends on the type of water heating outside the appliance and other infrastructural parameters, like length and insulation of the water line.

4.1.2 Internal heating with steam (or thermo-oil)

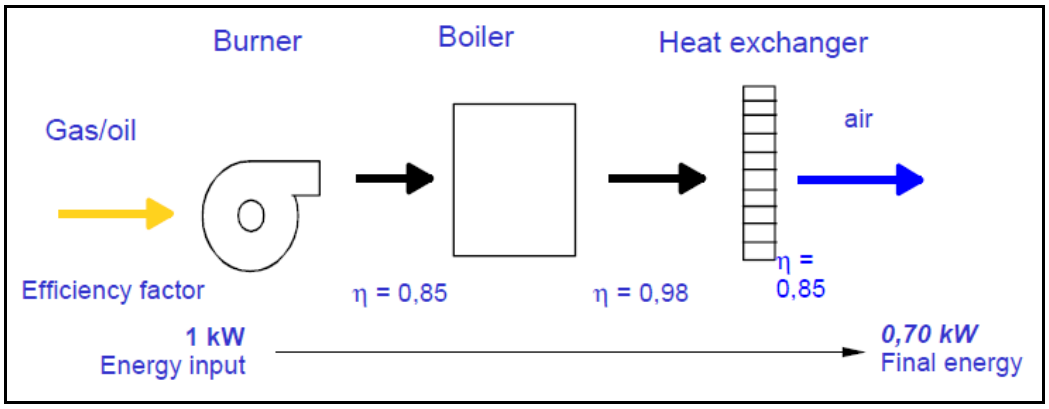
Washer extractors and dryers equipped with steam heating are mostly used in large commercial laundries (WM7 and D7) or in industries which basically need steam for their processes.

Some professional washing machines or dryers are equipped with special heating elements in which the heat, produced for example by district heating, is let in. A separate boiler produces high-pressure steam distributing it into all steam using appliances. This steam is used for heating up the water in the washing machine to the desired temperature. Thus, nearly no electricity is used for the heating process (only approx. 5% for the electronic components). Furthermore, in some large laundries a steam management is applied to prevent energy losses. Figure 20 shows the conversion of the energy input in a steam heating system

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[38] It is a general rule, that only one method of heating supply is used. In order to achieve economies of scale it would not make sense to install multiple heating systems like steam heating, thermo-oil or natural gas in parallel in commercial or industrial laundries.

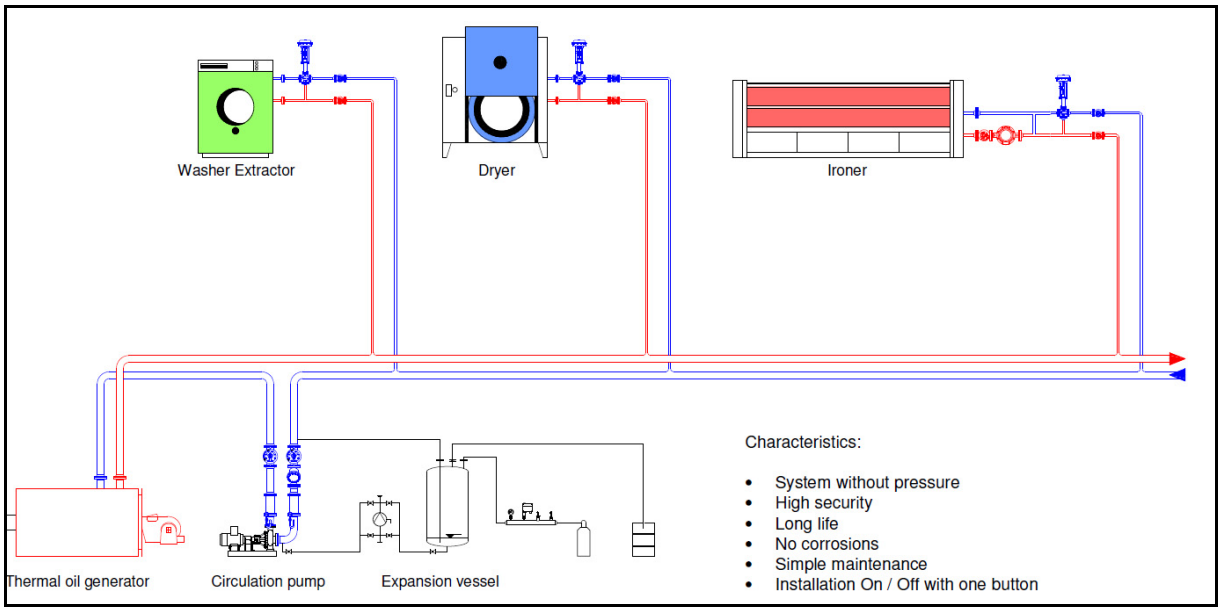
[39] Öko-Institut e.V.; Rüdenauer, I.; Gensch, C.-O.; Quack, D.; Eco-Efficiency Analysis of Washing machines – Life Cycle Assessment and determination of optimal life span (2004)



(Source: Laundry Sustainability)

Figure 20 Energy conversion process in a steam heating system

The laundry equipment machines could also directly be heated with thermo oil. Figure 21 shows an example of a thermal oil heating laundry.[40]



(Source: Regiomat)

Figure 21 Diagram of a thermal oil heating laundry

4.1.3 Internal (direct) heating with natural gas

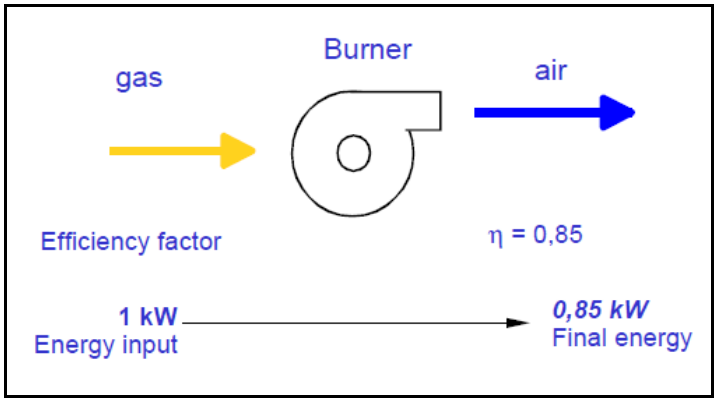
In some laundries gas is used for heating the water of the washing machines or the air of the dryers. The main environmental advantage is that natural gas burns almost free of particles

40 http://www.regiomat.com/Regiomat_Homepage_English/pdf_english/Thermal%20oil%20or%20Steam.pdf

with much less CO_2 compared to electricity production; thus the carbon dioxide emissions are reduced by up to 50%.[41] With gas heating a faster heat-up and cost savings due to the cheaper purchase price of gas compared to electricity are possible. Further, compared to steam heating, the operation costs can be significantly reduced by the use of natural gas heating due to the following reasons:[42]

- Steam and condensate lines are hot and must be insulated separately.
- Heat-up times of gas-heated dryers are much shorter compared to those in (indirect) steam-heated dryers.
- The steam boiler plant has a loss in efficiency of 10 to 15%. These losses can be avoided by using a direct gas dryer. Gas dryers have an improved combustion efficiency compared to electricity because natural gas is burnt inside the dryer to produce heat. Thus, the drying performance of direct-heated dryers is significantly higher.
- Finally, gas dryers provide an improved temperature-controlling of the drying process.

The following figure shows the conversion of the energy input in a direct gas heating system.



(Source: Laundry Sustainability)

Figure 22 Energy conversion process in a direct (internal) gas heating system

The following table provides a brief overview of the different heating sources and their advantages and drawbacks.

41 http://www.gewerbegas-online.de/

42 http://www.gewerbegas-online.de/index.php?id=270

Table 7 Information on different types of heating

	Advantages	Drawbacks	Details
Electricity	▪ Easy & economic ▪ installation ▪ Easy maintenance ▪ Clean	▪ Expensive operating cost	▪ Recommended for small units up to 100 kg/hour
Gas	▪ Cheap operating cost ▪ Any type of gas available ▪ Ideal for Tumble dryers (see Section 3.2.2	▪ Cannot be installed everywhere (ventilation) ▪ Requires strict maintenance ▪ Not available for WE except side loaded WE and for chest ironers	▪ For medium size installations up to 100 / 150 kg/hour
Steam	▪ Cheap operating cost ▪ Ideal for any type of ironer	▪ Additional cost for installation ▪ Requires additional room ▪ Safety norms	▪ Recommended for large laundries
Thermo-oil	▪ Simple installations and placements ▪ 30–40% less investment costs as a steam plant ▪ No losses of condensate and energy ▪ High security, Long life	▪ Additional costs for maintenance ▪ Operational hazards (e.g. leakage)	▪ Recommended for large laundries

The infrastructure options are differently applied in the various customer segments and product categories (cf. Task 3). The choice for a specific professional washing machine depends inter alia from the locally applicable infrastructure. In case of new investments or re-planning of a laundry, however, improvements by changing the heating source or implementing the following options could be realised.

- The existing energy supply system can be adapted to the state of the art or using BAT. For example an existing steam supply could be substituted by a new, more energy efficient steam supply in laundries.[43]
- Another approach aims at the conversion of the energy supply structure of laundries. For example: an existing central steam supply can be converted to a system with decentralised gas heating.

[43] E.g. Gläßer, B.; Energiy efficient steam supply in laundries. 44th International Detergemce Conference. Düsseldorf 2009

4.1.4 Smart portal display (changes to appliances operation)

Based on experiences from the household appliances sector another infrastructural option could be to manage the required power on the grid. By means of a smart portal display the available power on the grid coming from conventional and renewable resources could be harmonised with the respective demand. Thus, professional washing machines or dryers could be linked to cheaper energy sources, such as night charge. The machines could be started within a predefined time interval. The portal display is informed about the selected programme or at least the expected energy demand.[44] However, in the professional context, the use of this application is limited. In some market segments (e.g. Coin & Card Laundry), users expect to wash and dry their laundry directly and not delayed. In large laundries, the machines are already operated in several shifts during the whole day.

There is no information on a possible environmental saving potential of this application.

4.2 Laundry system solutions

In commercial or industrial laundries usually a wide range of machinery and options are used to process the different types of laundry. To optimize the laundry operation both under environmental and cost aspects, the machines used for washing, extraction, drying and finishing are often integrated into a comprehensive laundry system.

In addition to optimisation at the level of the single machines and process steps of the laundry process there are further improvement potentials which could be realised at system level. Basically, there are different approaches at this level for implementing measures:

- Improvement potentials can be achieved by a concept which is called “media integration”. The energy flow between different laundry process steps is optimised. Examples for this approach are the use of energy from the ironer’s exhaust heat for (pre-) heating the wash water or the filtration and recycling of waste water from tunnel washing machines for washer extractors. [45]
- Also, the spin speed of washing machines influences the energy consumption of the subsequent drying process. This is due to the physical fact that for the drying process, the water has to be evaporated by using thermal energy and removed through an air flow. The more water is removed by mechanical treatment (usually through spinning in the washing machine) the less thermal energy is required for subsequent drying. Water removal by an increased spinning in a washing machine needs about 100 times less energy[46] than thermal drying. The additional energy demand through higher spin

[44] University of Bonn, Synergy Potential of Smart Domestic Appliances in Renewable Energy Systems, Prof.Dr. R. Stamminger (Stamminger 2009)

[45] E.g. Langer, A.; The green laudry. 44th International Detergence Conference, Düsseldorf 2009

[46] http://www.topten.info/uploads/File/Efficient%20Heat%20Pump%20Dryers%20-%20EEDAL%2009.pdf

speeds of the washing machine is negligible compared to the reductions in thermal energy demand of the dryers.[47] However this design option is not suitable for all garments.

- Efficient Laundry Management Information Systems (LMIS) enable to spare resources: important machine and process data is easily available, including for example the machine load. The consumption of chemicals, water and energy to a large extent depends on optimal utilisation of the machine, and can be monitored with such a system.[48] With the help of LMIS it is possible to find out which machines are using more resources and therefore which ones could be replaced from the environmental point of view. Further, especially for hospitals where disinfection programmes are used this system serves as data documentation to comply with legislation.

Such concepts at system level could result in considerable savings. However, the infra-structural and systemic approaches are highly dependent on site-specific boundaries and side conditions like

- amount and kind of laundry,
- existing energy infrastructure,
- existing equipment to be integrated into an energy flow system and
- degree of on-premise laundry (OPL), i.e. need of internal logistics and differentiation of division of work respectively.

Thus, such concepts can not be considered more detailed in this study at a quantitative level.

[47] Öko-Institut e.V.; Rüdenauer, I.; Gensch, C.-O.; Quack, D.; Eco-Efficiency Analysis of Washing machines – Life Cycle Assessment and determination of optimal life span. Freiburg 2004.

[48] Association Internationale de la Savonnerie, de la Détergence et des Produits d'Entretien (2000), Professional laundry and the environment

5 Annex

5.1 Questionnaires for stakeholders

These questionnaires are provided separately:

- EuP_Lot24_Wash_T6_Final_Questionnaire.xls
- EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

5.2 Stakeholder feedback to draft versions of Task 6

Please note that the feedback refers to prior versions of draft Task 6 report; thus, the indicated numerations of chapters, tables, figures or pages might have changed.

Feedback		**Comment**
Xeros Ltd.		
Comment on Draft Final task 6	Throughout the report: Change the word to 'pellet' to 'bead'	included
	Section 2.2.1 / T 1.13: Change the level of estimated savings to 60% for water, detergent and energy Change the date for coming to market to 2011/12	included
	Section 2.3 / table 3 / T1.13: Energy 60%, Water 60% Advantages: saves significant energy, water and detergent Drawbacks: technology not yet validated in the market	included
	Section 2.3 text and table 4: Should the polymer beads not be considered for Task 7 since we are able to quantify potential savings? I accept that it is a more radical change than the other technologies highlighted for inclusion and that independent verification of the wash performance and savings is not yet available to you or to other stakeholders.	included
	With reference to your table 3 in 2.2.1, is it really true in T 1.14 that Ozone is proven to have no influence on washing performance? We are not using ozone, but I do know that there are machines on the market that have ozone so it is somewhat surprising that it does not work!	noted

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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

May 2011

Final Report, Part:
Washing Machines and Dryers

Task 7: Improvement Potential

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For reasons of better readability, two Task 7 reports were prepared.

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

The Task 7 report on *professional dishwashers*
is published separately.

For the benefit of the environment, this document has been optimised for **double-sided printing**.

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1 Introduction

1.1 Objective of Task 7

The objective of Task 7 is to assess the environmental and economic impacts of the base cases with the improvement options identified in Task 6. Impacts include the monetary consequences in terms of Life Cycle Cost (LCC) for the user, environmental costs and benefits, economic and social impacts. The solution with the Least Life Cycle Cost (LLCC) and the Best Available Technology (BAT) will be highlighted. The available design options are investigated by assessing the environmental impact and LCC of each against the base case using the MEEuP EcoReport, as in Task 5.

The assessment of LCC is relevant to indicate how design solutions might affect total user expenditure over the total product lifetime (purchase, operating and end-of-life costs). The gap between the LLCC option and the BAT indicates the remaining room for product-differentiation (competition), in cases where the LLCC option is set as a minimum target. The BAT represents a short- to medium-term target, for which promotional measures would probably be more appropriate than restrictions. The Best Not yet Available Technology (BNAT) gives an idea of long-term possibilities and helps to define the exact scope and definition of any possible measures.

2 Design options

The Technical Analysis of BAT (Task 6) identified and described individual design options for environmental improvement according to the usual criteria:

- The design option(s) should not change significantly the functionality or performance parameters compared to the base case.
- The design option(s) should have a significant potential for improvement regarding at least one of the following eco-design parameters without deteriorating others: consumption of energy, water and other resources, use of hazardous substances, emissions to air, water or soil, weight and volume of the product, use of recycled material, quantity and nature of consumables needed for proper use and maintenance, ease of reuse and recycling, extension of lifetime or amount of waste generated.
- The design option(s) should not entail excessive costs. Redesign, testing, investment and/or production costs should be investigated, taking into account economies of scale, sector-specific margins and market structure, and the time required for market penetration of the new design option(s) and replacement of the existing products. Assessment of the costs includes an estimation of possible price increase due to

implementation of the design option either by looking at product prices on the market and/or by applying a production cost model with sector-specific margins.

- In the following section, the influence of the implementation of the improvement options on base case products is assessed in more detail.

NOTE: The following calculations only reflect technical design options. Transversely to all base cases, there is also **improvement potential at infrastructural level**, by changing the energy source for heating the water or air in professional washing machines and dryers from electricity to more efficient alternative heating (e.g. gas or steam). In Section 3.15 of Task 5, we exemplified calculations of such an infrastructural change for the base cases WM1 and D4. The results show that for both professional washing machines and dryers, the alternative heating product scores better for all environmental impacts. Furthermore, the better environmental performance of the alternative heated products goes along with important monetary savings for the customer and no additional costs for the manufacturer.

2.1 Description of individual design options

Based on the currently applied BAT design options, the general constraints with regard to implementation and combination possibilities and the infeasibility to quantify the improvement potential of some options, fourteen design options were chosen for further proceedings.

For these selected design options, manufacturers were asked to quantify the concrete saving potential and price differences compared to the base case products as defined in Task 5. The inquiry was sent out to manufacturers (see Annex 8). The following tables in Section 2 present the aggregated and averaged results of filled in questionnaires.[1] Against this background, we strongly point out again to the **important note about the assessment of data quality** (see Task 6, Section 1.2).

The improvement options are applicable to washing machines that will be analysed in this task (all options do not necessarily apply to all base cases; for detailed description, see 2.2.1 in Task 6):

- **M 1.1: Increased motor efficiency**: enhancing the efficiency of the motor would enable some energy savings within the professional washing machine. A three-phase system is more economical compared to a single- or two-phase system or a direct current motor at the same voltage.
- **M 1.2: Heat exchanger**: it enables energy savings by recovering partly the energy contained in the warm wastewater. Different technological alternatives of heat exchangers are available.

[1] Responses received from five manufacturers.

- **M 1.3: Water recovery systems**: washing machines with a water recycling system collect the wash water from all previous rinse cycles for a re-use in the next prewash and main wash cycle, thus decreasing the amount of fresh water required.
- **M 1.4: Load control**: the machine is equipped with sensors that evaluate the load weight and the degree of soiling of the laundry, adapting consequently the amount of water and detergent needed as well as the programme duration.
- **M 1.5: Further control systems**: automated dosage systems are often used for dispensing the liquid detergents, powders, pastes or additives (bleach, alkali) for the prewash, main wash and the fabric softener for the final rinse.
- ***M 1.6: Ozone technology****: Ozone works as bleaching agent at low temperatures and furthermore shortens wash time cycles so that energy savings are possible. As we did not receive any data on the specific savings potential and costs, this option is not included in the following calculations.*
- **M 1.7: Drum construction:** in recent years, the drums of professional washing machines had cylindrical perforations resulting in an inter-fibre friction caused by the rough edges. Better drum design can be used to protect delicate textile fibres.
- ***M 1.8: Wash process with lower temperature****: Changing user behaviour by lowering the wash temperatures might result in energy savings. However, the possible application depends on the specific hygiene demands in the respective customer segments and might require reformulated detergents to receive same hygiene performance at lower temperatures. This option is not included in the following calculations.*
- Along with these seven individual design options, one overall combination of design options will be added for each base case. This option will be labelled **Best Available (BA) product** (see Section 2.2).

For dryers, the possible options implemented will be (for detailed description, see 3.2.1 in Task 6):

- **M 2.1: Increased motor efficiency**: optimizing the motor control system (adaptive acceleration, speed, positional control, and agitation patterns) would provide possible improvements regarding the energy consumption, the uniformity of drying and a gentler treatment of the laundry.
- **M 2.2: Heat pump**: the energy consumption of a dryer with heat pump can be reduced by approximately 40 to 60% compared to a conventional condenser dryer. A heat pump consists of a refrigeration loop containing a refrigerant steam compressor, an evaporator heat exchanger, a condensing heat exchanger, and an expansion valve.
- **M 2.3: Heat recovery systems**: heat recovery systems are usually based on a heat exchange principle by using the warm exhaust air produced by the tumble dryer to

preheat the cold inlet air. This system leads to energy savings, especially when the incoming air is not exceeding 24°C.

- **M 2.4: Improved air flow system**: tumble dryers can be equipped with different air flow systems (axial, radial, mixed or others).
- **M 2.5: Load Control**: weight sensors directly measure the weight of the load and can adapt the drying process in case of partial load.
- **M 2.6: Residual Moisture Control (RMC)**: the residual moisture control system promotes an optimal end-point determination to avoid both still wet laundry as a result of too short drying and over-drying by extended drying.
- **M 2.7: Improved insulation**: improved geometry and materials for the casing, drum, tubing, etc. shall ensure that as little heat as possible is lost to the surroundings.
- Along with these seven individual design options, one overall combination of design options will be added for each base case. This option will be labelled **Best Available (BA) product** (see 2.2).

The following subsections will summarise the changes in an improved product that would result from the implementation of the various single design options (and their combination) in each base case.

The parameters of the analysis that are kept constant are the same which were used for the base case analysis (see Task 5). Table 1 and Table 2 first summarize the capacities, prices and consumption values of the base cases as defined in Tasks 3, 4 and 5. These values represent the 100% baseline for the assessment of the design options as provided in the following subsections.

Table 1 Capacities, prices and consumption values of professional washing machines bases cases

Parameters	WM 1 Semi-prof. washer extractor	WM 2 Prof. washer extractor, <15 kg	WM 3 Prof. washer extractor, 15–40 kg	WM 4 Prof. washer extractor, > 40 kg	WM 5 Prof. washer dryer	WM 6 Prof. Barrier Washer	WM 7 Washing tunnel machine
Capacity per cycle (kg)	6	10	24	90	6	32	1 500 (kg/hour)
Typical market segment	Coin & Card, AHL	Coin & Card, AHL	Hospitality	Com-mercial Industrial Laundry	Hospitality	Healthcar e	Com-mercial Industrial Laundry
Nominal annual capacity (in kg laundry)	7 000	14 400	42 200	194 400	7 400	56 300	3 825 000
Main energy source to heat up the water	60% Electricity 40% Alternative	55% Electricity 45% Alternative	40% Electricity 60% Alternative	15% Electricity 85% Alternative	100% Electricity	25% Electricity 75% Alternative	100% Alternative

Parameters	WM 1 Semi-prof. washer extractor	WM 2 Prof. washer extractor, <15 kg	WM 3 Prof. washer extractor, 15–40 kg	WM 4 Prof. washer extractor, > 40 kg	WM 5 Prof. washer dryer	WM 6 Prof. Barrier Washer	WM 7 Washing tunnel machine
Purchase price (€)	2 670	5 000	15 250	58 750	8 000	38 250	390 000
Energy consumption (kWh/kg laundry)	0.15	0.17	0.21	0.35	0.8 (Wash and dry)	0.39	0.35
Water consumption (L/kg laundry)	9	12	13	14	10	16	6
Detergent consumption (g/kg laundry)	17	17	14	18	14	18	9

Table 2 Capacities, prices and consumption values of professional dryers bases cases

Parameters	D 1 Semi-prof. dryer, condenser	D 2 Semi-prof. dryer, air vented	D 3 Prof. Cabinet dryer	D 4 Prof. tumble dryer, <15 kg	D 5 Prof. tumble dryer, 15–40 kg	D 6 Prof. tumble dryer, >40 kg	D 7 Pass-through (transfer) tumble dryer
Capacity per cycle (kg)	6	6	8	10	23	70	400 (kg/hour)
Typical market segment	Coin & Card, AHL	Coin & Card, AHL	Coin & Card, AHL	Coin & Card, AHL	Hospitality	Commercial Industrial Laundry	Commercial Industrial Laundry
Nominal annual capacity (in kg laundry)	6 500	6 500	6 300	14 400	40 500	168 000	1 020 000
Main energy source to heat up the air	100 % Electricity	65% Electricity 35% Alternative	100 % Electricity	45% Electricity 55% Alternative	30% Electricity 70% Alternative	10% Electricity 90% Alternative	100 % Alternative heating
Purchase price (€)	1 970	1 680	3 500	4 000	7 125	21 500	62 500
Energy consumption (kWh/kg laundry)	0.6	0.56	0.75	0.55	0.65	0.85	0.80

2.1.1 Bill of materials

The implementation of improvement options can involve the addition of components to enhance product performance (e.g. heat pump). These components increase the quantity of raw materials required to manufacture the product, the weight and volume, as well as the quantity of materials discarded at the end-of-life of the laundry appliance. Tables 3, 4 and 5 list the additional materials required for each improvement option considered. The composition of heat pumps varies depending on the base case considered.

Table 3 Material composition of the design options for washing machines[2]

Design Option / Material category	M 1.1 Increased motor efficiency [g]	M 1.2 Heat exchanger [g]	M 1.3 Water recovery [g]	M 1.4 Load control [g]	M 1.5 Further control systems [g]	M 1.7 Drum construc-tion [g]
PP					+ 200	
Stainless steel	- 100	+ 8 000	+ 15 000		+ 2 500	- 200
Aluminium diecast		+ 3 000			+ 750	
Electronics				+ 200	+ 250	
Misc.					+ 100	

Table 4 Material composition of the design options for dryers[3]

Design Option / Material category	M 2.1 Increased motor efficiency [g]	M 2.2 Heat pump [g]	M 2.3 Heat re-covery from exhaust air [g]	M 2.4 Improved air flow system [g]	M 2.5 Load control [g]	M 2.6 Residual moisture control [g]	M 2.7 Improved insulation [g]
Bulk plastics		See Table below	+ 1 400				+ 200
PP				+ 500			
Stainless steel	- 200		+ 21 000	+ 500			
Copper wire			+ 850	+ 1 500			
Aluminium diecast			+4 700	+ 500			
Electronics				+ 100			
Misc.					+ 200	+ 100	

Table 5 Material composition of a heat pump, by dryer base case

Design Option / Material category	WM 1	WM 2	WM 3	WM 4	WM 5	WM 6
	M 2.2 Heat pump [g]					
Stainless steel	40 433	38 418	103 072	112 500	251 731	500 373
Copper wire	1 617	1 537	4 123	4 500	10 069	20 015
Aluminium diecast	9 165	8 708	23 363	25 500	57 059	113 418
Electronics	270	256	687	750	1 678	3 336
Refrigerant R-134a	431	410	1 099	1 200	2 685	5 337

[2] Sources: Task 6, Section 2.2.1.

[3] Sources: Task 6, Section 3.2.1

The additional weight of the heat pump was considered proportional to the weight of the base case dryer, and original data was obtained for base case WM 4. Data for the other base cases was then extrapolated by using the following composition within the heat pump: 75% stainless steel, 4.5% copper wire, 17% aluminium diecast, 1.2% electronics and 0.8% refrigerant (other materials were neglected).

According to manufacturers, the refrigerant R-134a is commonly used in laundry appliances heat pumps. Thus, this is the type of refrigerant used as an input in EcoReport. This refrigerant has a negligible ozone depletion potential and a 100-year Global Warming Potential of 1 430[4]. Fugitive and dumped refrigerant of 15% over the whole lifecycle is assumed.

2.1.2 Volume

It was assumed that the density of the complete product remains the same. Thus the change in volume of the packaged product between the base case and the product with the improvement option is the same than the change in mass. These values were calculated from the bills of materials (see Table 3, Table 4, and Task 5) and are shown in Table 6 and Table 7. Given the results of Task 5, this input has a very low influence on the final outcomes of the environmental analysis, and no influence at all on the economic analysis.

Table 6 Relative volume by improvement option in comparison with the base case, for washing machines[5]

	M 1.1 Increased motor efficiency	M 1.2 Heat ex-changer	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion
WM 1 Semi-professional washer extractor	1.00	1.14	1.20	1.00	1.05	1.00
WM 2 Professional washer extractor (<15kg)	1.00	1.05	1.07	1.00	1.02	1.00
WM 3 Professional washer extractor (15–40 kg)	1.00	1.02	1.02	1.00	1.00	1.00
WM 4 Professional washer extractor (>40kg)	1.00	1.00	1.01	1.00	1.00	n.a.
WM 5 Professional washer dryer	1.00	n.a.	n.a.	1.00	1.01	n.a.
WM 6 Professional barrier washer	1.00	1.01	1.01	1.00	1.00	n.a.
WM 7 Washing tunnel machine	1.00	1.00	n.a.	n.a.	n.a.	n.a.

[4] IPCC Fourth Assessment Report (AR4), 2007

[5] ‘n.a‘ means that the option cannot be implemented in the product category considered.

Table 7 Relative volume by improvement option in comparison with the base case, for dryers

	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual moisture control	M 2.7 Improved insulation
D 1 Semi-professional dryer, condenser	1.00	1.86	n.a.	1.05	1.00	1.00	1.00
D 2 Semi-professional dryer, air vented	1.00	1.86	1.49	1.05	1.00	1.00	1.00
D 3 Professional cabinet dryer	n.a.	1.86	1.18	1.02	n.a.	n.a.	1.00
D 4 Professional tumble dryer (<15 kg)	1.00	1.86	1.17	1.02	1.00	1.00	1.00
D 5 Professional tumble dryer (15 - 40 kg)	1.00	1.86	1.07	1.00	1.00	1.00	1.00
D 6 Professional tumble dryer (>40 kg)	1.00	1.86	1.04	1.00	1.00	1.00	1.00
D 7 Pass-through (transfer) tumble dryer	1.00	n.a	1.01	n.a	n.a	n.a	1.00

2.1.3 Energy consumption

The following tables (Table 8 and Table 9) show the overall energy performance improvement due to the single design options. Manufacturers' aggregated and averaged estimations on the changes in energy consumption are provided assuming the values of the base cases represent 100% each.

The savings are applied with the same proportions for electricity consumption and heat input than the split assumed in the definition of the base cases: for example, if the energy consumption is reduced to 95% of the base case consumption, both the electricity consumption value and the heat input value are reduced by 5%. The underlying reason is that the base cases are 'virtual' product and that manufacturers gave estimations on the overall energy savings, which cannot be directly linked to a specific part of the machine. Like in Task 5, the alternative heating option selected in EcoReport for the heat input is a gas boiler (non-condensed) with an efficiency of 90%[6].

[6] Lower Heating Value

Table 8 Estimated energy savings potential by improvement option, for washing machines [7]

	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion
WM 1 Semi-professional washer extractor	99%	90%	90%	85%	90%	99%
WM 2 Professional washer extractor, <15kg	99%	90%	90%	83%	93%	98%
WM 3 Professional wash-er extractor, 15-40 kg	99%	90%	90%	83%	95%	98%
WM 4 Professional washer extractor, >40kg	99%	77%	70%	90%	97%	n.a.
WM 5 Professional washer dryer	99%	n.a.	n.a.	80%	90%	n.a.
WM 6 Professional barrier Washer	99%	77%	70%	90%	97%	n.a.
WM 7 Washing tunnel machine	99%	70%	(incl. in base case)	(incl. in base case)	(incl. in base case)	n.a.

Table 9 Estimated energy savings potential by improvement option, for dryers [8]

	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Im-proved air flow system	M 2.5 Load control	M 2.6 Residual moisture control	M 2.7 Im-proved insula-tion
D 1 Semi-professional dryer, condenser	98%	45%	n.a.	90%	90%	90%	90%
D 2 Semi-professional dryer, air vented	98%	50%	90%	90%	90%	90%	90%
D 3 Professional cabinet dryer	n.a.	40%	90%	90%	n.a.	n.a.	90%
D 4 Professional tumble dryer, <15 kg	97%	40%	90%	92%	88%	88%	93%
D 5 Professional tumble dryer, 15-40 kg	98%	40%	91%	89%	90%	90%	94%
D 6 Professional tumble dryer´, >40 kg	99%	40%	92%	95%	95%	95%	98%
D 7 Pass-through (transfer) tumble dryer	99%	n.a.	88%	n.a.	(incl. in the tunnel washer associated)	n.a.	97%

[7] Source: Manufacturers' questionnaires

[8] Source: Manufacturers' questionnaires

2.1.4 Water and detergent consumption

In Table 10 and Table 11, manufacturers' aggregated and averaged estimations on the change in the water and detergent consumption are provided, assuming the values of the base cases represent 100% each.

Table 10 Relative water consumption by improvement option, in comparison with the base case, for professional washing machines[9]

	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion
WM 1 Semi-professional washer extractor	100%	100%	70%	80%	90%	99%
WM 2 Professional washer extractor (<15kg)	100%	100%	70%	78%	93%	98%
WM 3 Professional wash-er extractor (15-40 kg)	100%	100%	70%	78%	95%	98%
WM 4 Professional washer extractor (>40kg)	100%	100%	63%	78%	97%	n.a.
WM 5 Professional washer dryer	100%	n.a.	n.a.	70%	90%	n.a.
WM 6 Professional barrier washer	100%	100%	63%	78%	97%	n.a.
WM 7 Washing tunnel machine	100%	100%	n.a.	n.a.	n.a.	n.a.

9 Source: Manufacturers' questionnaires

Table 11 Relative detergent consumption by improvement option, in comparison with the base case, for professional washing machines[10]

	M 1.1 Increased motor efficiency	M 1.2 Heat ex-changer	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion
WM 1 Semi-professional washer extractor	100%	100%	85%	80%	90%	99%
WM 2 Professional washer extractor (<15kg)	100%	100%	85%	80%	95%	98%
WM 3 Professional washer extractor (15-40 kg)	100%	100%	85%	80%	95%	98%
WM 4 Professional washer extractor (>40kg)	100%	100%	63%	78%	97%	n.a.
WM 5 Professional washer dryer	100%	n.a.	n.a.	70%	90%	n.a.
WM 6 Professional barrier washer	100%	100%	68%	78%	98%	n.a.
WM 7 Washing tunnel machine	100%	100%	n.a.	n.a.	n.a.	n.a.

2.1.5 Prices and costs

The changes in purchase prices are shown in Table 12 and Table 13. The maintenance and repair costs of improved products are assumed to represent the same share of the purchase price as for the base cases: 3% for WM 1-2-3-5 and D 1-2-3-4-5, 25% for WM 4-6-7 and 18% for D 6-7. As a result, they change in the same way as purchase prices. Manufacturers' aggregated and averaged estimations on the change in prices are provided assuming the values of the base cases represent 100% each.

Installation costs represent around 4% of the purchase price for most appliances, except for WM 7 and D 7 for which they account for 9%. These costs are considered to be constant in comparison with the base cases, except for options M 1.2, M 1.3, M 1.6, M 2.2 and M 2.3 which require the installation of additional modules. For these options, the installation costs will be assumed to follow the same variation than the purchase prices and repair costs, presented in the table below.

[10] Source: Manufacturers' questionnaires

Table 12 Purchase prices (and repair costs) by improvement option in comparison with the base case, for professional washing machines [11]

	M 1.1 Increased motor efficiency	M 1.2 Heat ex-changer*	M 1.3 Water recovery*	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion
WM 1 Semi-professional washer extractor	102%	105%	150%	116%	107%	103%
WM 2 Professional washer extractor (<15kg)	102%	105%	150%	116%	101%	102%
WM 3 Professional washer extractor (15-40 kg)	102%	105%	150%	116%	101%	102%
WM 4 Professional washer extractor (>40kg)	102%	120%	130%	112%	103%	n.a.
WM 5 Professional washer dryer	102%	n.a.	n.a.	102%	100%	n.a.
WM 6 Professional barrier washer	102%	120%	130%	112%	103%	n.a.
WM 7 Washing tunnel machine	105%	115%	n.a.	n.a.	n.a.	n.a.

Table 13 Purchase prices (and repair costs) by improvement option in comparison with the base case, for professional dryers [11]

	M 2.1 Increased motor efficiency	M 2.2 Heat pump*	M 2.3 Heat re-covery from exhaust air*	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual moisture control	M 2.7 Improved insulation
D 1 Semi-professional dryer, condenser	103%	180%	n.a.	108%	110%	110%	110%
D 2 Semi-professional dryer, air vented	103%	160%	130%	108%	110%	110%	110%
D 3 Professional cabinet dryer	n.a.	200%	130%	105%	n.a.	n.a.	110%
D 4 Professional tumble dryer (<15 kg)	102%	180%	123%	105%	115%	105%	105%
D 5 Professional tumble dryer (15-40 kg)	102%	180%	124%	106%	114%	109%	106%
D 6 Professional tumble dryer (>40 kg)	102%	180%	137%	108%	111%	115%	109%
D 7 Pass-through (transfer) tumble dryer	106%	n.a.	116%	n.a.	n.a.	n.a.	109%

[11] Source: Manufacturers' questionnaires. For options with *, the installation costs follow the evolutions given in the table. For other options, they are assumed constant (same value than for the base case product).

2.2 Combination of design options: Best available products

Most of the improvement options presented can be implemented at the same time in a single product but the marginal savings decrease with the number of options implemented.

The objective of this section was to find out the lowest, technically achievable energy and water consumption by using all available and technically feasible improvement options and best available technology components. Because carrying out a thorough analysis of the marginal savings for each combination of improvement options would not be realistic and because the data obtained through the Tasks 6-7 questionnaire was not substantially completed by all manufacturers, only the overall combination of improvement options for each BC is presented in this task. This corresponds to the best available product (BA product) on the market and the results are based on existing products produced by manufacturers. The individual design options that are implemented in the BA product for each BC are presented in Table 14 for washing machines and Table 15 for dryers.

No BA product was taken into account for the BC WM 5 washer dryer as the variety of models currently offered for this product category is relatively low and already represented by the single improvement options.

Table 14 Description of the best available products, for washing machines [12]

	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion
WM 1 Semi-professional washer extractor	Yes	Yes	-	Yes	Yes	Yes
WM 2 Professional washer extractor (<15kg)	Yes	Yes	-	Yes	Yes	Yes
WM 3 Professional washer extractor (15-40 kg)	Yes	Yes	-	Yes	Yes	Yes
WM 4 Professional washer extractor (>40kg)	Yes	Yes	-	Yes	Yes	-
WM 6 Professional barrier washer	Yes	Yes	-	Yes	Yes	-
WM 7 Washing tunnel machine	Yes	Yes	Yes	Yes	Yes	-

[12] Source: Manufacturers questionnaires. This is an “average” Bill of Materials for the product as the best available products of different manufacturers do not necessarily implement the same technical improvement features. Given the low importance of the production phase in the overall environmental impacts, this approximation is estimated reasonable.

Table 15 Description of the best available products, for dryers[13]

	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual moisture control	M 2.7 Improved insulation	Infrared control
D 1 Semi-professional dryer, condenser	Yes	Yes	-	Yes	Yes	Yes	Yes	-
D 2 Semi-professional dryer, air vented	Yes	-	Yes	Yes	Yes	Yes	Yes	-
D 3 Professional cabinet dryer	-	Yes	-	Yes	-	-	Yes	-
D 4 Professional tumble dryer (<15 kg)	Yes	Yes	-	Yes	Yes	Yes	Yes	-
D 5 Professional tumble dryer (15 - 40 kg)	Yes	Yes	-	-	Yes	Yes	Yes	-
D 6 Professional tumble dryer (>40 kg)	Yes	Yes	-	-	Yes	Yes	Yes	-
D 7 Pass-through (transfer) tumble dryer	Yes	-	Yes	-	Yes	-	Yes	Yes

The bills of materials of these BA products are directly derived from Table 3, by adding the indicated components of relevant options to the composition of the corresponding base case.

The energy and water consumption and price changes in comparison with the base cases were obtained from manufacturers' information and are summarised in Table 16 and Table 17. In terms of energy consumption, the base case WM 7 shows the highest improvement potential with the BA product consuming 65% of the initial consumption of the base case. The same situation happens for water and detergent consumption (50% reduction), while the purchase price increases by 30%. For dryers, the BA product of base case D3 has the highest reduction (68%, i.e. 32% of the base case consumption) in energy consumption while its price goes up to 250% of the base case purchase price. In general, the increase of the purchase price of the BA products is less important (in %) for large capacity machines (e.g. 130% for D7 but 250% for D1), as their purchase prices are larger in absolute values.

[13] Source: Manufacturers' questionnaires. This is an "average" Bill of Materials for the product as the best available products of different manufacturers do not necessarily implement the same technical improvement features. Given the low importance of the production phase in the overall environmental impacts, this approximation is estimated reasonable.

Table 16 Changes in the volume, energy water and detergent consumption and of the purchase price for BA products, for professional washing machines [14]

	BA product of					
	WM 1	**WM 2**	**WM 3**	**WM 4**	**WM 6**	**WM 7**
Volume	**119%**	**106%**	**102%**	**106%**	**101%**	**100%**
Overall energy consumption	**72%**	**79%**	**81%**	**77%**	**77%**	**65%**
Overall water consumption	**63%**	**77%**	**78%**	**77%**	**78%**	**50%**
Overall detergent consumption	**63%**	**79%**	**80%**	**78%**	**78%**	**50%**
Purchase price (and repair and maintenance costs)	**200%**	**125%**	**130%**	**135%**	**135%**	**130%**

Table 17 Changes in the volume, energy and water consumption and of the purchase price for BA products, for professional dryers [14]

	BA product of						
	D 1	**D 2**	**D 3**	**D 4**	**D 5**	**D 6**	**D 7**
Volume	**192%**	**155%**	**188%**	**188%**	**186%**	**186%**	**101%**
Overall energy consumption	**33%**	**75%**	**32%**	**33%**	**40%**	**40%**	**75%**
Purchase price (and repair and maintenance costs)	**250%**	**150%**	**250%**	**180%**	**180%**	**180%**	**141%**

[14] Source: Manufacturers' answers through questionnaire. The change in volume was assessed from the change in mass in the Bills of Materials.

3 Impacts analysis

The aim of this sub-task is to quantify the environmental benefits and impacts of the different improvement options. All relevant design improvements are investigated to see how the design option affects the output values of the EcoReport. It is likely that the impact assessment will reveal trade-offs between some impact categories for a given option. For example, an option with less greenhouse gas emissions might result in increased non-renewable material consumption or waste generation. An appropriate weighting of the different impact categories is not easy to establish, and this matter merits further discussion with the Commission and experts.

3.1 Base Case WM 1: Semi-professional washer extractor

The results of the environmental analysis of the improvement options for Base Case WM 1 are shown below. The BA product provides the greatest energy savings (28%). This option has the greatest savings in most indicators, but emits more PAHs, heavy metals and particulate matter than the base case product, due to the additional metal content. Option M 1.4 Load control is the single option that provides the highest energy savings (16%).

Table 18 Environmental impacts by improvement option for Base Case WM 1

Life cycle indicators per unit	Unit	Base Case WM 1	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construction	BA product
Other resources and waste									
Total Energy (GER)	**GJ**	135.9	135.0	128.4	122.2	114.5	123.5	134.6	97.9
	% change with BC	0%	-1%	-5%	-10%	-16%	-9%	-1%	-28%
of which, electricity	**primary GJ**	74.2	73.5	67.1	67.2	63.3	67.1	73.5	54.2
	MWh	7.1	7.0	6.4	6.4	6.0	6.4	7.0	5.2
	% change with BC	0%	-1%	-10%	-9%	-15%	-10%	-1%	-27%
Water (process)	**kL**	688.1	688.0	688.2	484.5	551.2	619.8	681.2	435.6
	% change with BC	0%	0%	0%	-30%	-20%	-10%	-1%	-37%
Water (cooling)	**kL**	196.5	194.5	177.1	177.1	167.2	177.0	194.5	142.0
	% change with BC	0%	-1%	-10%	-10%	-15%	-10%	-1%	-28%
Waste, non-haz./ landfill	**kg**	203.0	202.1	215.9	204.4	181.1	196.2	201.5	189.3
	% change with BC	0%	0%	6%	1%	-11%	-3%	-1%	-7%
Waste, hazardous/ incinerated	**kg**	12.3	12.3	12.1	12.0	12.0	12.3	12.3	11.9
	% change with BC	0%	0%	-1%	-3%	-3%	0%	0%	-3%
Emissions (Air)									
Greenhouse Gases in GWP100	**t CO2 eq.**	6.2	6.2	5.9	5.7	5.3	5.7	6.2	4.6
	% change with BC	0%	-1%	-5%	-9%	-15%	-9%	-1%	-26%
Acidification, emissions	**kg SO2 eq.**	32.3	32.1	31.1	29.7	27.4	29.6	32.0	24.1
	% change with BC	0%	-1%	-4%	-8%	-15%	-8%	-1%	-25%
Volatile Organic Compounds (VOC)	**kg**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	-1%	0%	0%	-9%	-3%	-1%	-9%
Persistent Organic Pollutants (POP)	**µg i-Teq**	1.1	1.1	1.1	1.1	0.9	1.0	1.1	0.9
	% change with BC	0%	-1%	4%	4%	-12%	-4%	-1%	-11%

Life cycle indicators per unit	Unit	Base Case WM 1	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construction	BA product
Heavy Metals	**g Ni eq.**	5.5	5.5	6.6	7.6	5.2	5.7	5.5	6.5
	% change with BC	0%	-1%	20%	37%	-6%	4%	-1%	18%
PAHs	**g Ni eq.**	0.6	0.6	0.9	0.6	0.6	0.7	0.6	1.0
	% change with BC	0%	0%	46%	-3%	-4%	11%	0%	53%
Particulate Matter (PM, dust)	**kg**	6.0	6.0	6.6	6.8	5.9	6.2	6.0	6.7
	% change with BC	0%	0%	10%	12%	-2%	3%	0%	11%
Emissions (Water)									
Heavy Metals	**g Hg/20**	2.6	2.6	3.4	3.9	2.6	2.9	2.6	3.7
	% change with BC	0%	-1%	29%	48%	0%	11%	-1%	40%
Eutrophication	**kg PO4**	69.1	69.1	69.1	58.8	55.3	62.2	68.4	43.6
	% change with BC	0%	0%	0%	-15%	-20%	-10%	-1%	-37%

Figure 1 shows the primary energy and electricity consumption (with the percentage of the primary energy that it represents) over the lifecycle. For all options, the share of electricity represents around 52-56% of the total energy consumption.

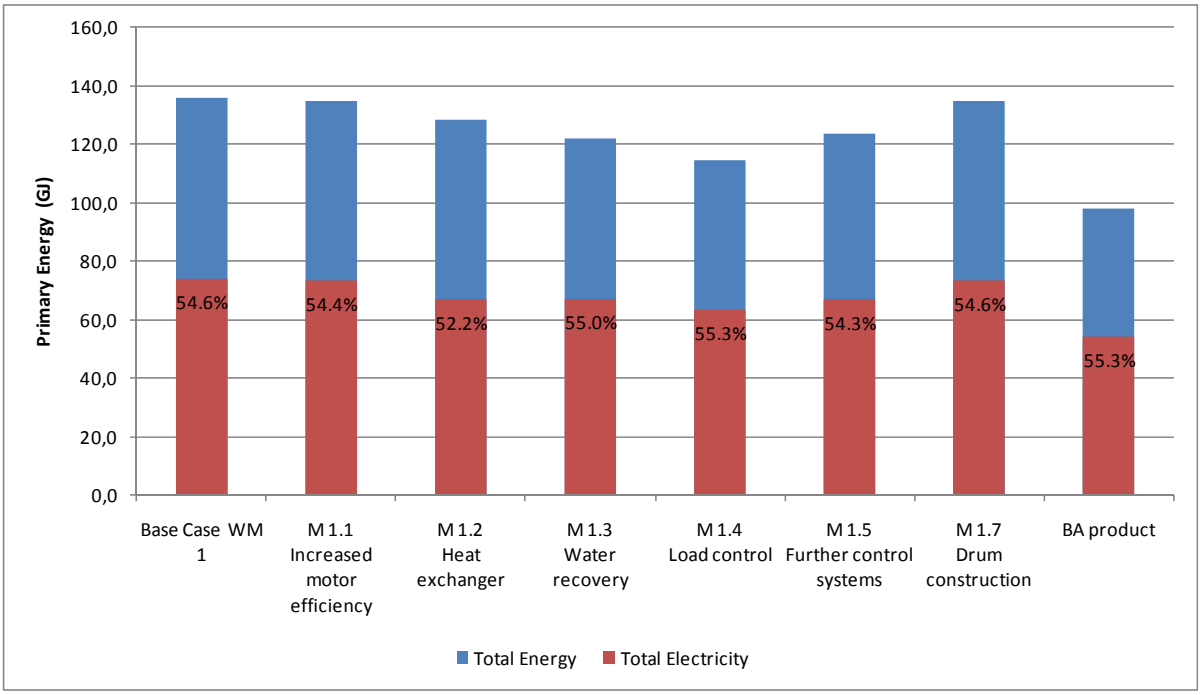


Figure 1 Energy consumption by improvement option for Base Case WM 1

The savings in other indicators are shown in Figure 2 below. Some options induce increase in PAHs emissions due to a larger metal content of the product.

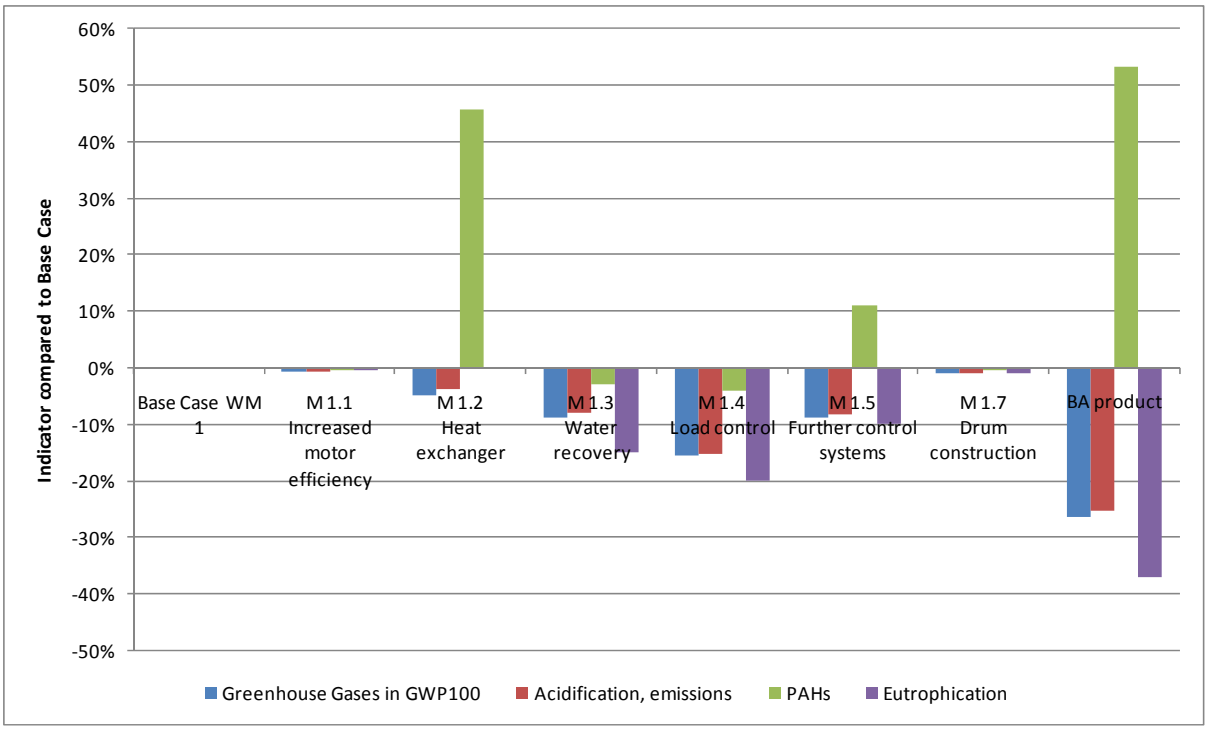


Figure 2 Improvement potential by improvement option for Base Case WM 1

3.2 Base Case WM 2: Professional washer extractor <15kg

The results of the environmental analysis of the improvement options for Base Case WM 2 are shown below.

The greatest energy savings are provided by the BA product. This savings are considered to be around 20%. The second greatest savings comes from option M 1.4 Load control (17%). This option also provides the greatest savings for many air emissions types (e.g. VOC, PAHs, heavy metals).

Table 19 Environmental impacts by improvement option for Base Case WM 2

Life cycle indicators per unit	Unit	Base Case WM 2	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
Other resources and waste									
Total Energy (GER)	**GJ**	449.7	446.6	420.7	401.6	373.0	422.7	441.1	361.5
	% change with BC	0%	-1%	-6%	-11%	-17%	-6%	-2%	-20%
of which, electricity	**primary GJ**	254.7	252.2	230.0	230.1	212.4	237.5	249.7	202.8
	MWh	24.3	24.0	21.9	21.9	20.2	22.6	23.8	19.3
	% change with BC	0%	-1%	-10%	-10%	-17%	-7%	-2%	-20%
Water (process)	**kL**	2 825.5	2 825.4	2 824.5	1 984.8	2 206.4	2 628.6	2 769.2	2 178.6
	% change with BC	0%	0%	0%	-30%	-22%	-7%	-2%	-23%
Water (cooling)	**kL**	667.4	660.7	601.0	601.1	554.3	620.9	654.1	527.9
	% change with BC	0%	-1%	-10%	-10%	-17%	-7%	-2%	-21%
Waste, non-haz./ landfill	**kg**	797.3	794.3	789.6	763.3	719.1	776.0	788.3	733.3
	% change with BC	0%	0%	-1%	-4%	-10%	-3%	-1%	-8%
Waste, hazardous/ incinerated	**kg**	18.4	18.3	17.8	17.3	16.9	18.1	18.2	17.0
	% change with BC	0%	0%	-3%	-6%	-8%	-1%	-1%	-8%
Emissions (Air)									
Greenhouse Gases in GWP100	**t CO2 eq.**	20.8	20.6	19.5	18.7	17.3	19.6	20.4	16.8
	% change with BC	0%	-1%	-6%	-10%	-17%	-6%	-2%	-19%
Acidification, emissions	**kg SO2 eq.**	106.1	105.4	100.3	95.6	88.5	100.2	104.1	86.6
	% change with BC	0%	-1%	-5%	-10%	-17%	-6%	-2%	-18%
Volatile Organic Compounds (VOC)	**kg**	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.2
	% change with BC	0%	-1%	-4%	-6%	-12%	-3%	-1%	-12%
Persistent Organic Pollutants (POP)	**µg i-Teq**	6.1	6.1	6.0	6.0	5.7	6.0	6.1	5.7
	% change with BC	0%	0%	-1%	-3%	-7%	-2%	-1%	-7%

Life cycle indicators per unit	Unit	Base Case WM 2	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
Heavy Metals	**g Ni eq.**	15.9	15.8	16.7	17.4	14.7	15.9	15.7	16.2
	% change with BC	0%	0%	5%	10%	-7%	0%	-1%	2%
PAHs	**g Ni eq.**	2.5	2.5	2.7	2.4	2.4	2.5	2.5	2.7
	% change with BC	0%	0%	10%	-3%	-5%	2%	-1%	10%
Particulate Matter (PM, dust)	**kg**	9.7	9.6	9.9	9.8	9.3	9.6	9.6	9.7
	% change with BC	0%	0%	2%	2%	-4%	0%	0%	0%
Emissions (Water)									
Heavy Metals	**g Hg/20**	8.8	8.8	9.5	10.0	8.6	9.0	8.8	9.7
	% change with BC	0%	0%	7%	13%	-2%	2%	-1%	10%
Eutrophication	**kg PO4**	212.4	212.4	212.4	180.6	170.0	201.8	208.2	167.9
	% change with BC	0%	0%	0%	-15%	-20%	-5%	-2%	-21%

The total electricity consumption represents approximately 56% of the primary energy consumption for all options.

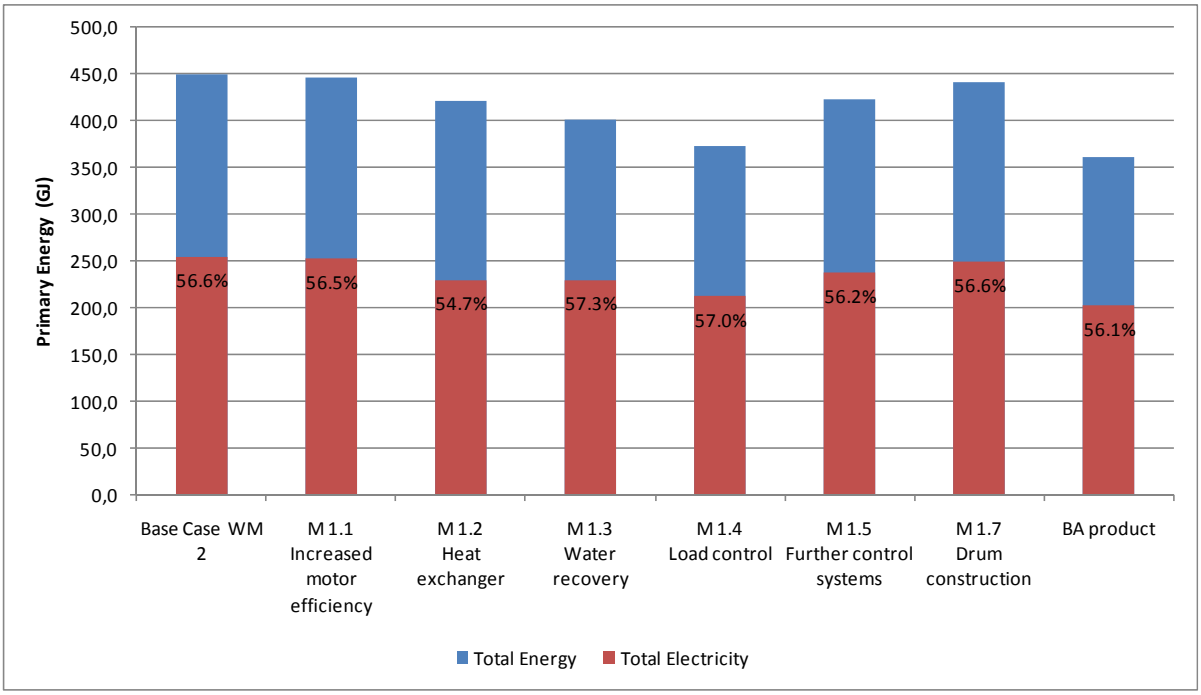


Figure 3 Energy consumption by improvement option for Base Case WM 2

The savings in other indicators are shown in the Figure 4 below. Some options induce increase in PAHs emissions due to a larger metal content of the product.

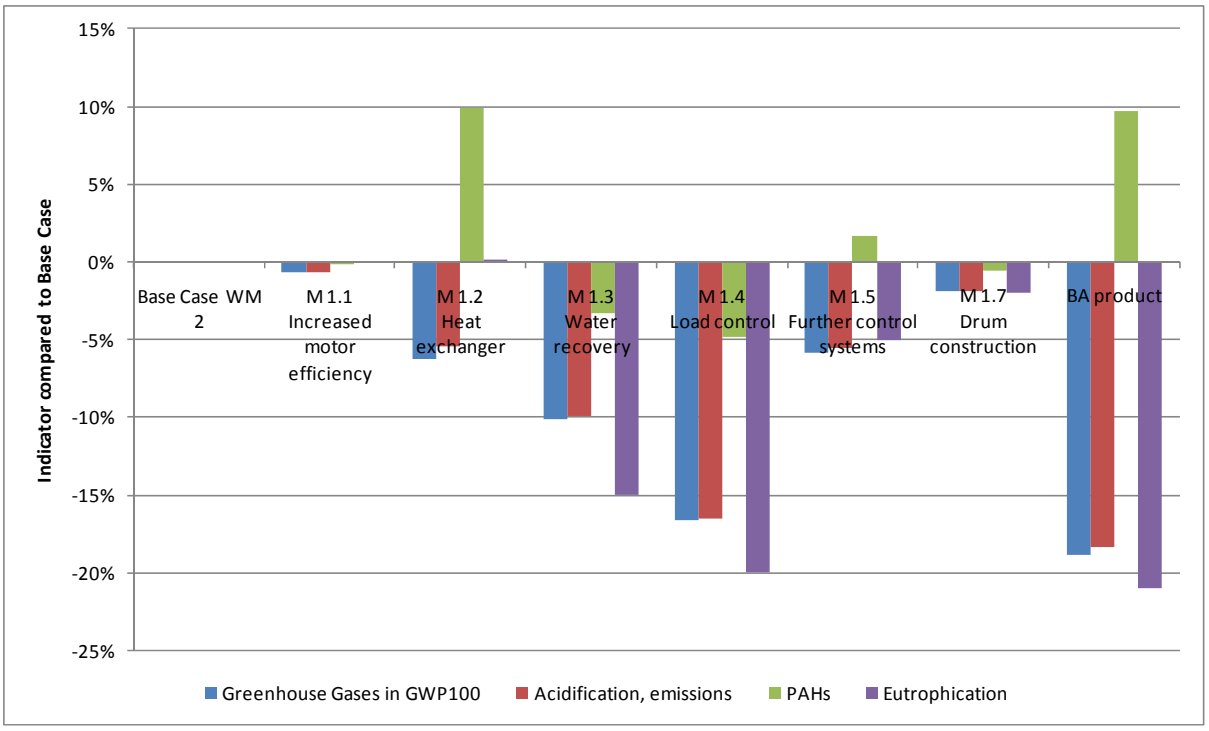


Figure 4 Improvement potential by improvement option for Base Case WM 2

3.3 Base Case WM 3: Professional washer extractor 15–40 kg

The results of the environmental analysis of the improvement options for Base Case WM 3 are shown below.

The BA product provides the greatest energy savings (19%), just before option M 1.4 Load control (17%). In terms of water used (process) and eutrophication, the option M 1.3 Water recovery reduces these impacts by 30% and 15 % respectively.

Table 20 Environmental impacts by improvement option for Base Case WM 3

Life cycle indicators per unit	Unit	Base Case WM 3	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
Other resources and waste									
Total Energy (GER)	**GJ**	1 514.1	1 502.9	1 403.4	1 350.0	1 252.7	1 440.7	1 484.6	1 231.7
	% change with BC	0%	-1%	-7%	-11%	-17%	-5%	-2%	-19%
of which, electricity	**primary GJ**	783.3	775.5	705.9	706.0	651.4	744.6	767.8	636.2
	MWh	74.6	73.9	67.2	67.2	62.0	70.9	73.1	60.6
	% change with BC	0%	-1%	-10%	-10%	-17%	-5%	-2%	-19%
Water (process)	**kL**	10 441.9	10 441.4	10 437.4	7 326.0	8 150.3	9 920.6	10 233.3	8 150.1
	% change with BC	0%	0%	0%	-30%	-22%	-5%	-2%	-22%
Water (cooling)	**kL**	2 106.0	2 085.3	1 900.3	1 899.3	1 754.2	2 002.9	2 064.6	1 714.5
	% change with BC	0%	-1%	-10%	-10%	-17%	-5%	-2%	-19%
Waste, non-haz./ landfill	**kg**	1 720.8	1 711.7	1 641.3	1 585.6	1 485.0	1 658.4	1 694.3	1 480.4
	% change with BC	0%	-1%	-5%	-8%	-14%	-4%	-2%	-14%
Waste, hazardous/ incinerated	**kg**	47.9	47.7	46.1	44.8	43.2	46.7	47.3	43.0
	% change with BC	0%	0%	-4%	-6%	-10%	-2%	-1%	-10%
Emissions (Air)									
Greenhouse Gases in GWP100	**t CO2 eq.**	70.6	70.1	65.4	63.1	58.5	67.2	69.2	57.6
	% change with BC	0%	-1%	-7%	-11%	-17%	-5%	-2%	-18%
Acidification, emissions	**kg SO2 eq.**	313.0	311.0	293.1	279.5	259.6	298.4	307.1	256.3
	% change with BC	0%	-1%	-6%	-11%	-17%	-5%	-2%	-18%
Volatile Organic Compounds (VOC)	**kg**	0.8	0.8	0.7	0.7	0.7	0.8	0.8	0.7
	% change with BC	0%	-1%	-7%	-9%	-15%	-4%	-2%	-16%
Persistent Organic Pollutants (POP)	**µg i-Teq**	11.8	11.7	11.3	11.0	10.4	11.4	11.6	10.4
	% change with BC	0%	0%	-4%	-6%	-11%	-3%	-1%	-11%

Life cycle indicators per unit	Unit	Base Case WM 3	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
Heavy Metals	**g Ni eq.**	41.5	41.3	41.4	41.5	38.0	40.9	41.1	39.3
	% change with BC	0%	0%	0%	0%	-8%	-1%	-1%	-5%
PAHs	**g Ni eq.**	2.8	2.8	2.7	2.6	2.4	2.7	2.8	2.4
	% change with BC	0%	-1%	-5%	-9%	-14%	-4%	-2%	-15%
Particulate Matter (PM, dust)	**kg**	26.4	26.3	26.2	26.0	25.2	26.2	26.2	25.5
	% change with BC	0%	0%	-1%	-1%	-4%	-1%	0%	-3%
Emissions (Water)									
Heavy Metals	**g Hg/20**	18.1	18.0	18.3	18.9	17.2	18.1	18.0	18.0
	% change with BC	0%	0%	1%	4%	-5%	0%	-1%	0%
Eutrophication	**kg PO4**	599.8	599.8	599.9	510.0	480.1	569.9	587.9	480.1
	% change with BC	0%	0%	0%	-15%	-20%	-5%	-2%	-20%

Figure 5 presents the proportions represented by electricity consumption amongst the total primary energy consumption.

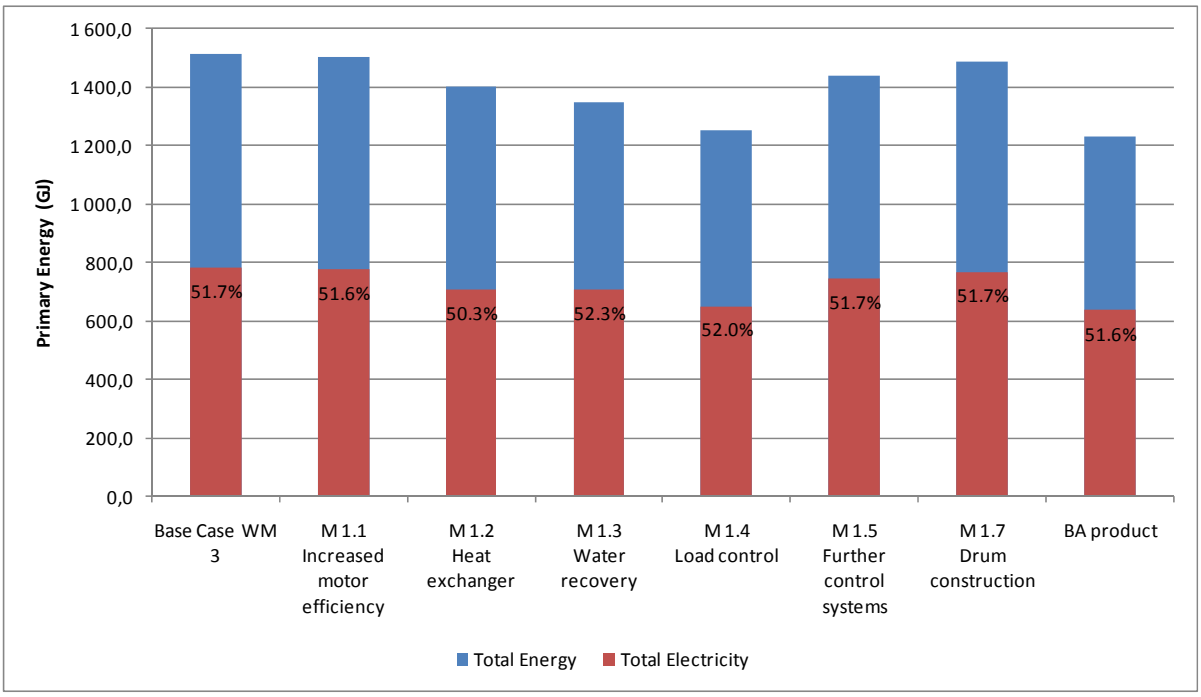


Figure 5 Energy consumption by improvement option for Base Case WM 3

The savings in other environmental indicators are shown in Figure 6 below.

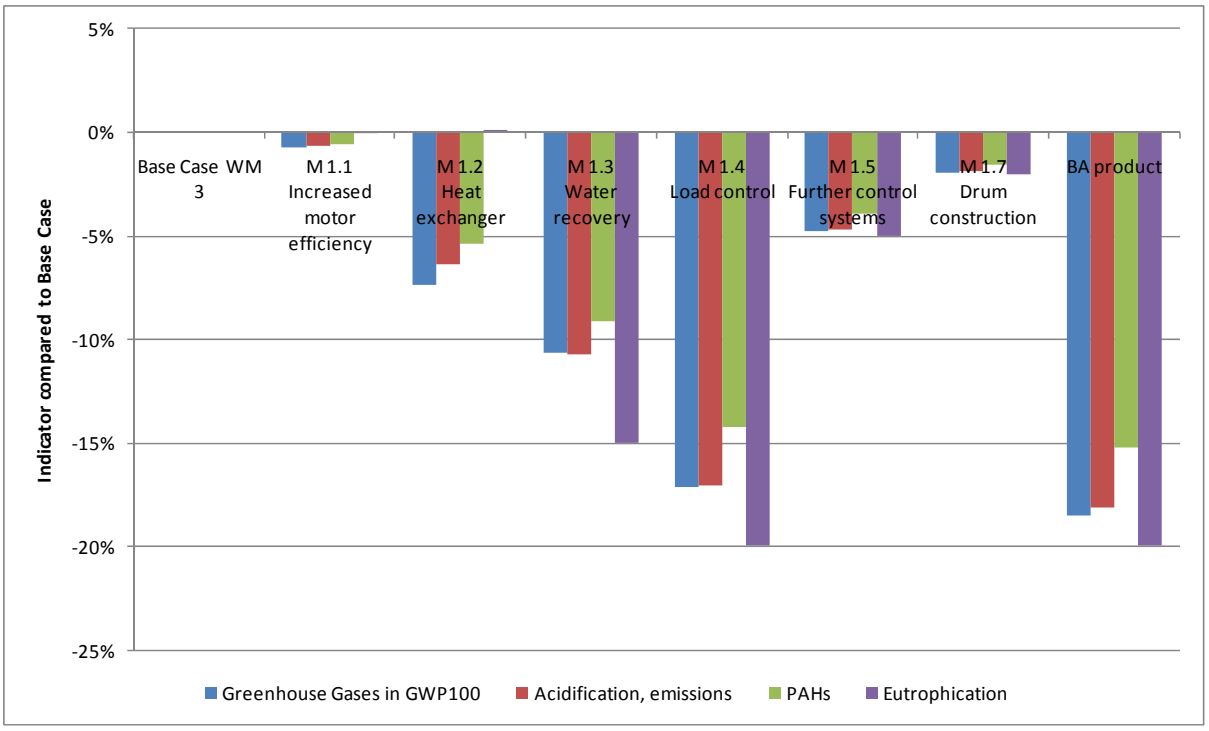


Figure 6 Improvement potential by improvement option for Base Case WM 3

3.4 Base Case WM 4: Professional washer extractor >40kg

The results of the environmental analysis of the improvement options for Base Case WM 4 are shown below.

In the case of the base case WM 4, option M 1.3 Water recovery provides the greatest reduction for all impacts. The savings in energy due to this option is 31%. The second greatest energy savings are due to the BA product (22%).

Table 21 Environmental impacts by improvement option for Base Case WM 4

Life cycle indicators per unit	Unit	Base Case WM 4	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	BA product
Other resources and waste								
Total Energy (GER)	**GJ**	10 193.4	10 113.4	8 354.0	7 047.8	8 949.6	9 893.3	7 910.9
	% change with BC	0%	-1%	-18%	-31%	-12%	-3%	-22%
of which, electricity	**primary GJ**	4 687.8	4 641.2	3 615.8	3 289.6	4 221.7	4 548.0	3 615.9
	MWh	446.5	442.0	344.4	313.3	402.1	433.1	344.4
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Water (process)	**kL**	49 390.3	49 387.2	49 319.4	31 154.6	38 571.1	47 910.0	38 041.6
	% change with BC	0%	0%	0%	-37%	-22%	-3%	-23%
Water (cooling)	**kL**	12 452.9	12 328.6	9 593.9	8 723.8	11 209.8	12 080.0	9 594.0
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Waste, non-haz./ landfill	**kg**	12 555.3	12 501.1	11 333.5	10 086.0	11 500.6	12 329.0	10 825.1
	% change with BC	0%	0%	-10%	-20%	-8%	-2%	-14%
Waste, hazardous/ incinerated	**kg**	230.3	229.2	205.6	180.9	209.3	225.8	195.5
	% change with BC	0%	0%	-11%	-21%	-9%	-2%	-15%
Emissions (Air)								
Greenhouse Gases in GWP100	**t CO2 eq.**	488.0	484.1	398.8	339.1	429.8	473.7	379.5
	% change with BC	0%	-1%	-18%	-31%	-12%	-3%	-22%
Acidification, emissions	**kg SO2 eq.**	1 866.0	1 853.5	1 578.3	1 297.4	1 625.7	1 813.0	1 463.6
	% change with BC	0%	-1%	-15%	-30%	-13%	-3%	-22%
Volatile Organic Compounds (VOC)	**kg**	5.4	5.4	4.5	3.9	4.8	5.3	4.3
	% change with BC	0%	-1%	-18%	-28%	-11%	-3%	-21%
Persistent Organic Pollutants (POP)	**µg i-Teq**	73.5	73.2	66.5	59.5	67.5	72.2	63.6
	% change with BC	0%	0%	-9%	-19%	-8%	-2%	-13%

Life cycle indicators per unit	Unit	Base Case WM 4	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	BA product
Heavy Metals	**g Ni eq.**	206.1	205.3	188.9	171.6	190.5	203.1	181.7
	% change with BC	0%	0%	-8%	-17%	-8%	-1%	-12%
PAHs	**g Ni eq.**	34.9	34.8	33.1	30.6	33.1	34.6	32.3
	% change with BC	0%	0%	-5%	-12%	-5%	-1%	-8%
Particulate Matter (PM, dust)	**kg**	104.5	104.2	98.6	92.7	99.4	103.5	96.3
	% change with BC	0%	0%	-6%	-11%	-5%	-1%	-8%
Emissions (Water)								
Heavy Metals	**g Hg/20**	95.0	94.7	88.9	87.3	92.0	94.3	89.1
	% change with BC	0%	0%	-6%	-8%	-3%	-1%	-6%
Eutrophication	**kg PO4**	3 377.8	3 377.7	3 377.7	2 128.6	2 635.0	3 276.5	2 635.0
	% change with BC	0%	0%	0%	-37%	-22%	-3%	-22%

Figure 7 presents the proportions represented by electricity consumption amongst the total primary energy consumption.

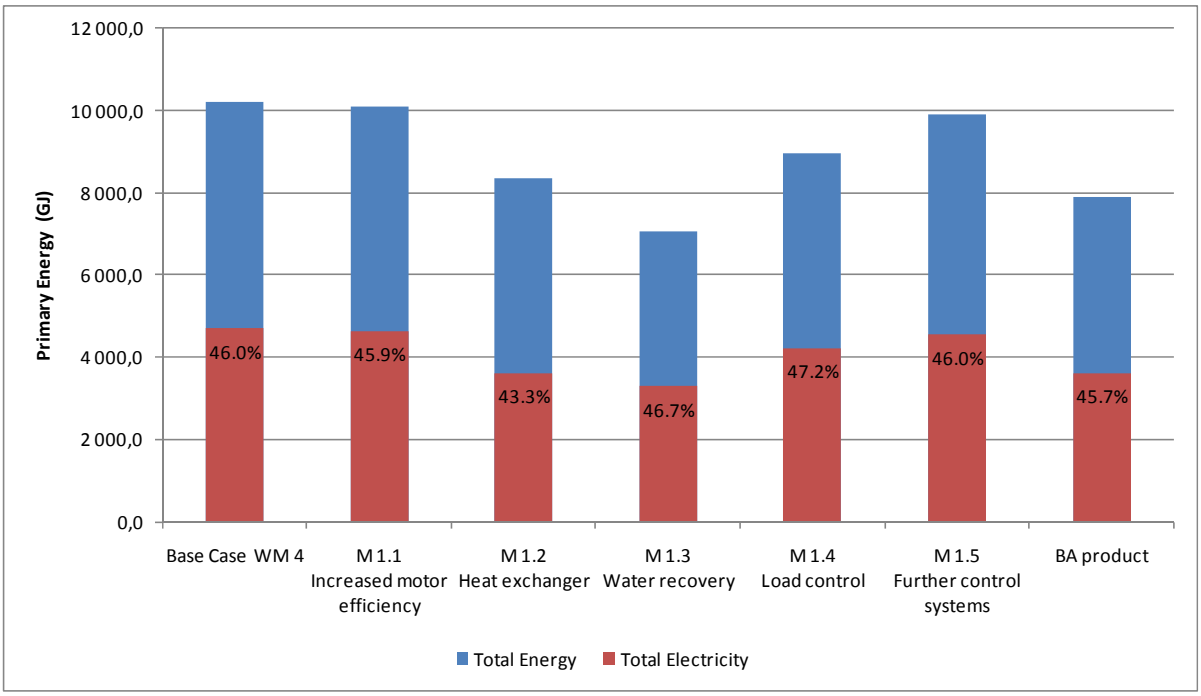


Figure 7 Energy consumption by improvement option for Base Case WM 4

The savings in other environmental indicators are shown in Figure 8 below.

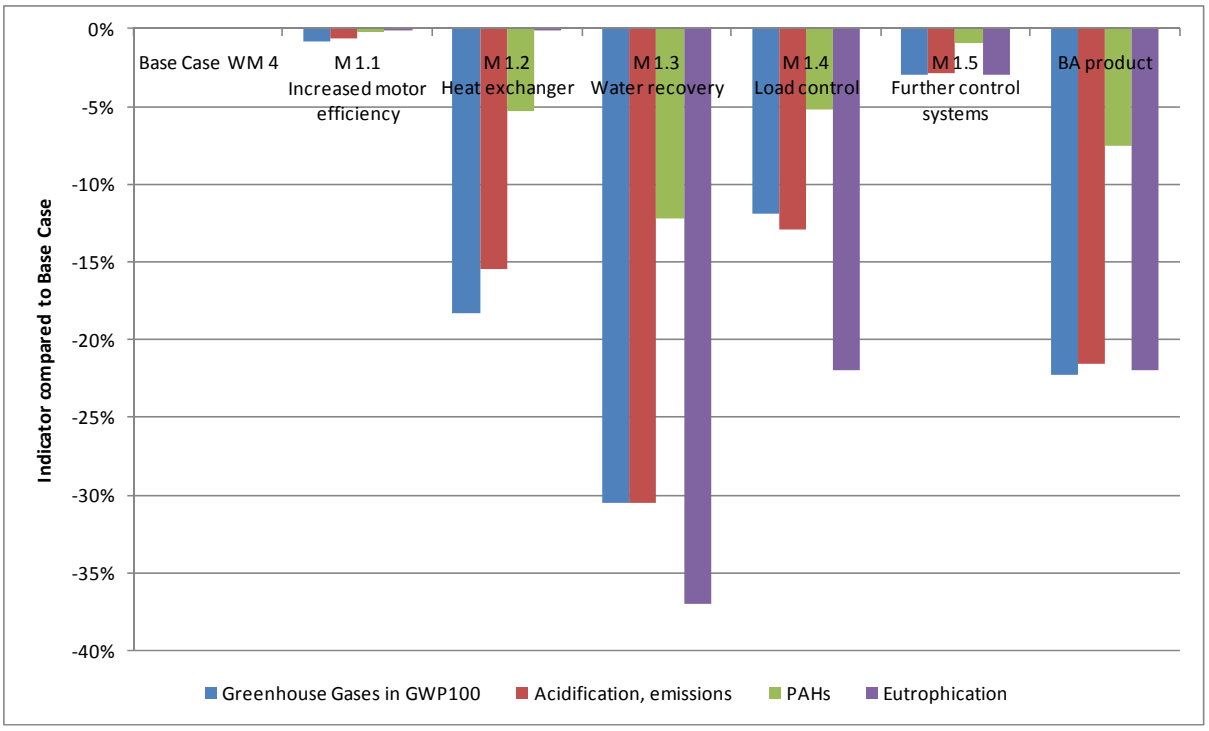


Figure 8 Improvement potential by improvement option for Base Case WM 4

3.5 Base Case WM 5: Professional washer dryer

The results of the environmental analysis of the improvement options for Base Case WM 5 are shown in Table 22. In terms of energy, the application of option M 1.4 Load control is the best option, reducing the energy consumption in about 20%. This option also represents the best improvement for all the other indicators, including water (process) and eutrophication.

Table 22 Environmental impacts by improvement option for Base Case WM 5

Life cycle indicators per unit	Unit	Base Case WM 5	M 1.1 Increased motor efficiency	M 1.4 Load control	M 1.5 Further control systems
Other resources and waste					
Total Energy (GER)	**GJ**	937.1	928.6	751.6	847.3
	% change with BC	0%	-1%	-20%	-10%
of which, electricity	**primary GJ**	865.4	856.8	694.6	780.1
	MWh	82.4	81.6	66.1	74.3
	% change with BC	0%	-1%	-20%	-10%
Water (process)	**kL**	1 165.3	1 164.8	824.0	1 050.0
	% change with BC	0%	0%	-29%	-10%
Water (cooling)	**kL**	2 282.7	2 260.0	1 826.9	2 054.9
	% change with BC	0%	-1%	-20%	-10%
Waste, non-haz./ landfill	**kg**	1 795.3	1 785.3	1 580.3	1 696.8
	% change with BC	0%	-1%	-12%	-5%
Waste, hazardous/ incinerated	**kg**	34.9	34.7	30.7	33.1
	% change with BC	0%	-1%	-12%	-5%
Emissions (Air)					
Greenhouse Gases in GWP100	**t CO2 eq.**	41.7	41.4	33.6	37.8
	% change with BC	0%	-1%	-19%	-9%
Acidification, emissions	**kg SO2 eq.**	245.1	242.9	197.3	222.1
	% change with BC	0%	-1%	-19%	-9%
Volatile Organic Compounds (VOC)	**kg**	0.5	0.5	0.4	0.5
	% change with BC	0%	-1%	-13%	-6%
Persistent Organic Pollutants (POP)	**µg i-Teq**	14.6	14.5	13.4	14.0
	% change with BC	0%	0%	-8%	-4%

Life cycle indicators per unit	Unit	Base Case WM 5	M 1.1 Increased motor efficiency	M 1.4 Load control	M 1.5 Further control systems
Heavy Metals	**g Ni eq.**	23.6	23.4	20.4	22.4
	% change with BC	0%	-1%	-13%	-5%
PAHs	**g Ni eq.**	3.6	3.6	3.3	3.6
	% change with BC	0%	0%	-10%	-2%
Particulate Matter (PM, dust)	**kg**	17.6	17.5	16.6	17.2
	% change with BC	0%	0%	-6%	-2%
Emissions (Water)					
Heavy Metals	**g Hg/20**	13.8	13.7	12.8	13.6
	% change with BC	0%	0%	-8%	-2%
Eutrophication	**kg PO4**	82.7	82.7	58.0	74.5
	% change with BC	0%	0%	-30%	-10%

Figure 9 presents the proportions represented by electricity consumption amongst the total primary energy consumption. From the figure it is clear that the electricity consumption of this base case is rather high (it is considered 100% electric heating, on the contrary to the other base cases). It represents more than 90% for all the options.

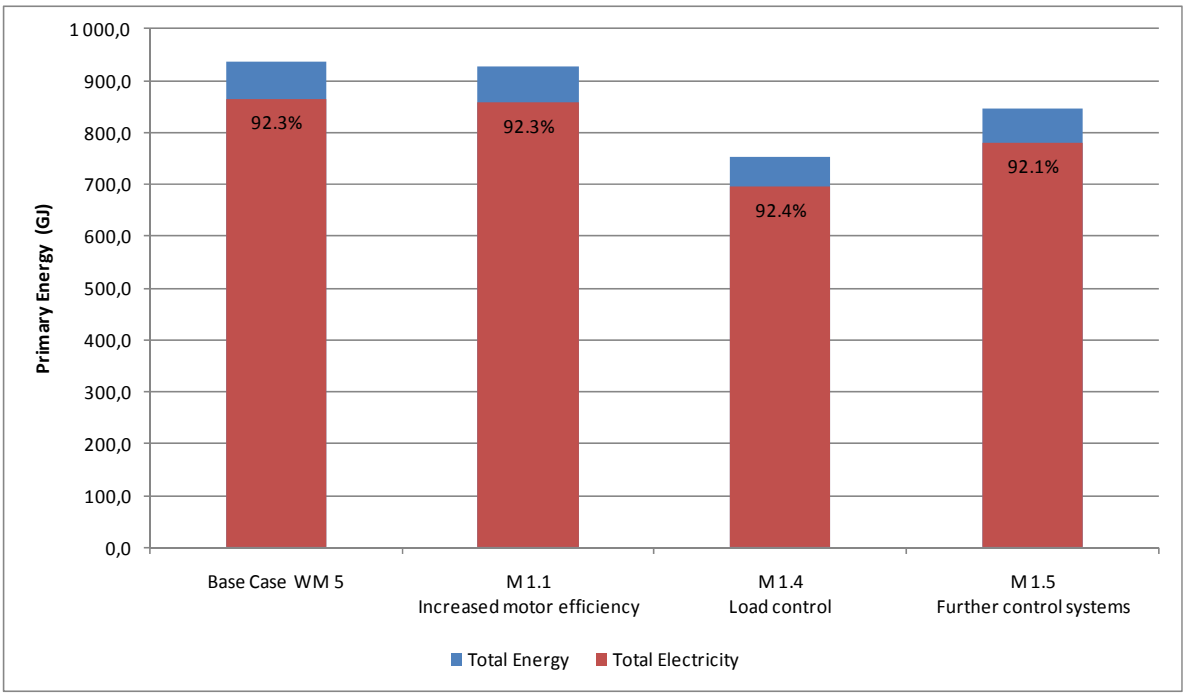


Figure 9 Energy consumption by improvement option for Base Case WM 5

Other environmental impacts are shown in Figure 10 below.

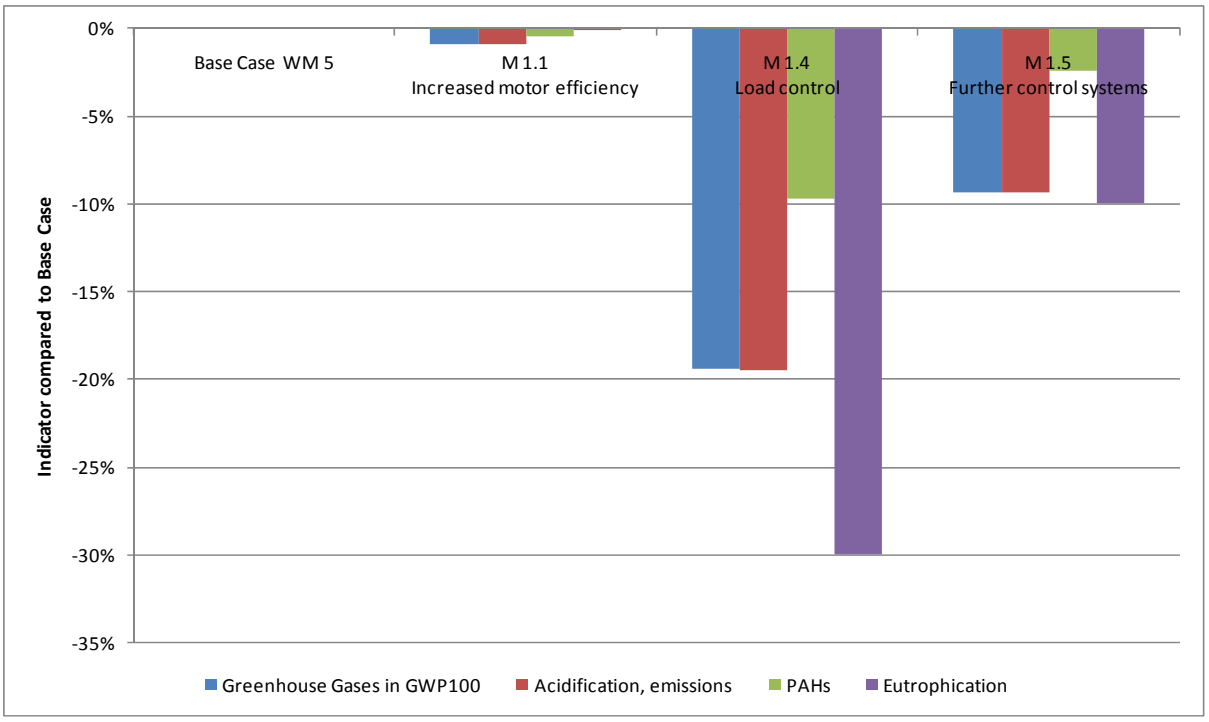


Figure 10 Improvement potential by improvement option for Base Case WM 5

3.6 Base Case WM 6: Professional Barrier Washer

The results of the environmental analysis of the improvement options for Base Case WM 6 are shown in Table 23. Most indicators considered are improved by option M 1.3 Water recovery. This option provides an efficient use of the resources. In terms of energy consumption, the reduction is around 30%. Option M 1.2 Heat exchanger is the single option that provides the third highest energy savings (18%), right behind the BA product (22%).

Table 23 Environmental impacts by improvement option for Base Case WM 6

Life cycle indicators per unit	Unit	Base Case WM 6	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	BA product
Other resources and waste								
Total Energy (GER)	**GJ**	2 998.9	2 975.2	2 453.4	2 085.3	2 641.3	2 917.1	2 333.9
	% change with BC	0%	-1%	-18%	-30%	-12%	-3%	-22%
of which, electricity	**primary GJ**	1 351.8	1 338.5	1 044.5	951.0	1 218.1	1 311.8	1 044.6
	MWh	128.7	127.5	99.5	90.6	116.0	124.9	99.5
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Water (process)	**kL**	15 271.4	15 270.5	15 251.5	9 641.6	11 930.3	14 814.7	11 919.5
	% change with BC	0%	0%	0%	-37%	-22%	-3%	-22%
Water (cooling)	**kL**	3 584.4	3 548.7	2 764.4	2 514.9	3 227.8	3 477.5	2 764.5
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Waste, non-haz./ landfill	**kg**	3 460.4	3 444.8	3 125.1	2 778.5	3 166.4	3 407.2	2 992.0
	% change with BC	0%	0%	-10%	-20%	-8%	-2%	-14%
Waste, hazardous/ incinerated	**kg**	109.6	109.3	102.5	95.7	103.8	108.6	99.9
	% change with BC	0%	0%	-6%	-13%	-5%	-1%	-9%
Emissions (Air)								
Greenhouse Gases in GWP100	**t CO2 eq.**	145.2	144.0	118.6	101.7	128.4	141.3	113.4
	% change with BC	0%	-1%	-18%	-30%	-12%	-3%	-22%
Acidification,	**kg SO2 eq.**	540.5	536.9	458.2	380.8	473.3	527.0	427.3

Life cycle indicators per unit	Unit	Base Case WM 6	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	BA product
emissions	**% change with BC**	0%	-1%	-15%	-30%	-12%	-2%	-21%
Volatile Organic Compounds (VOC)	**kg**	1.7	1.7	1.4	1.3	1.6	1.7	1.4
	% change with BC	0%	-1%	-17%	-26%	-10%	-2%	-19%
Persistent Organic Pollutants (POP)	**µg i-Teq**	22.6	22.5	20.7	18.8	20.9	22.3	19.9
	% change with BC	0%	0%	-9%	-17%	-7%	-1%	-12%
Heavy Metals	**g Ni eq.**	105.0	104.8	101.0	97.0	100.7	104.6	99.3
	% change with BC	0%	0%	-4%	-8%	-4%	0%	-5%
PAHs	**g Ni eq.**	7.9	7.9	7.6	6.7	7.4	7.9	7.5
	% change with BC	0%	0%	-4%	-15%	-6%	0%	-6%
Particulate Matter (PM, dust)	**kg**	52.2	52.1	50.8	49.2	50.7	52.0	50.2
	% change with BC	0%	0%	-3%	-6%	-3%	0%	-4%
Emissions (Water)								
Heavy Metals	**g Hg/20**	51.9	51.8	50.7	50.6	51.0	51.9	51.0
	% change with BC	0%	0%	-2%	-2%	-2%	0%	-2%
Eutrophication	**kg PO4**	913.7	913.7	913.7	576.1	713.0	895.5	713.0
	% change with BC	0%	0%	0%	-37%	-22%	-2%	-22%

The proportions total energy and total electricity remain constant for all options. Total electricity is around 45% of total primary energy for all options.

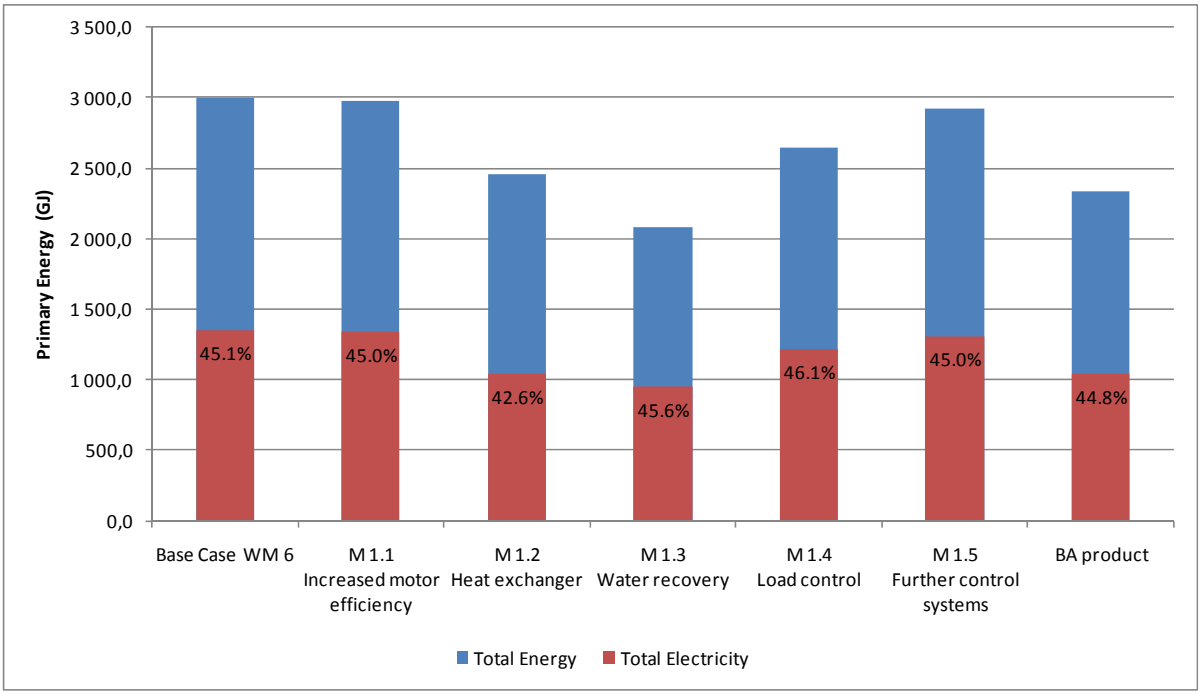


Figure 11 Energy consumption by improvement option for Base Case WM 6

The influence of each option on other impacts is shown in Figure 12 below.

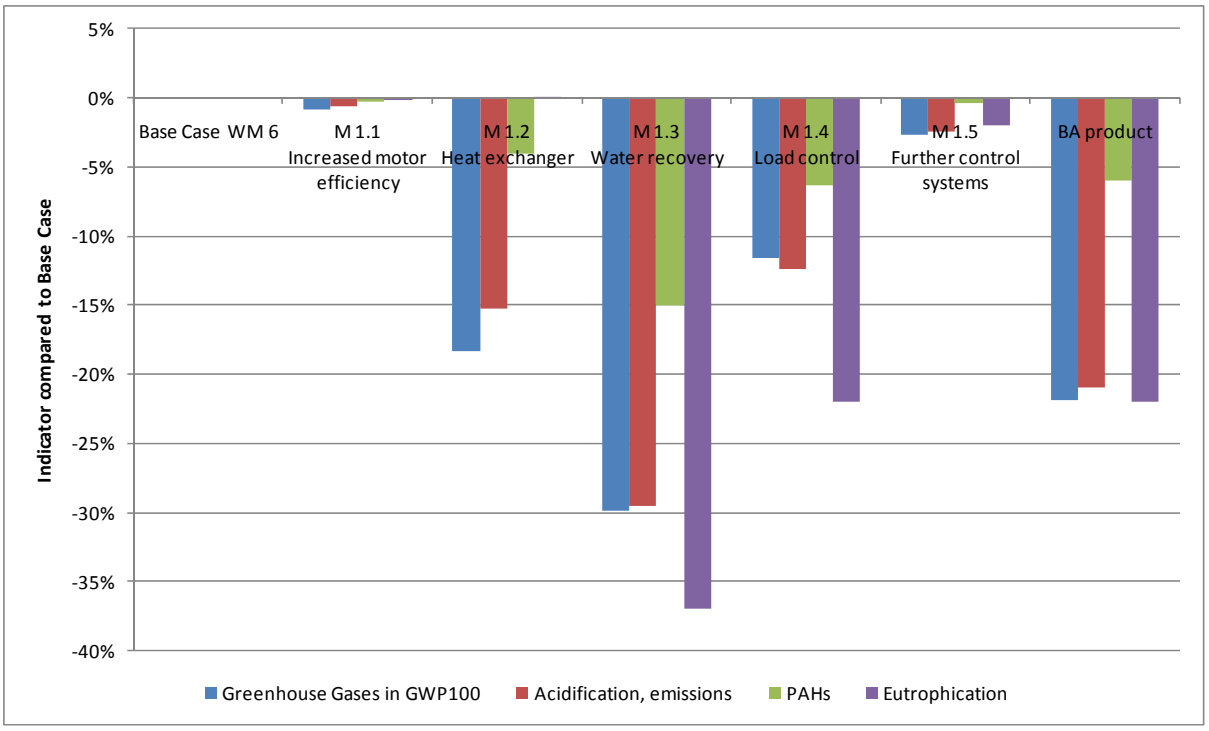


Figure 12 Improvement potential by improvement option for Base Case WM 6

3.7 Base Case WM 7: Washing tunnel machine

The results of the environmental analysis of the improvement options for Base Case WM 7 are shown in Table 24. The BA product leads to the greatest energy savings, around 37%, followed by option M 1.2 Heat exchanger (25%).

Table 24 Environmental impacts by improvement option for Base Case WM 7

Life cycle indicators per unit	Unit	Base Case WM 7	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	BA product
Other resources and waste					
Total Energy (GER)	**GJ**	114 095.0	113 136.2	85 330.7	71 942.6
	% change with BC	0%	-1%	-25%	-37%
of which, electricity	**primary GJ**	11 242.1	11 132.5	7 953.0	7 404.8
	MWh	1 070.7	1 060.2	757.4	705.2
	% change with BC	0%	-1%	-29%	-34%
Water (process)	**kL**	359 961.7	359 954.3	359 743.0	180 491.9
	% change with BC	0%	0%	0%	-50%
Water (cooling)	**kL**	29 406.3	29 113.9	20 634.9	19 173.0
	% change with BC	0%	-1%	-30%	-35%
Waste, non-haz./ landfill	**kg**	51 073.4	50 946.2	47 268.7	36 668.7
	% change with BC	0%	0%	-7%	-28%
Waste, hazardous/ incinerated	**kg**	895.0	892.5	819.2	608.6
	% change with BC	0%	0%	-8%	-32%
Emissions (Air)					
Greenhouse Gases in GWP100	**t CO2 eq.**	6 010.1	5 958.3	4 458.1	3 824.4
	% change with BC	0%	-1%	-26%	-36%
Acidification, emissions	**kg SO2 eq.**	9 380.2	9 338.3	8 123.5	5 686.5
	% change with BC	0%	0%	-13%	-39%
Volatile Organic Compounds (VOC)	**kg**	75.7	75.0	55.9	49.4
	% change with BC	0%	-1%	-26%	-35%
Persistent Organic Pollutants (POP)	**µg i-Teq**	307.0	306.3	285.5	225.6
	% change with BC	0%	0%	-7%	-27%
Heavy Metals	**g Ni eq.**	1 982.0	1 980.1	1 926.8	1 769.9
	% change with BC	0%	0%	-3%	-11%

Life cycle indicators per unit	Unit	Base Case WM 7	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	BA product
PAHs	**g Ni eq.**	76.5	76.2	69.3	51.2
	% change with BC	0%	0%	-9%	-33%
Particulate Matter (PM, dust)	**kg**	472.7	471.9	447.7	396.2
	% change with BC	0%	0%	-5%	-16%
Emissions (Water)					
Heavy Metals	**g Hg/20**	980.8	980.1	960.3	956.7
	% change with BC	0%	0%	-2%	-2%
Eutrophication	**kg PO4**	28 809.3	28 809.3	28 809.2	14 416.5
	% change with BC	0%	0%	0%	-50%

Figure 13 presents the proportions represented by electricity consumption amongst the total primary energy consumption. This proportion is constant for all options (only 10% approximately, due to high use of gas as energy source for this kind of product).

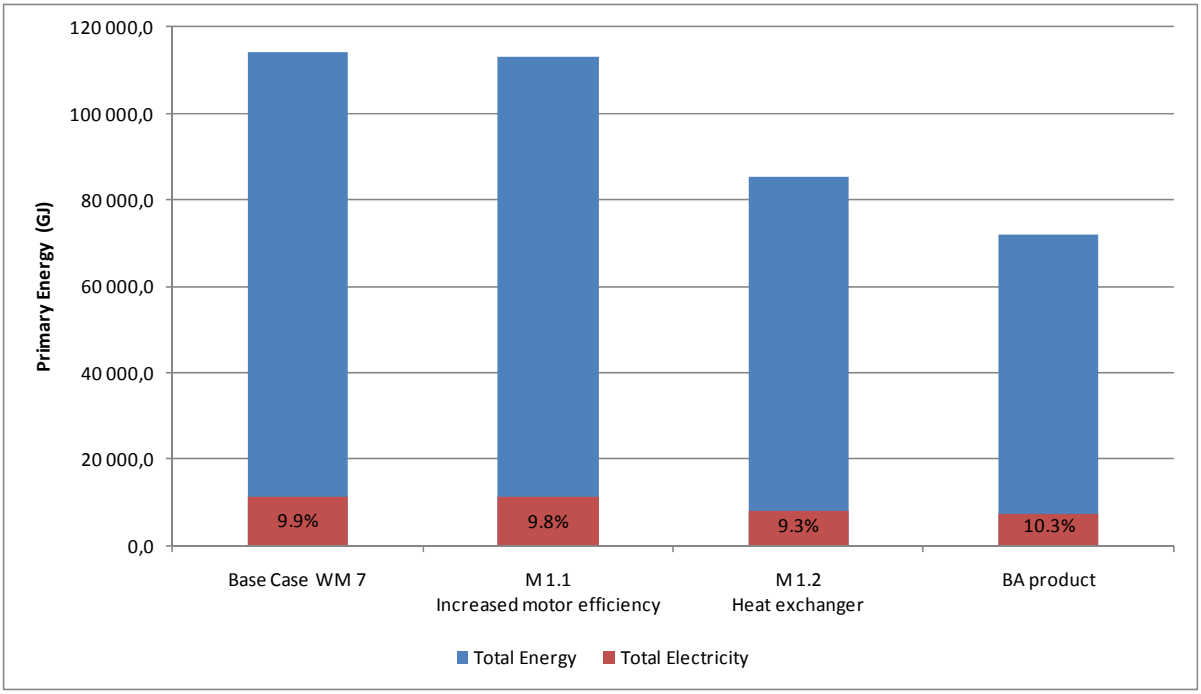


Figure 13 Energy consumption by improvement option for Base Case WM 7

Other impacts are represented in Figure 14 below.

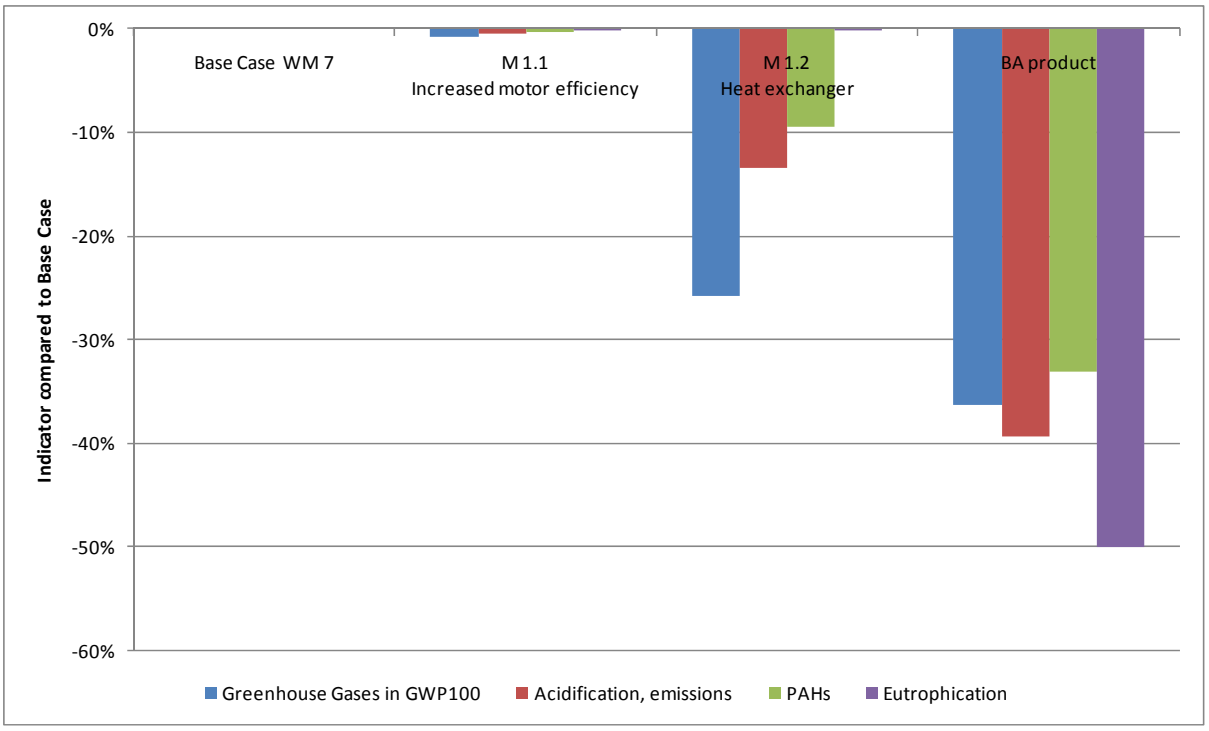


Figure 14 Improvement potential by improvement option for Base Case WM 7

3.8 Base Case D 1: Semi-professional dryer, condenser

The results of the environmental analysis of the improvement options for Base Case D 1 are shown in Table 25. The BA product leads to the best improvement of all indicators. In particular, it leads to 64% of primary energy reduction. Option M 2.2 Heat pump is the single option that provides the second highest energy savings (53%).

Table 25 Environmental impacts by improvement option for Base Case D 1

Life cycle indicators per unit	Unit	Base Case D 1	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Other resources and waste									
Total Energy (GER)	**GJ**	417.1	408.9	197.8	376.6	376.3	376.2	376.1	149.4
	% change with BC	0%	-2%	-53%	-10%	-10%	-10%	-10%	-64%
of which, electricity	**primary GJ**	411.9	403.7	187.6	371.1	371.1	371.0	371.0	138.7
	MWh	39.2	38.5	17.9	35.3	35.3	35.3	35.3	13.2
	% change with BC	0%	-2%	-54%	-10%	-10%	-10%	-10%	-66%
Water (process)	**kL**	31.0	30.5	19.3	28.4	28.4	28.4	28.3	16.2
	% change with BC	0%	-2%	-38%	-8%	-8%	-9%	-9%	-48%
Water (cooling)	**kL**	1 094.2	1 072.4	494.0	985.0	985.0	985.0	985.0	362.9
	% change with BC	0%	-2%	-55%	-10%	-10%	-10%	-10%	-67%
Waste, non-haz./ landfill	**kg**	584.6	574.9	439.7	570.4	537.5	537.3	537.1	416.3
	% change with BC	0%	-2%	-25%	-2%	-8%	-8%	-8%	-29%
Waste, hazardous/ incinerated	**kg**	20.3	20.2	15.3	19.8	19.5	19.5	19.5	15.0
	% change with BC	0%	-1%	-25%	-3%	-4%	-4%	-4%	-26%
Emissions (Air)									
Greenhouse Gases in GWP100	**t CO2 eq.**	18.4	18.0	9.1	16.6	16.6	16.6	16.6	7.0
	% change with BC	0%	-2%	-50%	-10%	-10%	-10%	-10%	-62%
Acidification, emissions	**kg SO2 eq.**	109.8	107.6	55.5	99.8	99.3	99.3	99.2	43.6
	% change with BC	0%	-2%	-49%	-9%	-10%	-10%	-10%	-60%
Volatile Organic Compounds (VOC)	**kg**	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.1
	% change with BC	0%	-2%	-35%	-7%	-7%	-8%	-8%	-43%
Persistent Organic Pollutants (POP)	**µg i-Teq**	3.1	3.1	2.1	2.9	2.9	2.9	2.9	1.8

Life cycle indicators per unit	Unit	Base Case D 1	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
	% change with BC	0%	-2%	-34%	-8%	-9%	-9%	-9%	-44%
Heavy Metals	g Ni eq.	12.8	12.7	15.3	12.3	12.2	12.2	12.1	14.6
	% change with BC	0%	-1%	19%	-4%	-5%	-5%	-5%	14%
PAHs	g Ni eq.	1.3	1.2	1.8	1.2	1.2	1.2	1.2	1.8
	% change with BC	0%	-1%	39%	-1%	-5%	-6%	-6%	38%
Particulate Matter (PM, dust)	kg	6.1	6.1	7.2	6.1	5.9	5.9	5.9	7.1
	% change with BC	0%	-1%	18%	-1%	-3%	-4%	-3%	16%
Emissions (Water)									
Heavy Metals	g Hg/20	6.7	6.6	9.3	6.7	6.5	6.5	6.4	9.4
	% change with BC	0%	-1%	40%	0%	-3%	-3%	-4%	40%
Eutrophication	kg PO4	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2
	% change with BC	0%	-1%	82%	1%	0%	-1%	-1%	84%

Total electricity represents over 92% of total primary energy for all improvement options (the base case is considered 100% electric heating). This proportion is shown in Figure 15.

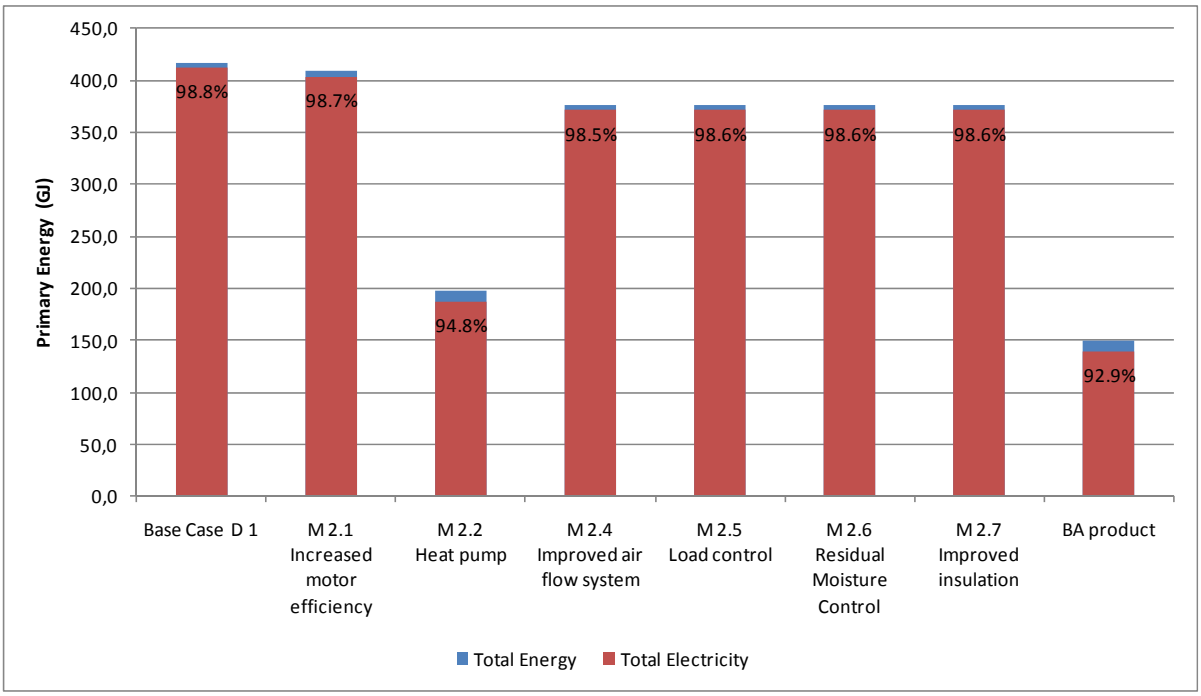


Figure 15 Energy consumption by improvement option for Base Case D 1

Impacts for other environmental indicators are shown below. The heat pump option and the BA product show the largest reduction in greenhouse gases and acidification emissions but also the largest increase in PAHs and eutrophication.

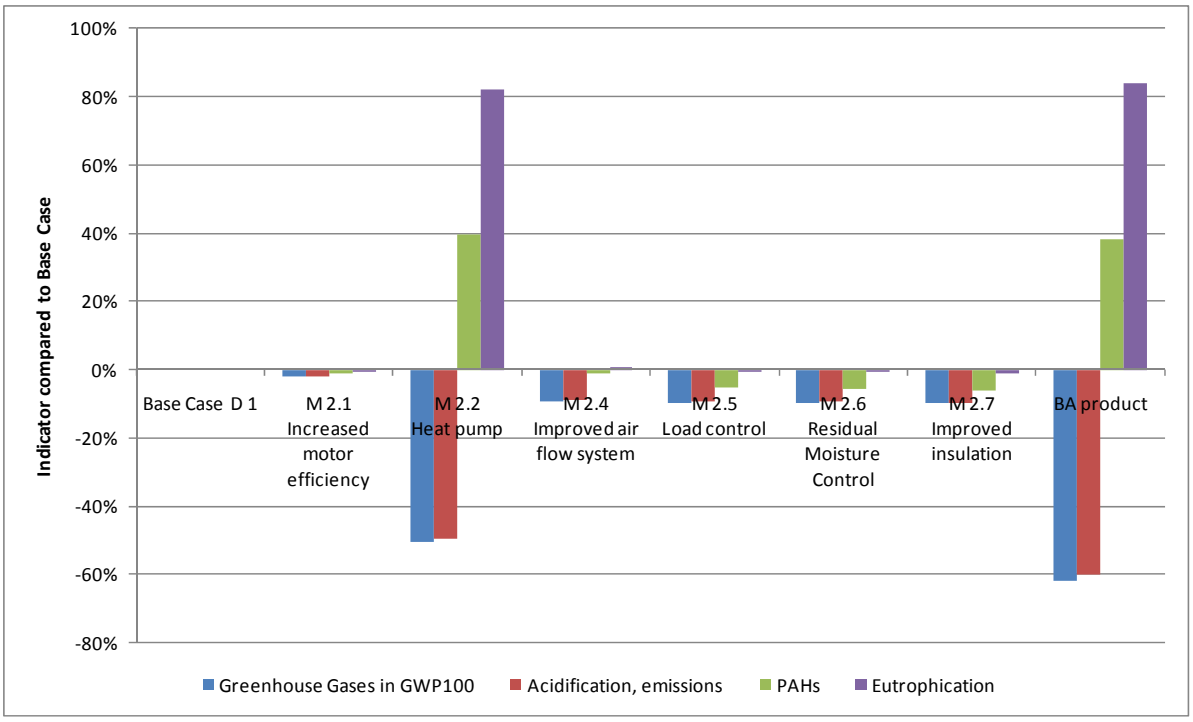


Figure 16 Improvement potential by improvement option for Base Case D 1

3.9 Base Case D 2: Semi-professional dryer, air vented

The results of the environmental analysis of the improvement options for Base Case D 2 are shown below. The greatest energy reduction is due to the heat pump option (47%). This option also leads to increases in other indicators such as heavy metals, PAHs and eutrophication. Presumably this is a consequence of the extra material and refrigerant use.

Table 26 Environmental impacts by improvement option for Base Case D 2

Life cycle indicators per unit	Unit	Base Case D 2	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Other resources and waste										
Total Energy (GER)	**GJ**	314.0	307.9	166.3	286.6	283.8	283.5	283.4	283.4	241.3
	% change with BC	0%	-2%	-47%	-9%	-10%	-10%	-10%	-10%	-23%
of which, electricity	**primary GJ**	257.4	252.2	130.7	232.3	231.9	231.9	231.9	231.8	194.3
	MWh	24.5	24.0	12.4	22.1	22.1	22.1	22.1	22.1	18.5
	% change with BC	0%	-2%	-49%	-10%	-10%	-10%	-10%	-10%	-24%
Water (process)	**kL**	20.6	20.2	15.1	20.5	18.9	19.0	18.9	18.9	18.1
	% change with BC	0%	-2%	-26%	0%	-8%	-8%	-8%	-8%	-12%
Water (cooling)	**kL**	682.3	668.7	342.5	614.6	614.3	614.2	614.2	614.2	512.6
	% change with BC	0%	-2%	-50%	-10%	-10%	-10%	-10%	-10%	-25%
Waste, non-haz./ landfill	**kg**	403.2	397.0	365.8	434.1	406.9	373.9	373.7	373.6	423.4
	% change with BC	0%	-2%	-9%	8%	1%	-7%	-7%	-7%	5%
Waste, hazardous/ incinerated	**kg**	15.7	15.5	12.9	16.1	15.5	15.2	15.1	15.2	15.9
	% change with BC	0%	-1%	-18%	3%	-1%	-3%	-3%	-3%	2%
Emissions (Air)										
Greenhouse Gases in GWP100	**t CO2 eq.**	14.5	14.2	8.0	13.3	13.1	13.1	13.1	13.1	11.3
	% change with BC	0%	-2%	-45%	-8%	-9%	-10%	-10%	-10%	-22%
Acidification, emissions	**kg SO2 eq.**	70.6	69.3	41.0	65.9	64.6	64.1	64.0	64.0	56.6
	% change with BC	0%	-2%	-42%	-7%	-9%	-9%	-9%	-9%	-20%
Volatile Organic Compounds (VOC)	**kg**	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1
	% change with BC	0%	-2%	-30%	-2%	-7%	-7%	-8%	-8%	-12%

Life cycle indicators per unit	Unit	Base Case D 2	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Persistent Organic Pollutants (POP)	**µg i-Teq**	2.1	2.1	1.7	2.2	2.0	1.9	1.9	1.9	1.9
	% change with BC	0%	-2%	-21%	2%	-7%	-8%	-8%	-8%	-9%
Heavy Metals	**g Ni eq.**	9.9	9.8	13.7	12.7	9.6	9.5	9.5	9.5	12.3
	% change with BC	0%	-1%	39%	29%	-3%	-4%	-4%	-4%	24%
PAHs	**g Ni eq.**	1.0	0.9	1.6	1.4	1.0	0.9	0.9	0.9	1.4
	% change with BC	0%	-1%	67%	45%	1%	-4%	-5%	-5%	45%
Particulate Matter (PM, dust)	**kg**	5.1	5.1	6.7	6.4	5.1	5.0	5.0	5.0	6.3
	% change with BC	0%	-1%	31%	24%	0%	-3%	-3%	-2%	24%
Emissions (Water)										
Heavy Metals	**g Hg/20**	5.5	5.4	8.6	7.4	5.6	5.4	5.4	5.3	7.5
	% change with BC	0%	-1%	56%	35%	1%	-2%	-2%	-3%	37%
Eutrophication	**kg PO4**	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2
	% change with BC	0%	-1%	89%	49%	1%	0%	0%	-1%	51%

Total electricity represents over 78% of total primary energy for all improvement options.

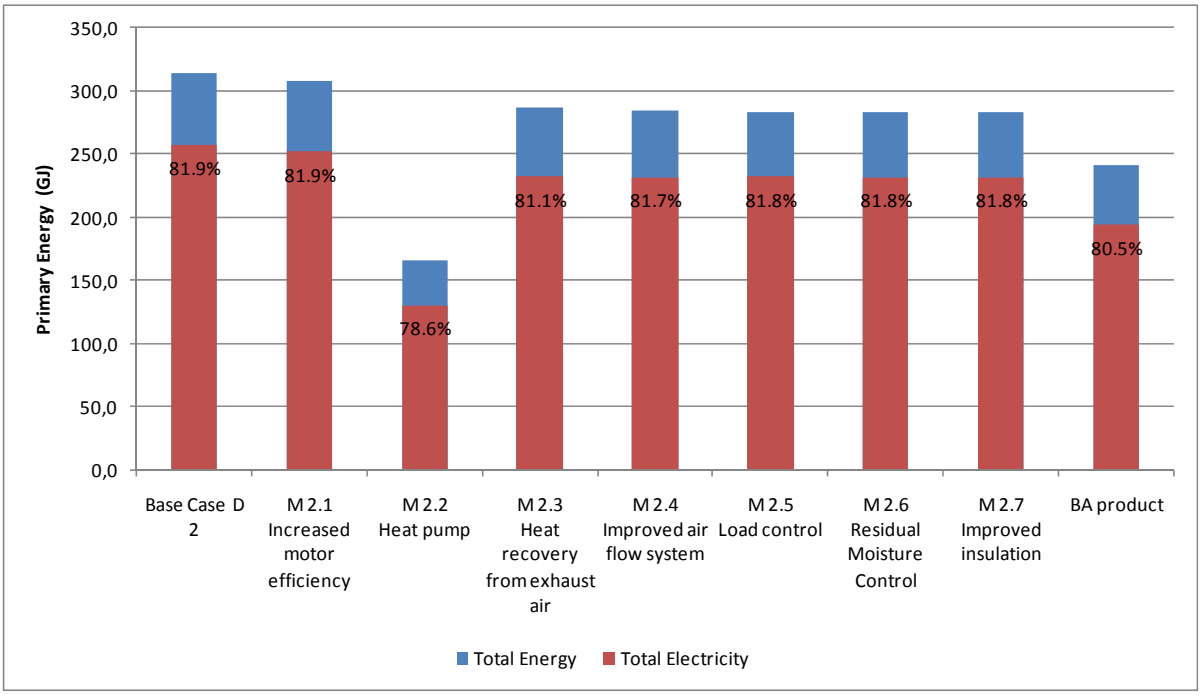


Figure 17 Energy consumption by improvement option for Base Case D 2

Other impacts are shown below. The Figure 18 shows how some of the options increase eutrophication instead of reducing it.

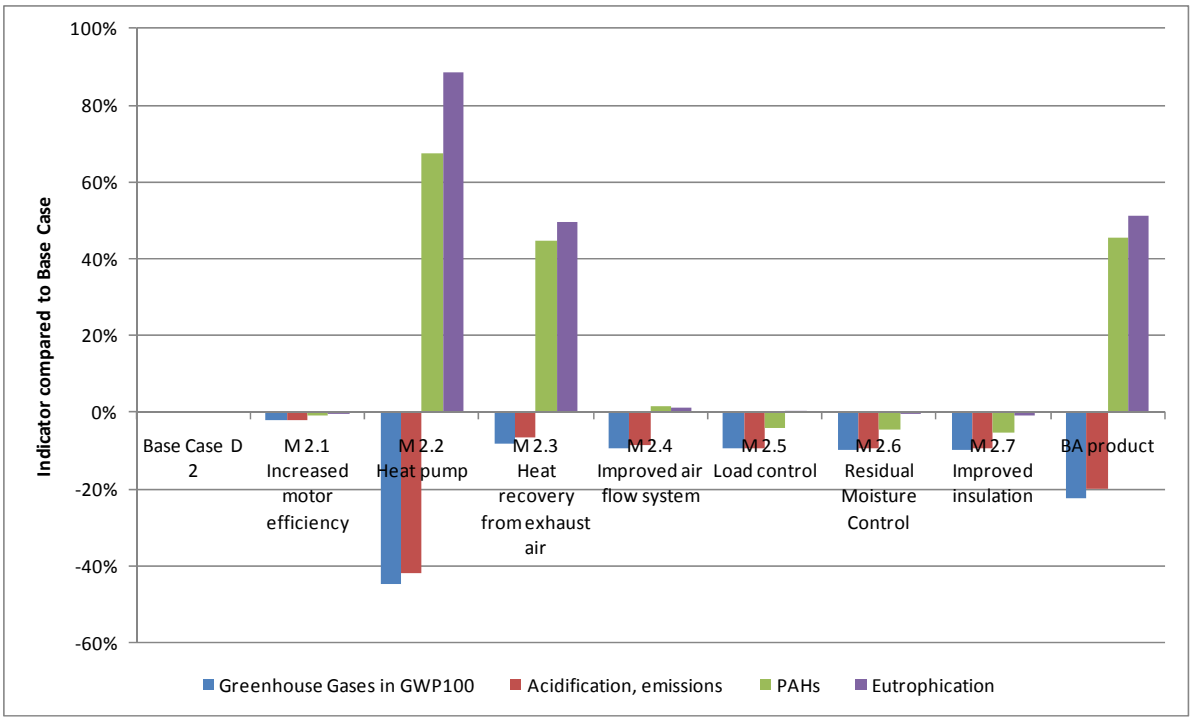


Figure 18 Improvement potential by improvement option for Base Case D 2

3.10 Base Case D 3: Professional cabinet dryer

The results of the environmental analysis of the improvement options for Base Case D 3 are shown below. In this case, the best option corresponds to the BA product. The energy reduction is around 65%. Option M 2.2 Heat pump is the single option that provides the second highest energy savings (57%).

Table 27 Environmental impacts by improvement option for Base Case D 3

Life cycle indicators per unit	Unit	Base Case D 3	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.7 Improved insulation	BA product
Other resources and waste							
Total Energy (GER)	**GJ**	949.1	405.0	859.1	856.3	855.9	330.8
	% change with BC	0%	-57%	-9%	-10%	-10%	-65%
of which, electricity	**primary GJ**	936.6	379.5	843.8	843.4	843.3	304.9
	MWh	89.2	36.1	80.4	80.3	80.3	29.0
	% change with BC	0%	-59%	-10%	-10%	-10%	-67%
Water (process)	**kL**	64.3	35.2	59.7	58.1	58.0	30.3
	% change with BC	0%	-45%	-7%	-10%	-10%	-53%
Water (cooling)	**kL**	2 489.3	998.0	2 240.9	2 240.5	2 240.5	799.0
	% change with BC	0%	-60%	-10%	-10%	-10%	-68%
Waste, non-haz./ landfill	**kg**	1 391.8	990.0	1 333.9	1 298.8	1 283.7	918.7
	% change with BC	0%	-29%	-4%	-7%	-8%	-34%
Waste, hazardous/ incinerated	**kg**	27.4	15.0	26.3	25.7	25.4	13.9
	% change with BC	0%	-45%	-4%	-6%	-7%	-50%
Emissions (Air)							
Greenhouse Gases in GWP100	**t CO2 eq.**	41.8	18.7	37.9	37.7	37.7	15.5
	% change with BC	0%	-55%	-9%	-10%	-10%	-63%
Acidification, emissions	**kg SO2 eq.**	245.2	109.9	223.0	221.4	221.2	90.9
	% change with BC	0%	-55%	-9%	-10%	-10%	-63%
Volatile Organic Compounds (VOC)	**kg**	0.4	0.3	0.4	0.4	0.4	0.2
	% change with BC	0%	-36%	-6%	-8%	-8%	-42%
Persistent Organic Pollutants (POP)	**µg i-Teq**	9.3	6.7	8.9	8.7	8.7	6.2
	% change with BC	0%	-28%	-4%	-6%	-7%	-33%

Life cycle indicators per unit	Unit	Base Case D 3	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.7 Improved insulation	BA product
Heavy Metals	**g Ni eq.**	17.9	24.3	19.6	16.4	16.3	23.2
	% change with BC	0%	36%	9%	-8%	-9%	30%
PAHs	**g Ni eq.**	4.1	5.5	4.4	4.0	4.0	5.4
	% change with BC	0%	32%	7%	-3%	-4%	30%
Particulate Matter (PM, dust)	**kg**	13.8	17.8	14.9	13.5	13.3	17.6
	% change with BC	0%	29%	8%	-2%	-4%	28%
Emissions (Water)							
Heavy Metals	**g Hg/20**	8.7	15.3	10.1	8.2	8.1	15.0
	% change with BC	0%	77%	17%	-5%	-7%	73%
Eutrophication	**kg PO4**	0.1	0.3	0.1	0.1	0.1	0.3
	% change with BC	0%	349%	72%	-1%	-4%	349%

Total electricity consumption is more than 92% of primary energy.

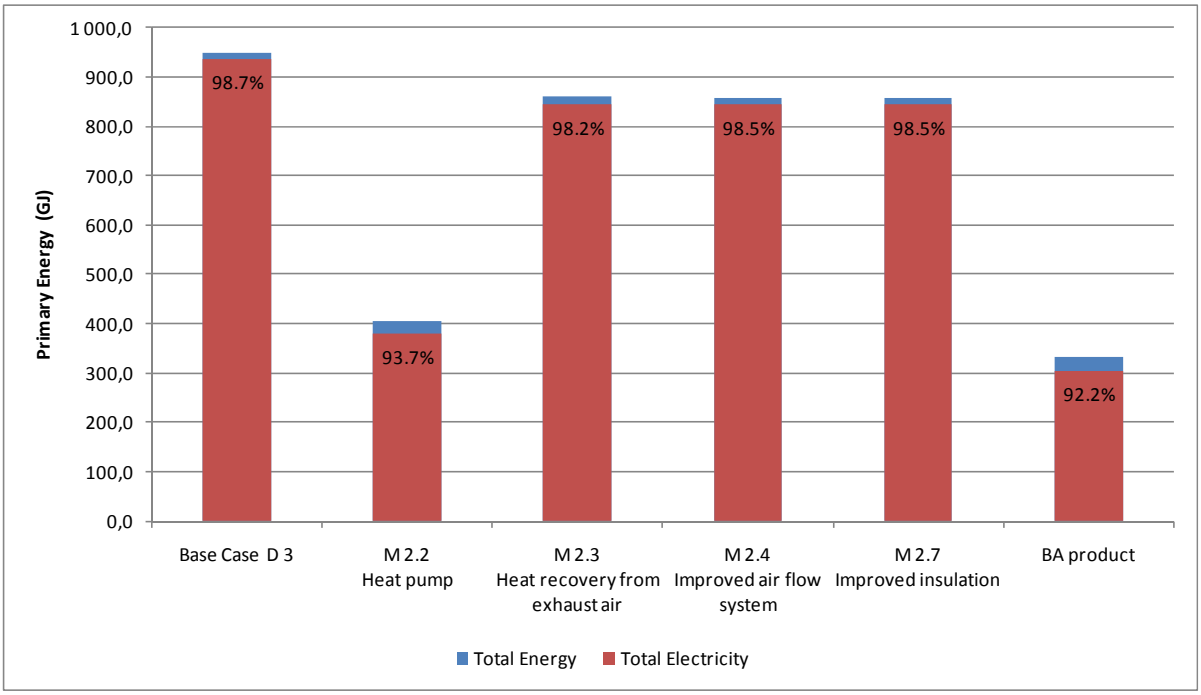


Figure 19 Energy consumption by improvement option for Base Case D 3

Other indicators are shown in Figure 20 below.

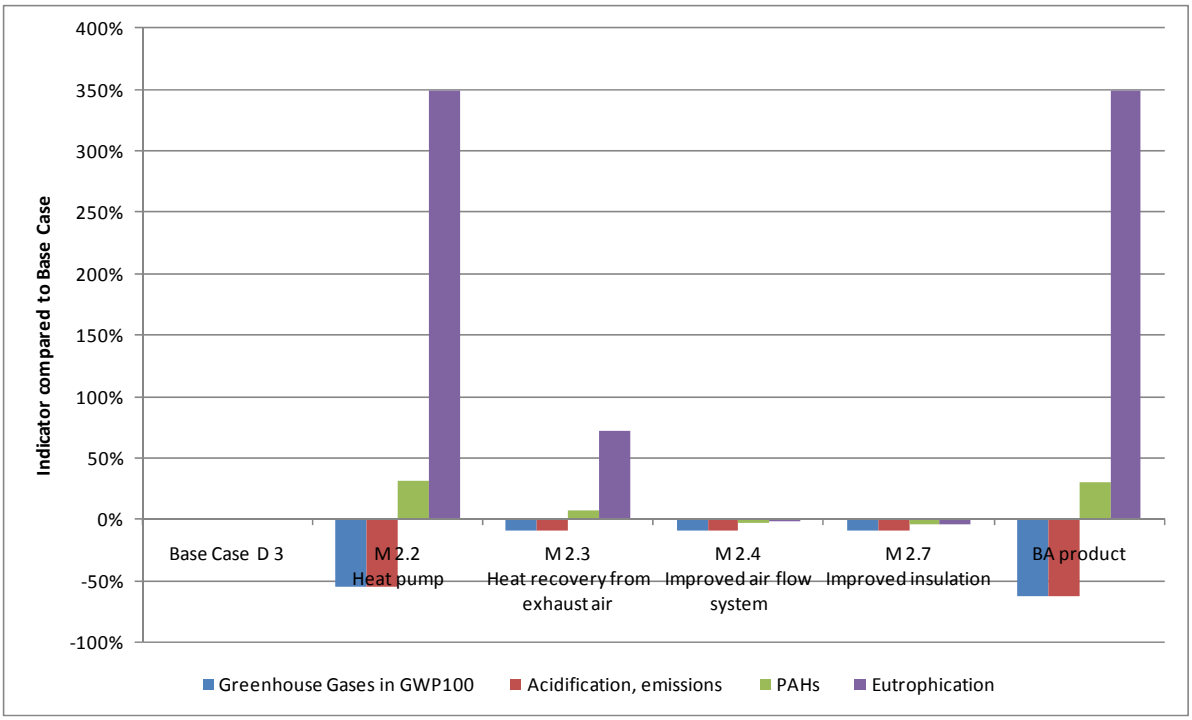


Figure 20 Improvement potential by improvement option for Base Case D 3

3.11 Base Case D 4: Professional tumble dryer (<15 kg)

The results of the environmental analysis of the improvement options for Base Case D 4 are shown below. The BA product results in the greatest reduction of energy consumption (65%) but also leads to increasing emissions (e.g. PAHs, particulate matter) due the additional materials required and the refrigerant.

Table 28 Environmental impacts by improvement option for Base Case D 4

Life cycle indicators per unit	Unit	Base Case D 4	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Other resources and waste										
Total Energy (GER)	**GJ**	960.4	931.9	402.6	867.8	884.7	846.4	846.4	893.9	336.4
	% change with BC	0%	-3%	-58%	-10%	-8%	-12%	-12%	-7%	-65%
of which, electricity	**primary GJ**	671.8	651.7	272.1	605.3	618.3	591.4	591.4	624.9	225.3
	MWh	64.0	62.1	25.9	57.6	58.9	56.3	56.3	59.5	21.5
	% change with BC	0%	-3%	-59%	-10%	-8%	-12%	-12%	-7%	-66%
Water (process)	**kL**	45.9	44.5	27.9	43.1	42.4	40.5	40.5	42.8	24.8
	% change with BC	0%	-3%	-39%	-6%	-8%	-12%	-12%	-7%	-46%
Water (cooling)	**kL**	1 789.5	1 735.9	724.3	1 612.1	1 646.9	1 575.1	1 575.1	1 664.4	599.6
	% change with BC	0%	-3%	-60%	-10%	-8%	-12%	-12%	-7%	-66%
Waste, non-haz./ landfill	**kg**	1 003.9	980.4	668.7	951.0	942.8	910.7	910.7	949.6	615.2
	% change with BC	0%	-2%	-33%	-5%	-6%	-9%	-9%	-5%	-39%
Waste, hazardous/ incinerated	**kg**	18.9	18.4	9.7	18.3	18.0	17.0	17.0	17.9	9.1
	% change with BC	0%	-2%	-49%	-3%	-5%	-10%	-10%	-5%	-52%
Emissions (Air)										
Greenhouse Gases in GWP100	**t CO2 eq.**	45.4	44.1	19.7	41.1	41.8	40.0	40.0	42.3	16.6
	% change with BC	0%	-3%	-57%	-9%	-8%	-12%	-12%	-7%	-63%
Acidification, emissions	**kg SO2 eq.**	179.8	174.4	81.1	163.5	165.7	158.5	158.5	167.4	68.8
	% change with BC	0%	-3%	-55%	-9%	-8%	-12%	-12%	-7%	-62%
Volatile Organic Compounds (VOC)	**kg**	0.5	0.5	0.3	0.5	0.5	0.5	0.5	0.5	0.3
	% change with BC	0%	-3%	-45%	-7%	-7%	-11%	-11%	-6%	-51%
Persistent Organic	**µg i-Teq**	7.6	7.4	5.9	7.3	7.2	7.0	7.0	7.3	5.6

Life cycle indicators per unit	Unit	Base Case D 4	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Pollutants (POP)	**% change with BC**	0%	-2%	-22%	-3%	-5%	-7%	-7%	-4%	-26%
Heavy Metals	**g Ni eq.**	14.2	13.8	24.5	16.3	13.4	12.8	12.8	13.4	23.7
	% change with BC	0%	-3%	72%	15%	-6%	-10%	-10%	-6%	67%
PAHs	**g Ni eq.**	1.7	1.7	2.5	1.9	1.6	1.5	1.5	1.6	2.5
	% change with BC	0%	-2%	50%	10%	-4%	-9%	-9%	-5%	46%
Particulate Matter (PM, dust)	**kg**	11.5	11.4	15.4	12.4	11.4	11.1	11.1	11.3	15.3
	% change with BC	0%	-1%	34%	8%	-1%	-4%	-4%	-2%	33%
Emissions (Water)										
Heavy Metals	**g Hg/20**	5.9	5.7	13.2	7.3	5.6	5.4	5.4	5.6	12.9
	% change with BC	0%	-3%	124%	24%	-5%	-9%	-9%	-5%	119%
Eutrophication	**kg PO4**	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.3
	% change with BC	0%	-2%	378%	72%	1%	-3%	-4%	-2%	380%

The shares of total electricity are constant for all improvement options (around 70% of primary energy consumption).

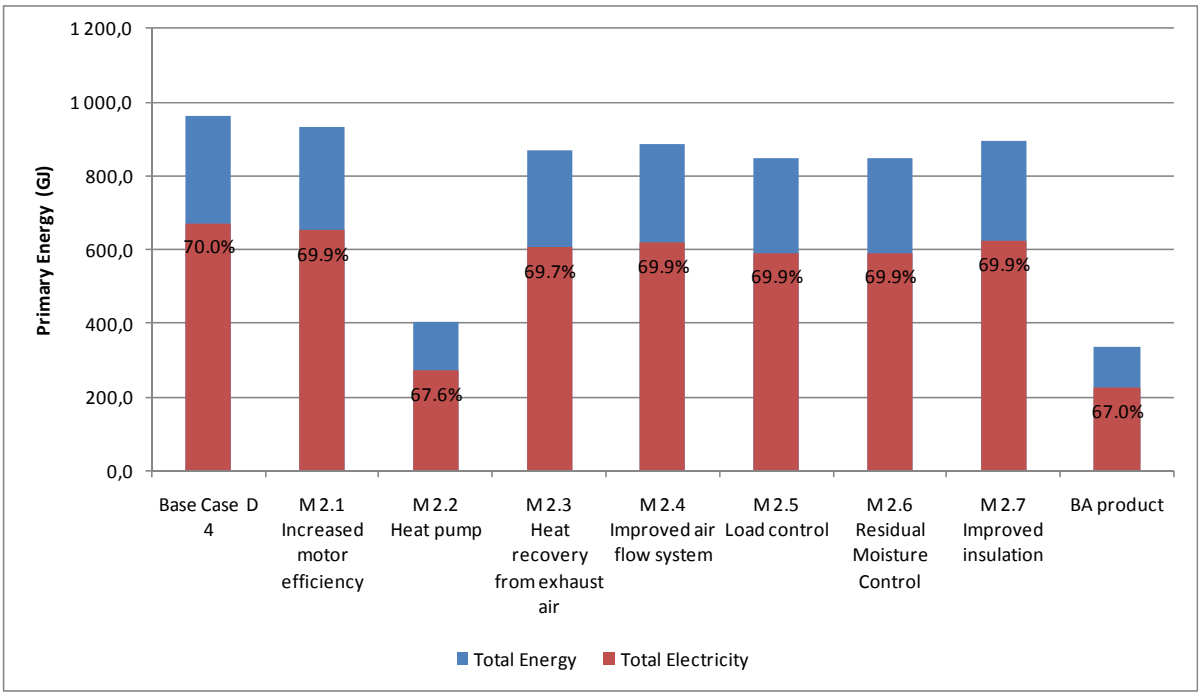


Figure 21 Energy consumption by improvement option for Base Case D 4

The impact on other indicators is shown in Figure 22 below. The impact of the heat pump and the BA product is particularly important in terms of PAHs emissions (almost +400%).

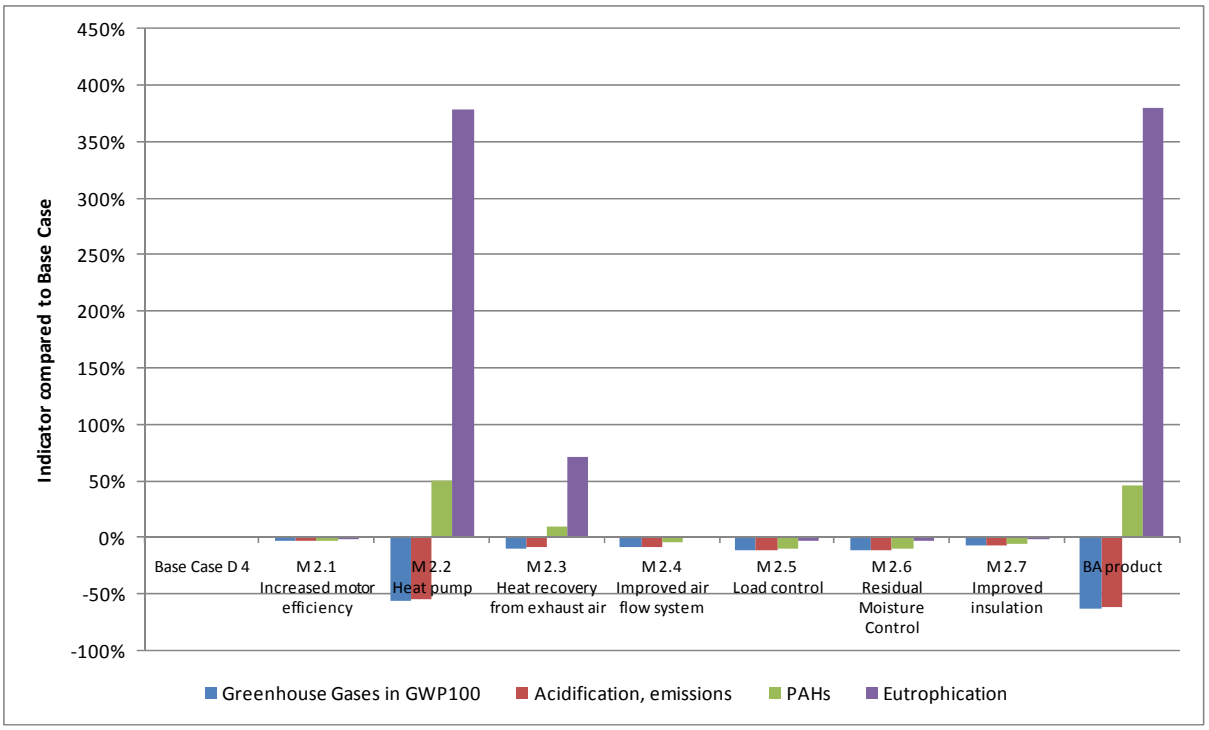


Figure 22 Improvement potential by improvement option for Base Case D 4

3.12 Base Case D 5: Professional tumble dryer (15–40 kg)

The results of the environmental analysis of the improvement options for Base Case D 5 are shown below. The option M 2.2 Heat pump provides the best improvement for most of the indicators, especially 58% for energy consumption. The BA product shows a very similar performance, and increases the emissions of PAHs and particulate matter due to the higher metal content.

Table 29 Environmental impacts by improvement option for Base Case D 5

Life cycle indicators per unit	Unit	Base Case D 5	M 2.1 In-creased motor efficien-cy	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insula-tion	BA product
Other resources and waste										
Total Energy (GER)	**GJ**	3 014.5	2 954.8	1 261.5	2 749.2	2 686.8	2 716.4	2 716.3	2 835.6	1 261.8
	% change with BC	0%	-2%	-58%	-9%	-11%	-10%	-10%	-6%	-58%
of which, electricity	**primary GJ**	1 727.0	1 692.7	703.4	1 573.0	1 538.3	1 555.5	1 555.4	1 624.0	703.6
	MWh	164.5	161.2	67.0	149.8	146.5	148.1	148.1	154.7	67.0
	% change with BC	0%	-2%	-59%	-9%	-11%	-10%	-10%	-6%	-59%
Water (process)	**kL**	122.2	119.9	73.7	113.5	109.7	110.8	110.8	115.3	73.8
	% change with BC	0%	-2%	-40%	-7%	-10%	-9%	-9%	-6%	-40%
Water (cooling)	**kL**	4 581.3	4 489.7	1 838.2	4 169.6	4 077.8	4 123.5	4 123.5	4 306.6	1 838.2
	% change with BC	0%	-2%	-60%	-9%	-11%	-10%	-10%	-6%	-60%
Waste, non-haz./ landfill	**kg**	2 659.2	2 619.2	2 067.4	2 530.3	2 455.5	2 460.5	2 460.3	2 539.8	2 067.8
	% change with BC	0%	-2%	-22%	-5%	-8%	-7%	-7%	-4%	-22%
Waste, hazardous/ incinerated	**kg**	56.2	55.4	33.6	53.7	52.3	52.4	52.3	54.0	34.0
	% change with BC	0%	-1%	-40%	-5%	-7%	-7%	-7%	-4%	-40%
Emissions (Air)										
Greenhouse Gases in GWP100	**t CO2 eq.**	147.1	144.2	63.4	134.3	131.2	132.6	132.6	138.4	63.4
	% change with BC	0%	-2%	-57%	-9%	-11%	-10%	-10%	-6%	-57%
Acidification, emissions	**kg SO2 eq.**	473.9	464.6	217.6	434.0	423.2	427.7	427.7	446.1	217.8
	% change with BC	0%	-2%	-54%	-8%	-11%	-10%	-10%	-6%	-54%
Volatile Organic Compounds (VOC)	**kg**	1.7	1.7	0.9	1.6	1.6	1.6	1.6	1.7	0.9
	% change with BC	0%	-2%	-48%	-8%	-10%	-9%	-9%	-5%	-48%
Persistent Organic	**µg i-Teq**	18.7	18.5	14.6	17.9	17.5	17.6	17.6	18.0	14.6

Life cycle indicators per unit	Unit	Base Case D 5	M 2.1 In-creased motor efficien-cy	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insula-tion	BA product
Pollutants (POP)	**% change with BC**	0%	-1%	-22%	-4%	-6%	-6%	-6%	-4%	-22%
Heavy Metals	**g Ni eq.**	36.4	35.8	57.9	37.0	33.3	33.5	33.5	34.6	57.9
	% change with BC	0%	-2%	59%	2%	-8%	-8%	-8%	-5%	59%
PAHs	**g Ni eq.**	5.0	5.0	8.8	5.2	4.7	4.7	4.7	4.8	8.8
	% change with BC	0%	-1%	75%	3%	-6%	-7%	-7%	-4%	75%
Particulate Matter (PM, dust)	**kg**	24.4	24.2	30.8	24.7	23.5	23.5	23.5	23.9	30.8
	% change with BC	0%	-1%	26%	1%	-4%	-4%	-4%	-2%	26%
Emissions (Water)										
Heavy Metals	**g Hg/20**	18.6	18.3	36.9	19.6	17.5	17.5	17.5	17.9	37.0
	% change with BC	0%	-1%	99%	6%	-6%	-6%	-6%	-4%	99%
Eutrophication	**kg PO4**	0.2	0.2	0.8	0.2	0.2	0.2	0.2	0.2	0.8
	% change with BC	0%	-1%	298%	24%	-2%	-2%	-2%	-2%	299%

Figure 23 presents the proportions represented by electricity consumption amongst the total primary energy consumption. It is around 57% for all improvement options.

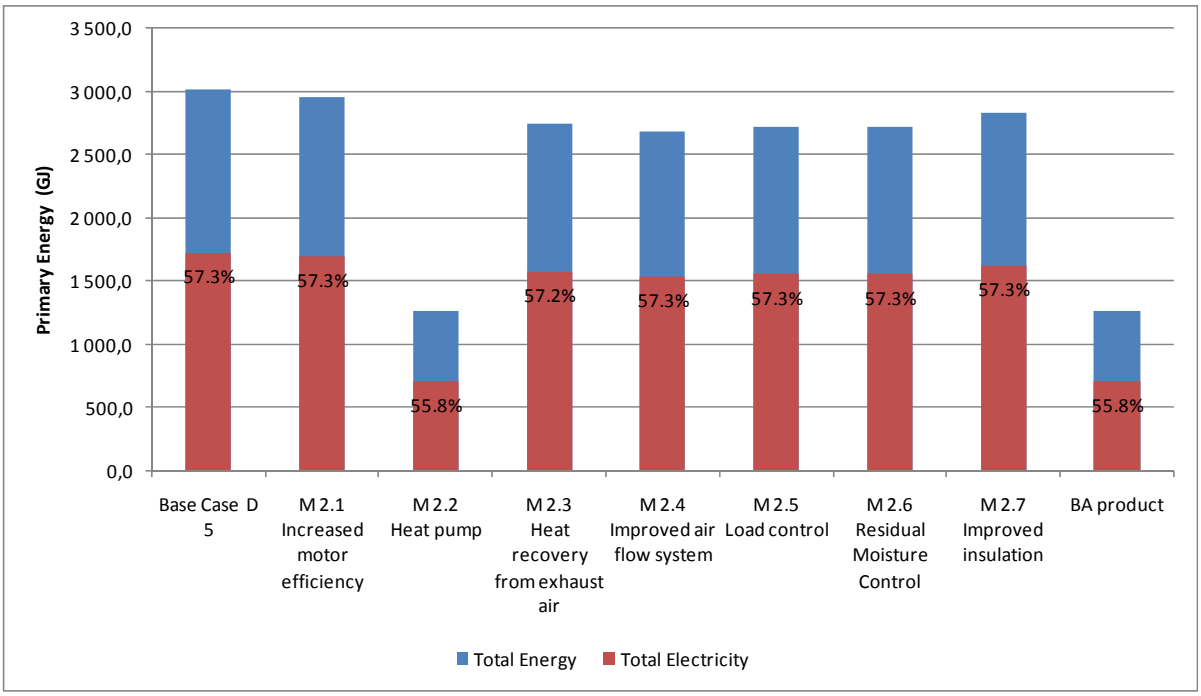


Figure 23 Energy consumption by improvement option for Base Case D 5

The impact of these options on other indicators is shown in Figure 24 below.

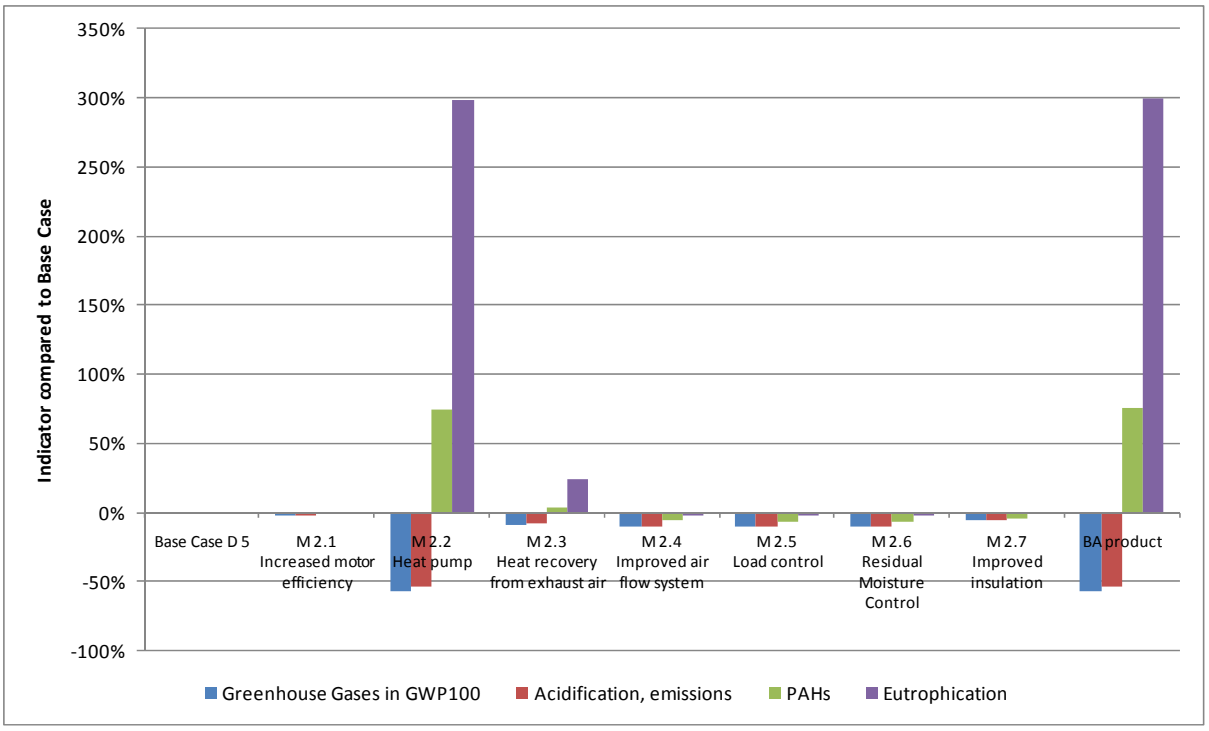


Figure 24 Improvement potential by improvement option for Base Case D 5

3.13 Base Case D 6: Professional tumble dryer (>40 kg)

The results of the environmental analysis of the improvement options for Base Case D 6 are shown below. Option M 2.2 Heat pump represents the greatest savings for many indicators. The reduction of the total energy is around 59%, while the reduction of electricity is about 60%. However, emissions of heavy metals, PAHs and particulate matter are again more important than for the base case because of the higher metal content.

Table 30 Environmental impacts by improvement option for Base Case D 6

Life cycle indicators per unit	Unit	Base Case D 6	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Other resources and waste										
Total Energy (GER)	**GJ**	12 858.0	12 730.1	5 256.8	11 837.8	12 218.9	12 218.6	12 218.5	12 602.2	5 257.0
	% change with BC	0%	-1%	-59%	-8%	-5%	-5%	-5%	-2%	-59%
of which, electricity	**primary GJ**	5 518.5	5 463.6	2 233.3	5 079.3	5 243.8	5 243.8	5 243.8	5 408.6	2 233.5
	MWh	525.6	520.3	212.7	483.7	499.4	499.4	499.4	515.1	212.7
	% change with BC	0%	-1%	-60%	-8%	-5%	-5%	-5%	-2%	-60%
Water (process)	**kL**	382.6	379.0	202.9	354.9	364.4	364.4	364.4	375.3	203.0
	% change with BC	0%	-1%	-47%	-7%	-5%	-5%	-5%	-2%	-47%
Water (cooling)	**kL**	14 665.2	14 518.7	5 877.7	13 492.9	13 932.4	13 932.4	13 932.3	14 372.1	5 877.8
	% change with BC	0%	-1%	-60%	-8%	-5%	-5%	-5%	-2%	-60%
Waste, non-haz./ landfill	**kg**	7 780.6	7 716.6	5 155.5	7 320.9	7 477.1	7 462.3	7 462.1	7 653.1	5 155.8
	% change with BC	0%	-1%	-34%	-6%	-4%	-4%	-4%	-2%	-34%
Waste, hazardous/ incinerated	**kg**	160.9	159.6	87.1	151.7	155.0	154.7	154.6	158.5	87.5
	% change with BC	0%	-1%	-46%	-6%	-4%	-4%	-4%	-1%	-46%
Emissions (Air)										
Greenhouse Gases in GWP100	**t CO2 eq.**	647.8	641.4	268.4	596.6	615.7	615.6	615.6	634.9	268.4
	% change with BC	0%	-1%	-59%	-8%	-5%	-5%	-5%	-2%	-59%
Acidification, emissions	**kg SO2 eq.**	1 557.3	1 542.0	679.9	1 436.4	1 480.9	1 480.8	1 480.7	1 526.7	680.0
	% change with BC	0%	-1%	-56%	-8%	-5%	-5%	-5%	-2%	-56%

Life cycle indicators per unit	Unit	Base Case D 6	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Volatile Organic Compounds (VOC)	**kg**	7.8	7.7	3.6	7.2	7.4	7.4	7.4	7.6	3.6
	% change with BC	0%	-1%	-54%	-7%	-5%	-5%	-5%	-2%	-54%
Persistent Organic Pollutants (POP)	**µg i-Teq**	51.7	51.4	35.4	49.1	50.0	49.9	49.9	51.0	35.4
	% change with BC	0%	-1%	-32%	-5%	-3%	-3%	-3%	-1%	-32%
Heavy Metals	**g Ni eq.**	109.1	108.2	130.3	104.9	104.6	104.4	104.4	107.2	130.3
	% change with BC	0%	-1%	19%	-4%	-4%	-4%	-4%	-2%	19%
PAHs	**g Ni eq.**	14.6	14.5	19.6	14.2	14.1	14.0	14.0	14.4	19.6
	% change with BC	0%	-1%	34%	-3%	-3%	-4%	-4%	-2%	34%
Particulate Matter (PM, dust)	**kg**	65.6	65.3	72.2	64.3	64.2	64.0	64.0	65.0	72.2
	% change with BC	0%	-1%	10%	-2%	-2%	-2%	-2%	-1%	10%
Emissions (Water)										
Heavy Metals	**g Hg/20**	51.4	51.1	79.9	50.6	49.8	49.7	49.7	50.7	80.0
	% change with BC	0%	-1%	55%	-2%	-3%	-3%	-3%	-1%	55%
Eutrophication	**kg PO4**	0.5	0.5	1.6	0.5	0.5	0.5	0.5	0.5	1.6
	% change with BC	0%	0%	239%	8%	-1%	-2%	-2%	-1%	239%

The share of total electricity is constant at 43% for almost all options and the base case.

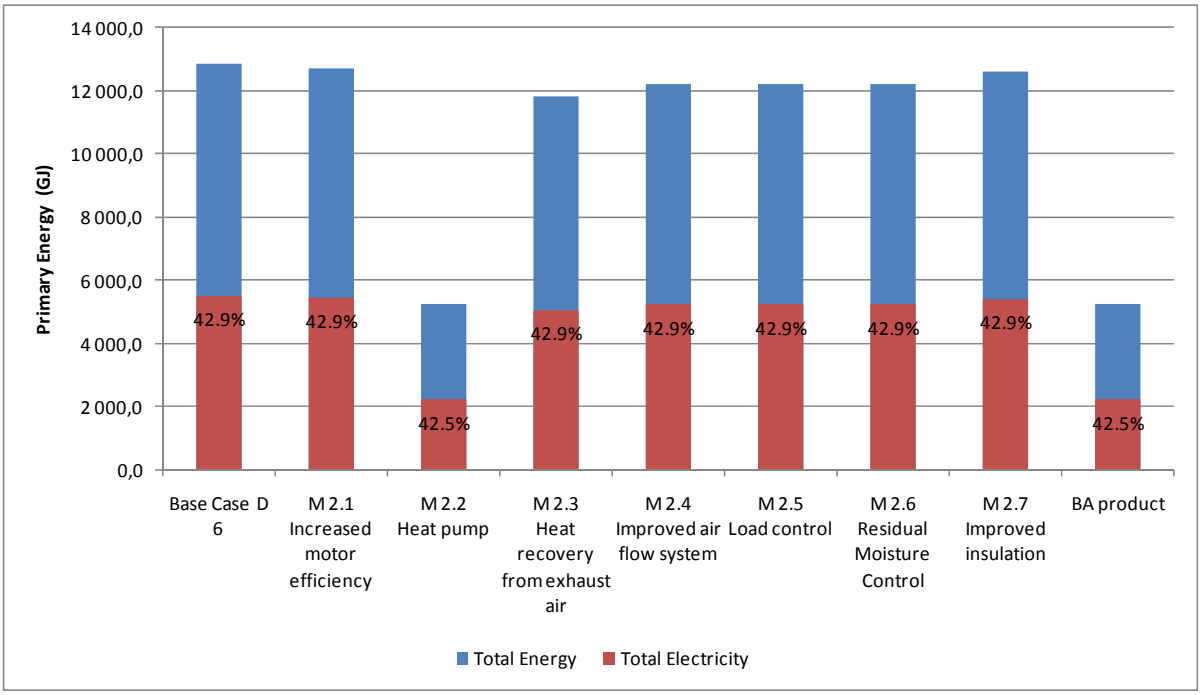


Figure 25 Energy consumption by improvement option for Base Case D 6

The impact of the options on other indicators is shown in Figure 26 below.

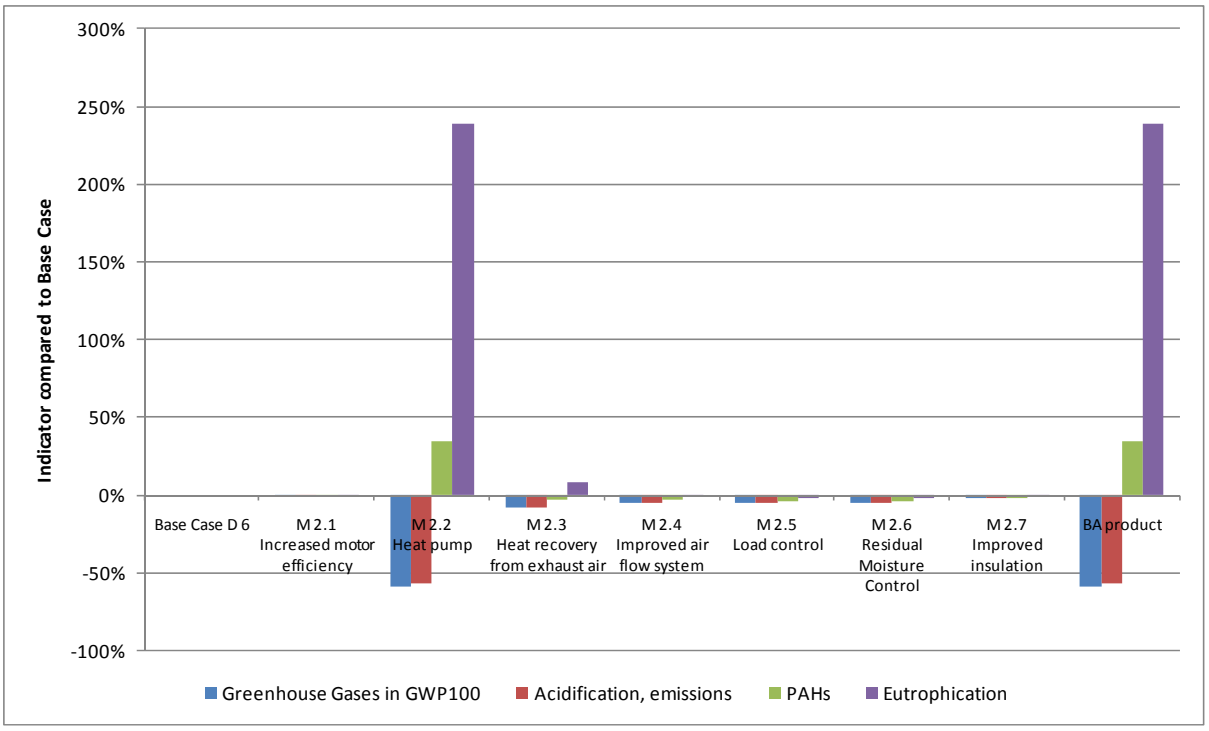


Figure 26 Improvement potential by improvement option for Base Case D 6

3.14 Base Case D 7: pass-through (transfer) tumble dryer

The results of the environmental analysis of the improvement options for Base Case D 7 are shown below. The BA product represents the highest reduction for all indicators, with 25% less total energy consumption and electricity consumption. The heat recovery option reduces energy consumption as well, by 12%.

Table 31 Environmental impacts by improvement option for Base Case D 7

Life cycle indicators per unit	Unit	Base Case D 7	M 2.1 Increased motor concept	M 2.3 Heat recovery from exhaust air	M 2.7 Improved insulation	BA product
Other resources and waste						
Total Energy (GER)	**GJ**	63 369.1	62 737.2	55 788.0	61 473.3	47 572.8
	% change with BC	0%	-1%	-12%	-3%	-25%
of which, electricity	**primary GJ**	14 738.6	14 591.6	12 974.7	14 297.5	11 063.4
	MWh	1 403.7	1 389.7	1 235.7	1 361.7	1 053.7
	% change with BC	0%	-1%	-12%	-3%	-25%
Water (process)	**kL**	983.7	973.9	867.7	954.3	740.2
	% change with BC	0%	-1%	-12%	-3%	-25%
Water (cooling)	**kL**	39 221.1	38 829.0	34 516.8	38 044.9	29 419.9
	% change with BC	0%	-1%	-12%	-3%	-25%
Waste, non-haz./ landfill	**kg**	22 386.0	22 215.3	20 373.3	21 874.7	18 157.0
	% change with BC	0%	-1%	-9%	-2%	-19%
Waste, hazardous/ incinerated	**kg**	348.1	344.7	308.4	338.1	264.5
	% change with BC	0%	-1%	-11%	-3%	-24%
Emissions (Air)						
Greenhouse Gases in GWP100	**t CO2 eq.**	3 335.4	3 302.2	2 936.9	3 235.7	2 504.9
	% change with BC	0%	-1%	-12%	-3%	-25%
Acidification, emissions	**kg SO2 eq.**	4 606.4	4 560.7	4 059.8	4 469.4	3 466.1
	% change with BC	0%	-1%	-12%	-3%	-25%
Volatile Organic Compounds (VOC)	**kg**	41.6	41.2	36.8	40.4	31.4
	% change with BC	0%	-1%	-12%	-3%	-25%
Persistent Organic Pollutants (POP)	**µg i-Teq**	173.7	172.7	162.3	170.8	149.8
	% change with BC	0%	-1%	-7%	-2%	-14%
Heavy Metals	**g Ni eq.**	273.1	270.5	246.1	265.5	213.2

Life cycle indicators per unit	Unit	Base Case D 7	M 2.1 Increased motor concept	M 2.3 Heat recovery from exhaust air	M 2.7 Improved insulation	BA product
	% change with BC	0%	-1%	-10%	-3%	-22%
PAHs	g Ni eq.	32.4	32.0	28.8	31.5	24.9
	% change with BC	0%	-1%	-11%	-3%	-23%
Particulate Matter (PM, dust)	kg	175.9	174.9	165.4	173.0	153.2
	% change with BC	0%	-1%	-6%	-2%	-13%
Emissions (Water)						
Heavy Metals	g Hg/20	108.6	107.7	99.1	105.8	86.8
	% change with BC	0%	-1%	-9%	-3%	-20%
Eutrophication	kg PO4	0.8	0.8	0.8	0.7	0.7
	% change with BC	0%	-1%	0%	-2%	-8%

Figure 27 presents the proportions represented by electricity consumption amongst the total primary energy consumption: 23.3% for all options.

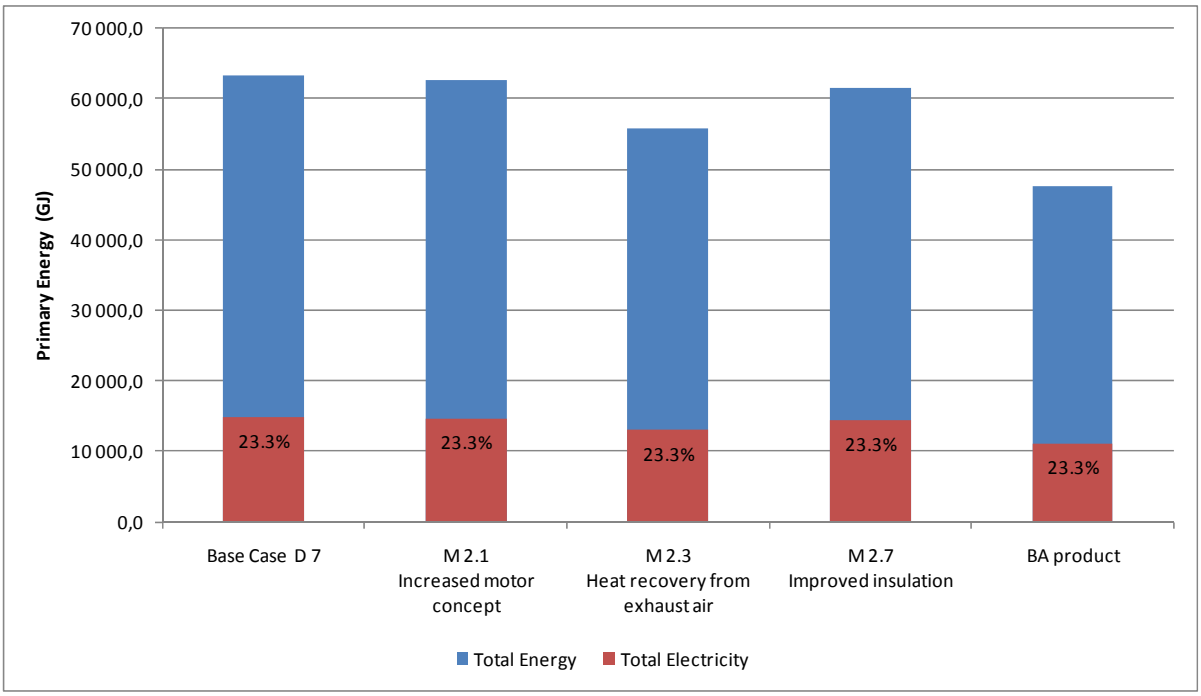


Figure 27 Energy consumption by improvement option for Base Case D 7

The impact of the heat recovery impact is positive with respect to GHG emissions. In general, the BA product is the best option, as it reduces the impact on all the indicators as shown below.

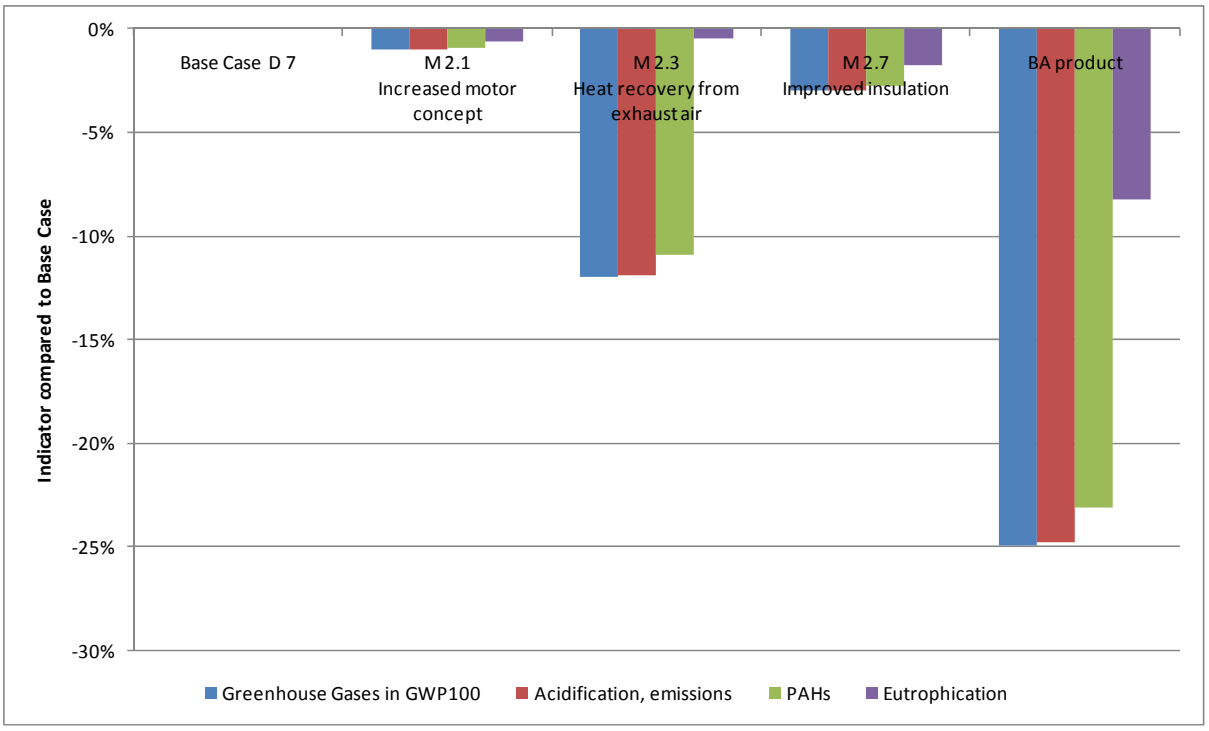


Figure 28 Improvement potential by improvement option for Base Case D 7

4 Costs analysis

The aim of this sub-task is to assess the LCC of each of the 14 individual improvement options (and their combination) considered. In doing so the quantification will cover both the PP (purchasing price) and the OE (operating expenses by consumers), as in Task 5.

The approach chosen, and deemed to be the most relevant for the type of options selected, is to consider the marginal costs due to the improvement options. The extent to which the various costs are expected to change from the LCC established for the base cases in Task 5 is analysed. This approach is relevant here because the options considered constitute more an evolution or additional features than a complete technological revolution of the products.

4.1 Base Case WM 1: Semi-professional washer extractor

Table 32 shows that the LCC is related to option M 1.4 Load control, reducing it around 6%. The BA product does not appear beneficial over the lifetime (+16%), and neither does option M 1.3 (Water recovery), even if the operating costs are highly reduced (-37% for water and detergent costs for the BA product, -28% for energy costs).

Table 32 Life cycle costs by improvement option for Base Case WM 1

Life cycle indicators per unit	Unit	Base Case WM 1	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construction	BA product
Economic indicators									
Purchase price	**€**	2 670	2 723	2 804	4 005	3 097	2 857	2 750	5 340
	% change with BC	0%	2%	5%	50%	16%	7%	3%	100%
Installation costs	**€**	107	107	112	160	107	107	107	214
	% change with BC	0%	0%	5%	50%	0%	0%	0%	100%
Electricity costs	**€**	809	801	728	728	688	728	801	583
	% change with BC	0%	-1%	-10%	-10%	-15%	-10%	-1%	-28%
Gas costs	**€**	139	138	125	125	118	125	138	100
	% change with BC	0%	-1%	-10%	-10%	-15%	-10%	-1%	-28%
Water costs	**€**	1 512	1 512	1 512	1 058	1 209	1 361	1 497	952
	% change with BC	0%	0%	0%	-30%	-20%	-10%	-1%	-37%
Detergents costs	**€**	2 168	2 168	2 168	1 843	1 734	1 951	2 146	1 366
	% change with BC	0%	0%	0%	-15%	-20%	-10%	-1%	-37%
Maintenance and repair costs	**€**	67	69	71	101	78	72	69	135
	% change with BC	0%	2%	5%	50%	16%	7%	3%	100%
Life cycle cost	**€**	7 472	7 518	7 520	8 021	7 032	7 201	7 508	8 690
	% change with BC	0%	1%	1%	7%	-6%	-4%	0%	16%

Figure 29 presents the breakdown of the LCC for the base case and all improvement options. The purchase price of the BA product represents a very important share of the total life cycle costs (61.5%).

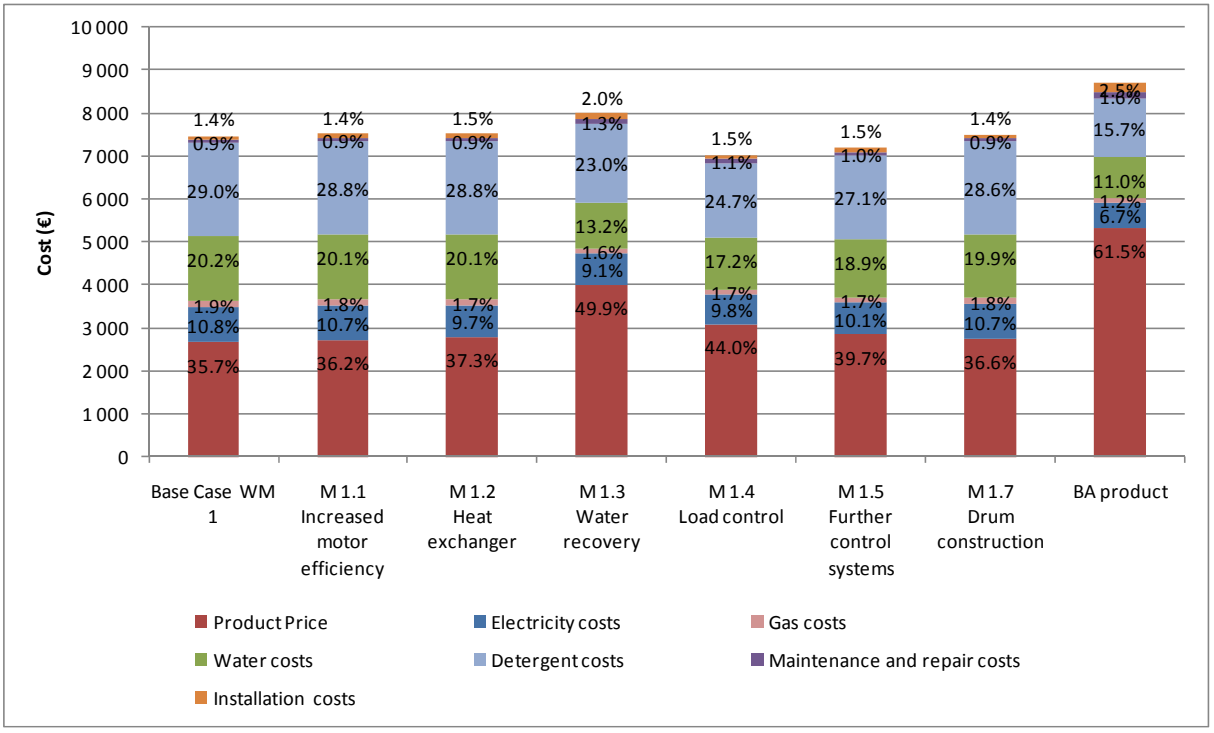


Figure 29 Life cycle costs breakdown by improvement option for Base Case WM 1

4.2 Base Case WM 2: Professional washer extractor <15kg

Again, option M 1.4 load control leads to the LLCC, reducing the LCC in 11% as shown in the Table 33. However, most options are now beneficial and reducing the LCC compared to the base case: -10% for the BA product, -4% for option M 1.5 Further control systems, -2% for option M 1.3 Water recovery.

Table 33 Life cycle costs by improvement option for Base Case WM 2

Life cycle indicators per unit	Unit	Base Case WM 2	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
Economic indicators									
Purchase price	**€**	5 000	5 100	5 250	7 500	5 800	5 050	5 100	6 250
	% change with BC	0%	2%	5%	50%	16%	1%	2%	25%
Installation costs	**€**	200	200	210	300	200	200	200	250
	% change with BC	0%	0%	5%	50%	0%	0%	0%	25%
Electricity costs	**€**	2 563	2 537	2 307	2 307	2 127	2 384	2 512	2 025
	% change with BC	0%	-1%	-10%	-10%	-17%	-7%	-2%	-21%
Gas costs	**€**	441	436	397	397	366	410	432	348
	% change with BC	0%	-1%	-10%	-10%	-17%	-7%	-2%	-21%
Water costs	**€**	5 780	5 780	5 780	4 046	4 508	5 375	5 664	4 451
	% change with BC	0%	0%	0%	-30%	-22%	-7%	-2%	-23%
Detergents costs	**€**	6 194	6 194	6 194	5 265	4 955	5 884	6 070	4 893
	% change with BC	0%	0%	0%	-15%	-20%	-5%	-2%	-21%
Maintenance and repair costs	**€**	117	120	123	176	136	118	120	147
	% change with BC	0%	2%	5%	50%	16%	1%	2%	25%
Life cycle cost	**€**	20 295	20 367	20 261	19 990	18 093	19 422	20 098	18 364
	% change with BC	0%	0%	0%	-2%	-11%	-4%	-1%	-10%

Figure 30 presents the breakdown of the LCC for the base case and all improvement options. Although the share of the product price is more important for M 1.4 Load control (322.1%), the investment reduces the shares of the water and detergent costs which results in a beneficial LCC.

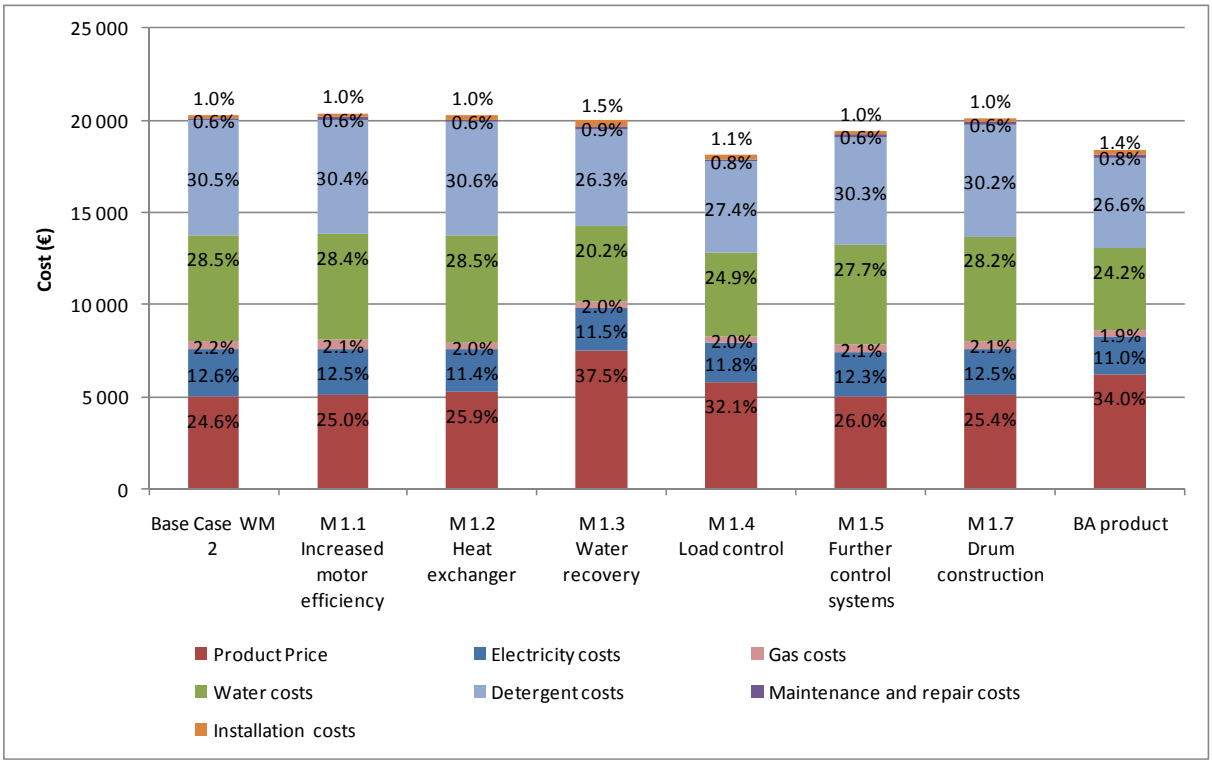


Figure 30 Life cycle costs breakdown by improvement option for Base Case WM 2

4.3 Base Case WM 3: Professional washer extractor 15–40 kg

The option M 1.4 Load control leads to the LLCC. The reduction in the expenses is reduced by 11%. The situation is similar to WM 2 where most improvement options lead to a reduction of the LCC.

Table 34 Life cycle costs by improvement option for Base Case WM 3

Life cycle indicators per unit	Unit	Base Case WM 3	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
Economic indicators									
Purchase price	**€**	15 250	15 555	16 013	22 875	17 690	15 403	15 555	19 825
	% change with BC	0%	2%	5%	50%	16%	1%	2%	30%
Installation costs	**€**	610	610	641	915	610	610	641	793
	% change with BC	0%	0%	5%	50%	0%	0%	5%	30%
Electricity costs	**€**	5 854	5 795	5 269	5 269	4 859	5 561	5 737	4 742
	% change with BC	0%	-1%	-10%	-10%	-17%	-5%	-2%	-19%
Gas costs	**€**	2 409	2 385	2 168	2 168	1 999	2 288	2 361	1 951
	% change with BC	0%	-1%	-10%	-10%	-17%	-5%	-2%	-19%
Water costs	**€**	20 653	20 653	20 653	14 457	16 109	19 620	20 240	16 109
	% change with BC	0%	0%	0%	-30%	-22%	-5%	-2%	-22%
Detergents costs	**€**	16 859	16 859	16 859	14 330	13 487	16 016	16 522	13 487
	% change with BC	0%	0%	0%	-15%	-20%	-5%	-2%	-20%
Maintenance and repair costs	**€**	345	352	362	518	400	349	352	449
	% change with BC	0%	2%	5%	50%	16%	1%	2%	30%
Life cycle cost	**€**	61 980	62 209	61 964	60 531	55 155	59 847	61 407	57 356
	% change with BC	0%	0%	0%	-2%	-11%	-3%	-1%	-7%

Figure 31 presents the breakdown of the LCC for the base case and all improvement options. The higher purchase prices are generally counterbalanced by reduced energy, water and detergent costs. Gas costs always represent a low share of the LCC (around 3-4%).

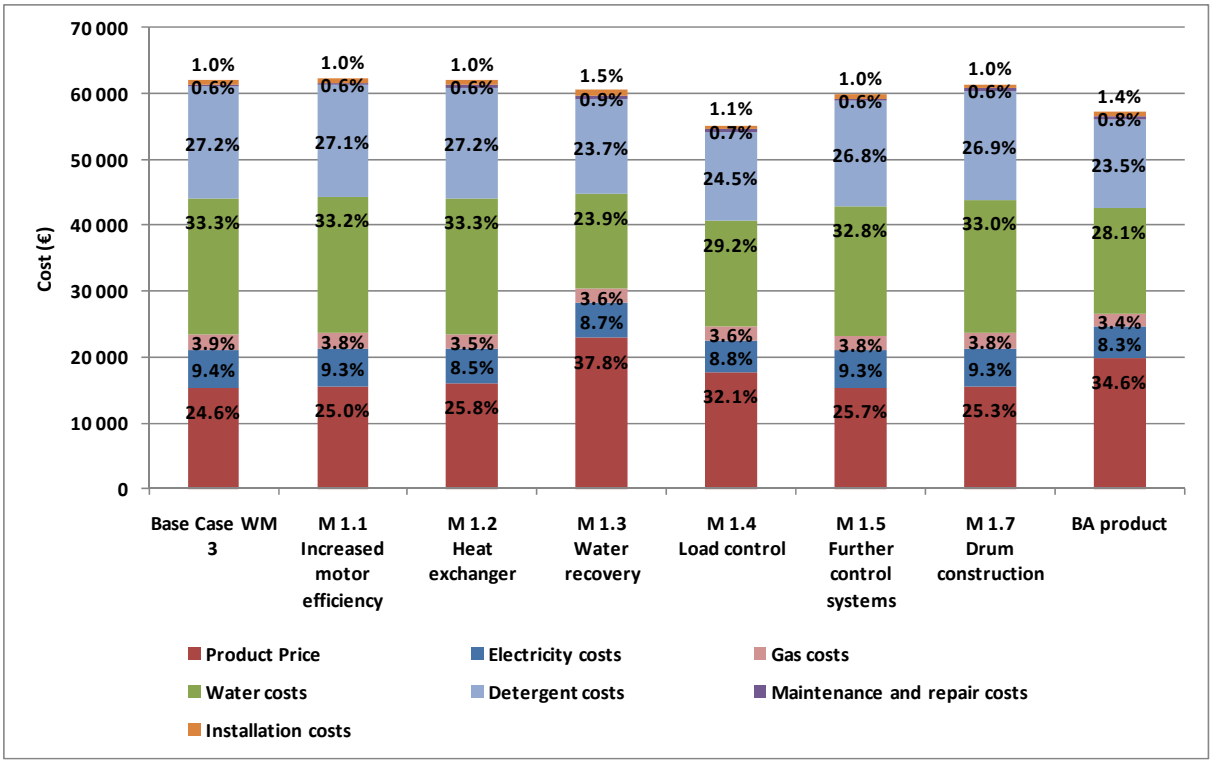


Figure 31 Life cycle costs breakdown by improvement option for Base Case WM 3

4.4 Base Case WM 4: Professional washer extractor >40kg

Option M 1.3 Water recovery leads to the LLCC with a reduction of 20% on the LCC. Option M 1.4 Load control and the BA product always result in important reduction of the LCC, respectively 12% and 9%. This is particularly due to the reduction of the water costs for these three options. Other options having no influence on the water and detergent consumption (M 1.1 Increased motor efficiency and M 1.2 Heat exchanger) do not reduce the LCC.

Table 35 Life cycle costs by improvement option for Base Case WM 4

Life cycle indicators per unit	Unit	Base Case WM 4	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	BA product
Economic indicators								
Purchase price	**€**	58 750	59 925	70 500	76 375	65 800	60 513	79 313
	% change with BC	0%	2%	20%	30%	12%	3%	35%
Installation costs	**€**	2 350	2 350	2 820	3 055	2 350	2 350	3 173
	% change with BC	0%	0%	20%	30%	0%	0%	35%
Electricity costs	**€**	29 617	29 321	22 805	20 732	26 655	28 728	22 805
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Gas costs	**€**	20 353	20 150	15 672	14 247	18 318	19 743	15 672
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Water costs	**€**	95 863	95 863	95 863	60 394	74 773	92 987	73 815
	% change with BC	0%	0%	0%	-37%	-22%	-3%	-23%
Detergents costs	**€**	93 372	93 372	93 372	58 824	72 830	90 571	72 830
	% change with BC	0%	0%	0%	-37%	-22%	-3%	-22%
Maintenance and repair costs	**€**	10 887	11 104	13 064	14 153	12 193	11 213	14 697
	% change with BC	0%	2%	20%	30%	12%	3%	35%
Life cycle cost	**€**	311 192	312 085	314 096	247 780	272 920	306 105	282 304
	% change with BC	0%	0%	1%	-20%	-12%	-2%	-9%

Figure 32 presents the breakdown of the LCC for the base case and all improvement options.

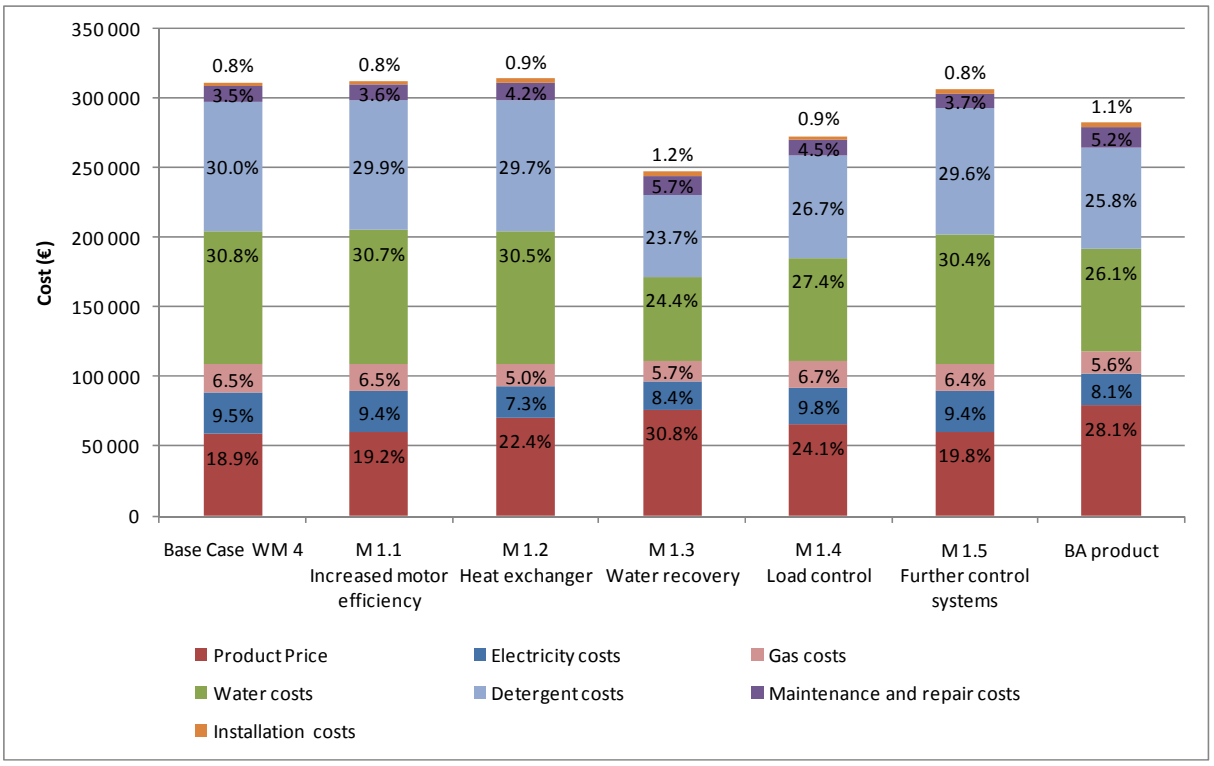


Figure 32 Life cycle costs breakdown by improvement option for Base Case WM 4

4.5 Base Case WM 5: Professional washer dryer

In this case, the improvement option M 1.4 load control leads to the LLCC. The reduction of the LCC is about 13%. Both energy and water and detergent costs are importantly reduced. Option M 1.5 Further control systems also leads to a LCC reduction (-6%), but this is not the case of option M 1.1 Increased motor efficiency.

Table 36 Life cycle costs by improvement option for Base Case WM 5

Life cycle indicators per unit	Unit	Base Case WM 5	M 1.1 Increased motor efficiency	M 1.4 Load control	M 1.5 Further control systems
Economic indicators					
Purchase price	**€**	8 000	8 160	8 160	8 000
	% change with BC	0%	2%	2%	0%
Installation costs	**€**	320	320	320	320
	% change with BC	0%	0%	0%	0%
Electricity costs	**€**	6 807	6 739	5 446	6 126
	% change with BC	0%	-1%	-20%	-10%
Water costs	**€**	2 310	2 310	1 617	2 079
	% change with BC	0%	0%	-30%	-10%
Detergents costs	**€**	2 453	2 453	1 717	2 208
	% change with BC	0%	0%	-30%	-10%
Maintenance and repair costs	**€**	191	195	195	191
	% change with BC	0%	2%	2%	0%
Life cycle cost	**€**	20 081	20 177	17 455	18 924
	% change with BC	0%	0%	-13%	-6%

Figure 33 presents the breakdown of the LCC for the base case and all improvement options. Electricity costs represent an important share (32-33%) of the LCC for all options, in comparison with other base cases.

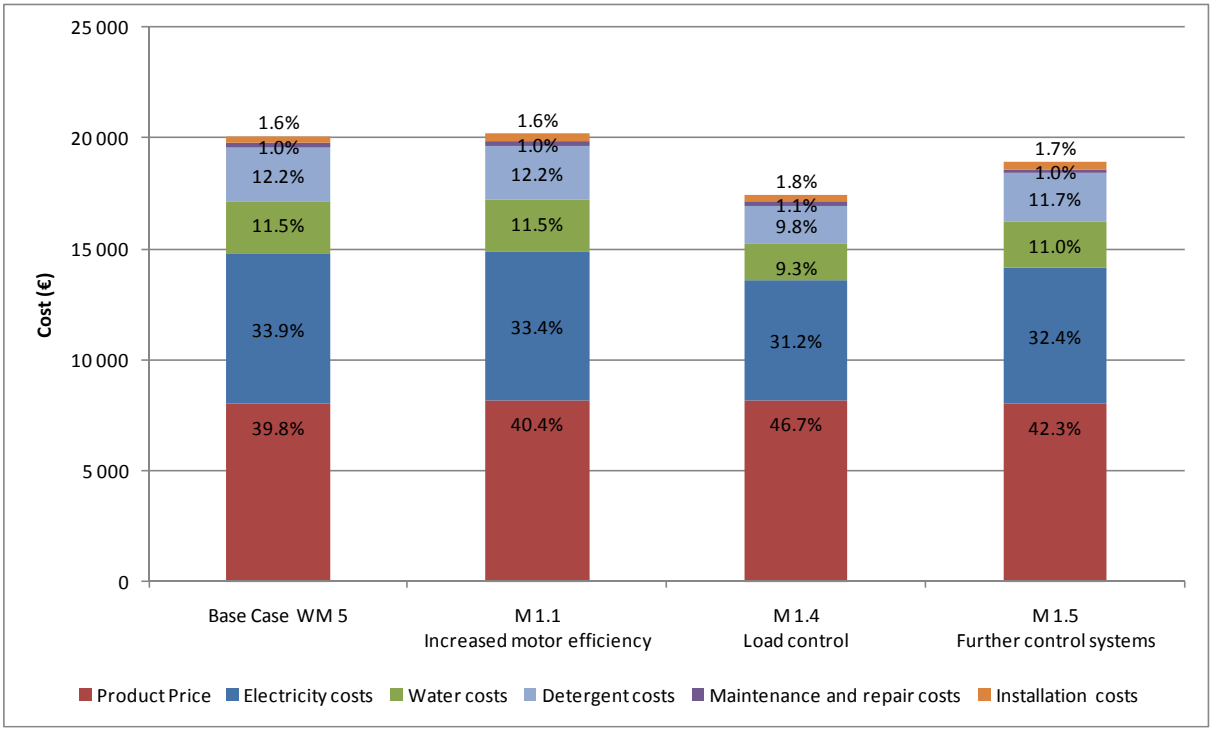


Figure 33 Life cycle costs breakdown by improvement option for Base Case WM 5

4.6 Base Case WM 6: Professional Barrier Washer

Option M 1.3 Water recovery leads to the LLCC, it reduces 10% of the LCC. Option M 1.4 Load control is also beneficial (4% reduction), also thanks to the reduction of water and detergent costs. The BA product has a similar LCC than the base case, which means that its improved environmental performance would be justified, even if not providing economic benefits.

Table 37 Life cycle costs by improvement option for Base Case WM 6

Life cycle indicators per unit	Unit	Base Case WM 6	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	BA product
Economic indicators								
Purchase price	**€**	38 250	39 015	45 900	49 725	42 840	39 398	51 638
	% change with BC	0%	2%	20%	30%	12%	3%	35%
Installation costs	**€**	1 530	1 530	1 836	1 989	1 530	1 530	2 066
	% change with BC	0%	0%	20%	30%	0%	0%	35%
Electricity costs	**€**	10 089	9 988	7 768	7 062	9 080	9 786	7 768
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Gas costs	**€**	7 344	7 271	5 655	5 141	6 610	7 124	5 655
	% change with BC	0%	-1%	-23%	-30%	-10%	-3%	-23%
Water costs	**€**	30 144	30 144	30 144	18 991	23 513	29 240	23 513
	% change with BC	0%	0%	0%	-37%	-22%	-3%	-22%
Detergents costs	**€**	25 690	25 690	25 690	16 184	20 038	25 176	20 038
	% change with BC	0%	0%	0%	-37%	-22%	-2%	-22%
Maintenance and repair costs	**€**	7 215	7 359	8 658	9 379	8 081	7 431	9 740
	% change with BC	0%	2%	20%	30%	12%	3%	35%
Life cycle cost	**€**	120 262	120 997	125 651	108 472	111 691	119 685	120 417
	% change with BC	0%	1%	4%	-10%	-7%	0%	0%

Figure 34 presents the breakdown of the LCC for the base case and all improvement options. The purchase price represents 45.8% of the LCC in the case of option M 1.3 Water recovery, while all the other costs are highly reduced, especially for water and detergent. The additional investment of M 1.2 Heat exchanger does not appear beneficial as the energy costs (gas and electricity) which are reduced do not represent a high enough share of the total LCC.

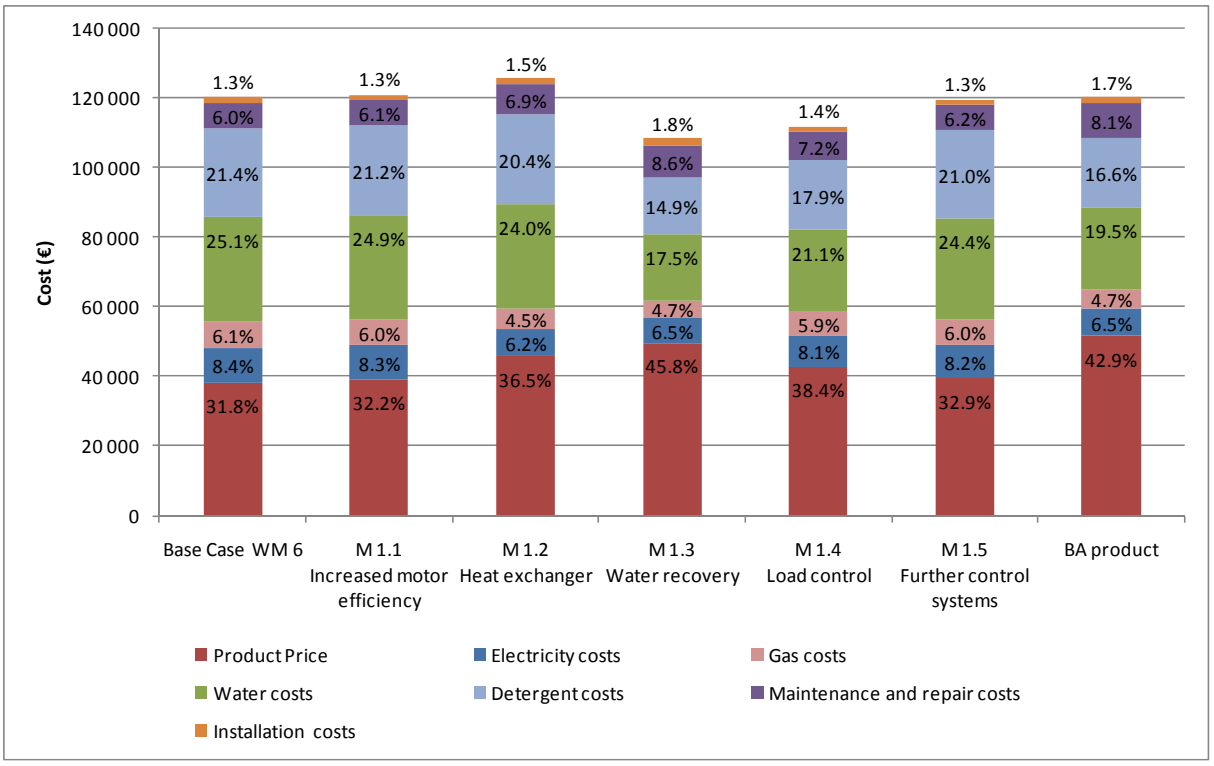


Figure 34 Life cycle costs breakdown by improvement option for Base Case WM 6

4.7 Base Case WM 7: Washing tunnel machine

The BA product represents the LLCC for this base case. It reduces the LCC by 32%, thanks to 50% reduction of the water and detergent costs. Therefore, the additional investment of 30% (purchase price, installation and maintenance), is quickly counterbalanced. Option M 1.2 Heat exchanger also appear significantly beneficial for the first time (-4%), amongst the different washing machine base cases.

Table 38 Life cycle costs by improvement option for Base Case WM 7

Life cycle indicators per unit	Unit	Base Case WM 7	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	BA product
Economic indicators					
Purchase price	**€**	390 000	409 500	448 500	507 000
	% change with BC	0%	5%	15%	30%
Installation costs	**€**	35 100	35 100	40 365	45 630
	% change with BC	0%	0%	15%	30%
Electricity costs	**€**	72 189	71 467	50 532	46 923
	% change with BC	0%	-1%	-30%	-35%
Water costs	**€**	726 013	726 013	726 013	363 006
	% change with BC	0%	0%	0%	-50%
Detergents costs	**€**	825 014	825 014	825 014	412 507
	% change with BC	0%	0%	0%	-50%
Maintenance and repair costs	**€**	74 892	78 637	86 126	97 360
	% change with BC	0%	5%	15%	30%
Gas costs	**€**	535 976	530 616	375 183	348 384
	% change with BC	0%	-1%	-30%	-35%
Life cycle cost	**€**	2 659 184	2 676 347	2 551 733	1 820 811
	% change with BC	0%	1%	-4%	-32%

Figure 35 presents the breakdown of the LCC for the base case and all improvement options. Detergent and water costs almost account for 60% of the LCC for all options and the base case, except the BA product.

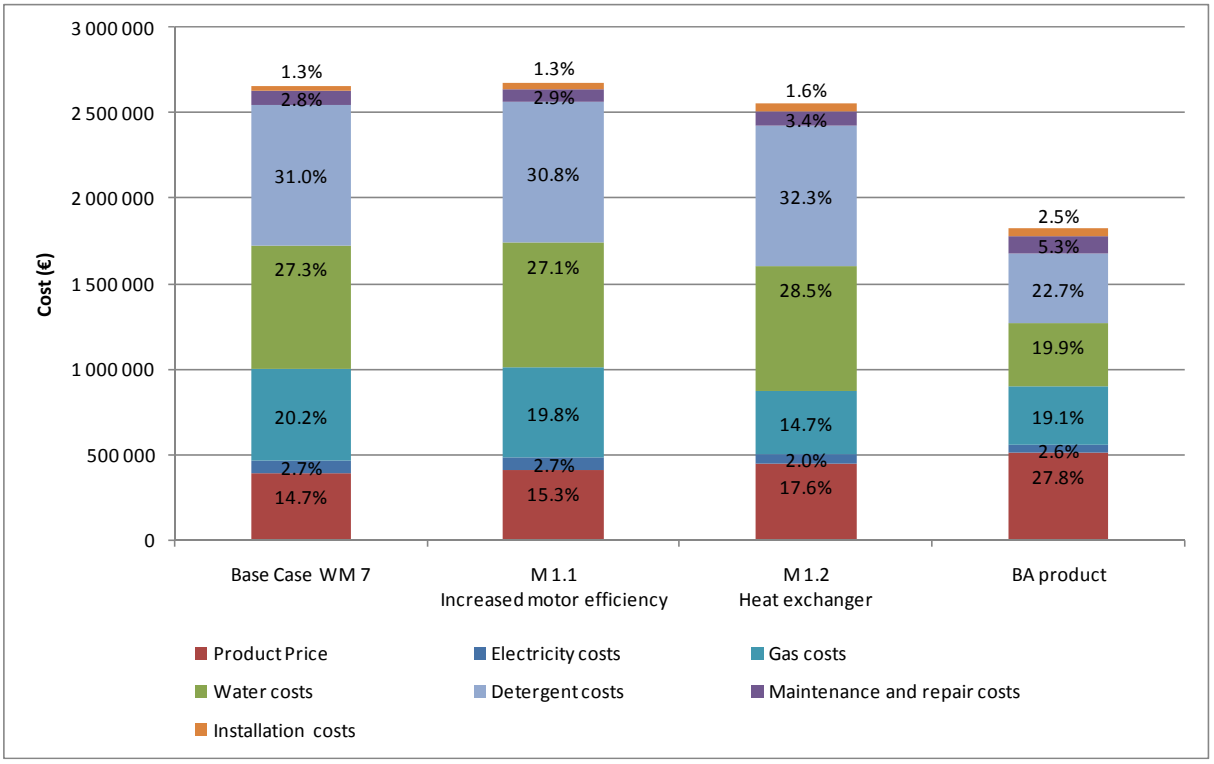


Figure 35 Life cycle costs breakdown by improvement option for Base Case WM 7

4.8 Base Case D 1: Semi-professional dryer, condenser

The option M 2.2 heat pump leads to the LLCC. It reduces 12% the LCC. All the other single improvement options reduce the LCC too, but the BA product does not (+2%) because of the higher purchase price (+150%). Electricity costs are nonetheless reduced by 67%.

Table 39 Life cycle costs by improvement option for Base Case D 1

Life cycle indicators per unit	Unit	Base Case D 1	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Economic indicators									
Purchase price	**€**	1 970	2 029	3 546	2 128	2 167	2 167	2 167	4 925
	% change with BC	0%	3%	80%	8%	10%	10%	10%	150%
Installation costs	**€**	79	81	142	79	79	79	79	197
	% change with BC	0%	3%	80%	0%	0%	0%	0%	150%
Electricity costs	**€**	4 531	4 441	2 039	4 078	4 078	4 078	4 078	1 495
	% change with BC	0%	-2%	-55%	-10%	-10%	-10%	-10%	-67%
Maintenance and repair costs	**€**	50	51	90	54	55	55	55	124
	% change with BC	0%	3%	80%	8%	10%	10%	10%	150%
Life cycle cost	**€**	6 630	6 602	5 816	6 338	6 379	6 379	6 379	6 742
	% change with BC	0%	0%	-12%	-4%	-4%	-4%	-4%	2%

Figure 36 presents the breakdown of the LCC for the base case and all improvement options. The electricity cost represents the highest proportion of expenditure for all options except the heat pump and the BA product. In this case, the purchase price is much higher.

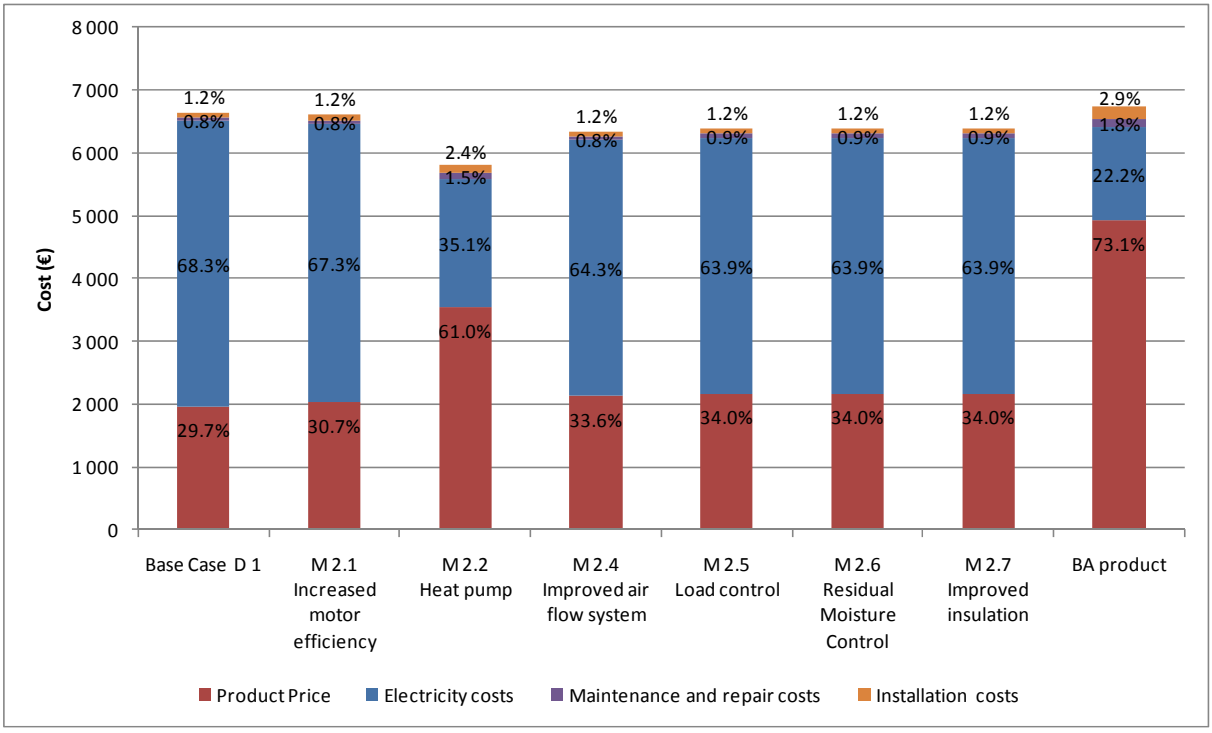


Figure 36 Life cycle costs breakdown by improvement option for Base Case D 1

4.9 Base Case D 2: Semi-professional dryer, air vented

The option M 2.2 Heat pump has the highest reduction of the LCC. It is around 11% of the total LCC. The BA product and option M 2.3 Heat recovery from exhaust air are the only two options which are not reducing the LCC (respectively +1% and +4%).

Table 40 Life cycle costs by improvement option for Base Case D 2

Life cycle indicators per unit	Unit	Base Case D 2	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Economic indicators										
Purchase price	**€**	1 680	1 730	2 688	2 184	1 814	1 848	1 848	1 848	2 520
	% change with BC	0%	3%	60%	30%	8%	10%	10%	10%	50%
Installation costs	**€**	67	67	108	87	67	67	67	67	101
	% change with BC	0%	0%	60%	30%	0%	0%	0%	0%	50%
Electricity costs	**€**	2 823	2 767	1 412	2 541	2 541	2 541	2 541	2 541	2 117
	% change with BC	0%	-2%	-50%	-10%	-10%	-10%	-10%	-10%	-25%
Maintenance and repair costs	**€**	42	44	68	55	46	47	47	47	64
	% change with BC	0%	3%	60%	30%	8%	10%	10%	10%	50%
Gas costs	**€**	457	448	229	411	411	411	411	411	343
	% change with BC	0%	-2%	-50%	-10%	-10%	-10%	-10%	-10%	-25%
Life cycle costs	**€**	5 070	5 056	4 503	5 279	4 879	4 914	4 914	4 914	5 144
	% change with BC	0%	0%	-11%	4%	-4%	-3%	-3%	-3%	1%

Figure 37 presents the breakdown of the LCC for the base case and all improvement options. Gas costs represent a very low share in comparison with the electricity costs. For option M 2.2 Heat pump, the purchase price represents 60% of the LCC but the energy costs are so importantly reduced that this option ends up being the LLCC.

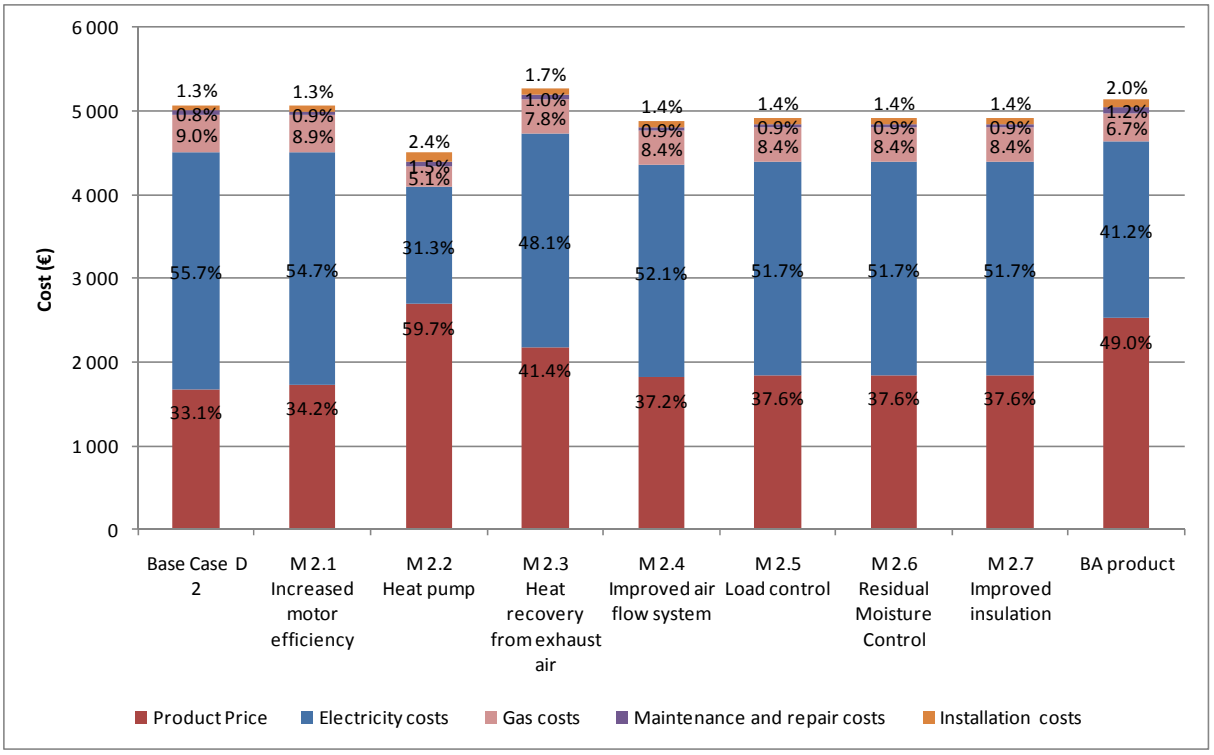


Figure 37 Life cycle costs breakdown by improvement option for Base Case D 2

4.10 Base Case D 3: Professional Cabinet dryer

The option M 2.2 heat pump leads to the LLCC. It reduces 14% the LCC, thanks to a 60% reduction of the energy costs. Again, all the other options except option M 2.3 Heat recovery from exhaust air reduce the LCC (between 4% and 6%). The BA product reduces the most the electricity costs (-68%) but also has the higher purchase price (+150%).

Table 41 Life cycle costs by improvement option for Base Case D 3

Life cycle indicators per unit	Unit	Base Case D 3	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.7 Improved insulation	BA product
Economic indicators							
Purchase price	**€**	3 500	7 000	4 550	3 675	3 850	8 750
	% change with BC	0%	100%	30%	5%	10%	150%
Installation costs	**€**	140	280	182	140	140	350
	% change with BC	0%	100%	30%	0%	0%	150%
Electricity costs	**€**	9 089	3 636	8 180	8 180	8 180	2 909
	% change with BC	0%	-60%	-10%	-10%	-10%	-68%
Maintenance and repair costs	**€**	78	156	101	82	86	195
	% change with BC	0%	100%	30%	5%	10%	150%
Life cycle cost	**€**	12 807	11 071	13 014	12 077	12 256	12 203
	% change with BC	0%	-14%	2%	-6%	-4%	-5%

The purchase share for M 2.2 and BA product are the highest among all the options and the base case. In particular for the case of the BA product option this is the result of having reduced energy costs as shown in the figure below.

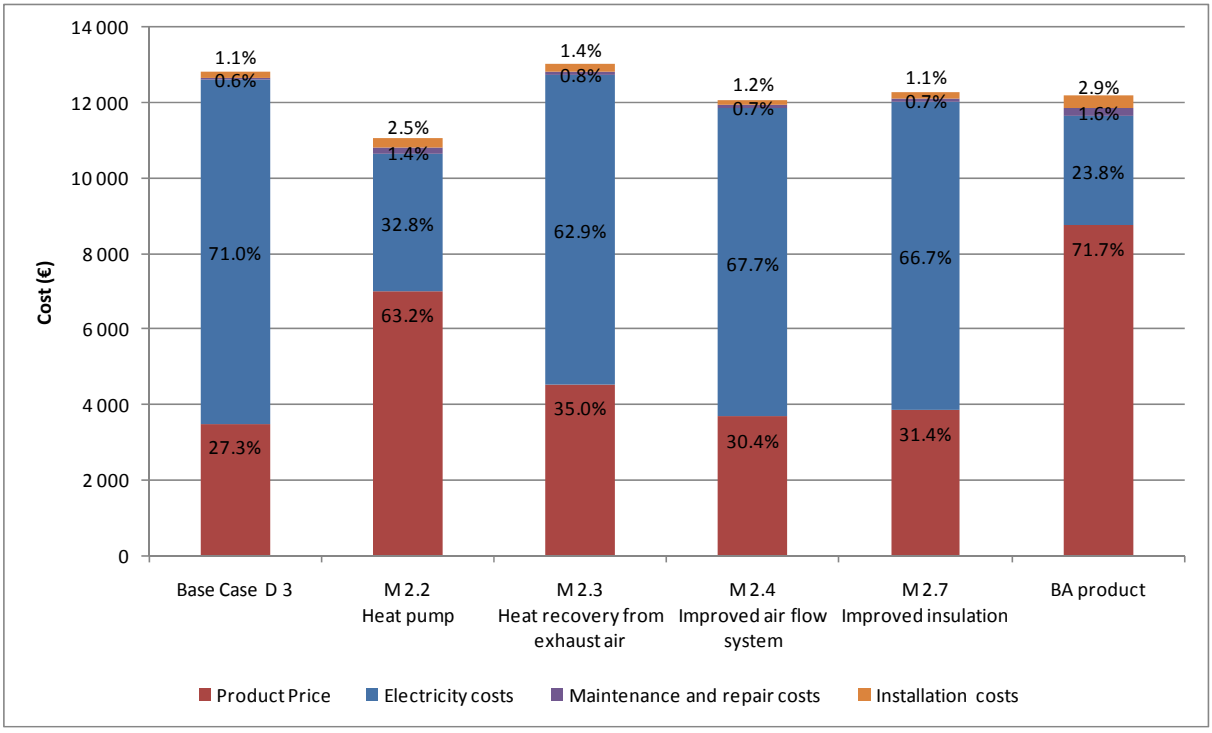


Figure 38 Life cycle costs breakdown by improvement option for Base Case D 3

4.11 Base Case D 4: Professional tumble dryer (<15 kg)

The BA product leads to the LLCC. It reduces 20% the LCC. Option M 2.2 heat pump also reduces the LCC by 15% thanks to reduced gas and electricity costs (-60%). Option M 2.3 Heat recovery from exhaust air is still not economically beneficial over the lifetime but all other improvement options are.

Table 42 Life cycle costs by improvement option for Base Case D 4

Life cycle indicators per unit	Unit	Base Case D 4	M 2.1 In-creased motor effici-ency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insula-tion	BA product
Economic indicators										
Purchase price	**€**	4 000	4 080	7 200	4 920	4 200	4 600	4 200	4 200	7 200
	% change with BC	0%	2%	80%	23%	5%	15%	5%	5%	80%
Installation costs	**€**	160	160	288	197	160	160	160	160	288
	% change with BC	0%	0%	80%	23%	0%	0%	0%	0%	80%
Electricity costs	**€**	6 764	6 561	2 706	6 087	6 223	5 952	5 952	6 290	2 232
	% change with BC	0%	-3%	-60%	-10%	-8%	-12%	-12%	-7%	-67%
Maintenance and repair costs	**€**	92	94	166	113	97	106	97	97	166
	% change with BC	0%	2%	80%	23%	5%	15%	5%	5%	80%
Gas costs	**€**	2 252	2 184	901	2 026	2 071	1 981	1 981	2 094	743
	% change with BC	0%	-3%	-60%	-10%	-8%	-12%	-12%	-7%	-67%
Life cycle cost	**€**	13 268	13 079	11 260	13 344	12 751	12 800	12 390	12 841	10 629
	% change with BC	0%	-1%	-15%	1%	-4%	-4%	-7%	-3%	-20%

The purchase shares for M 2.2 (63.9%) and the BA product (67.7%) are the highest among all the options and the base case and are in both cases counterbalanced by the reduction of the energy costs.

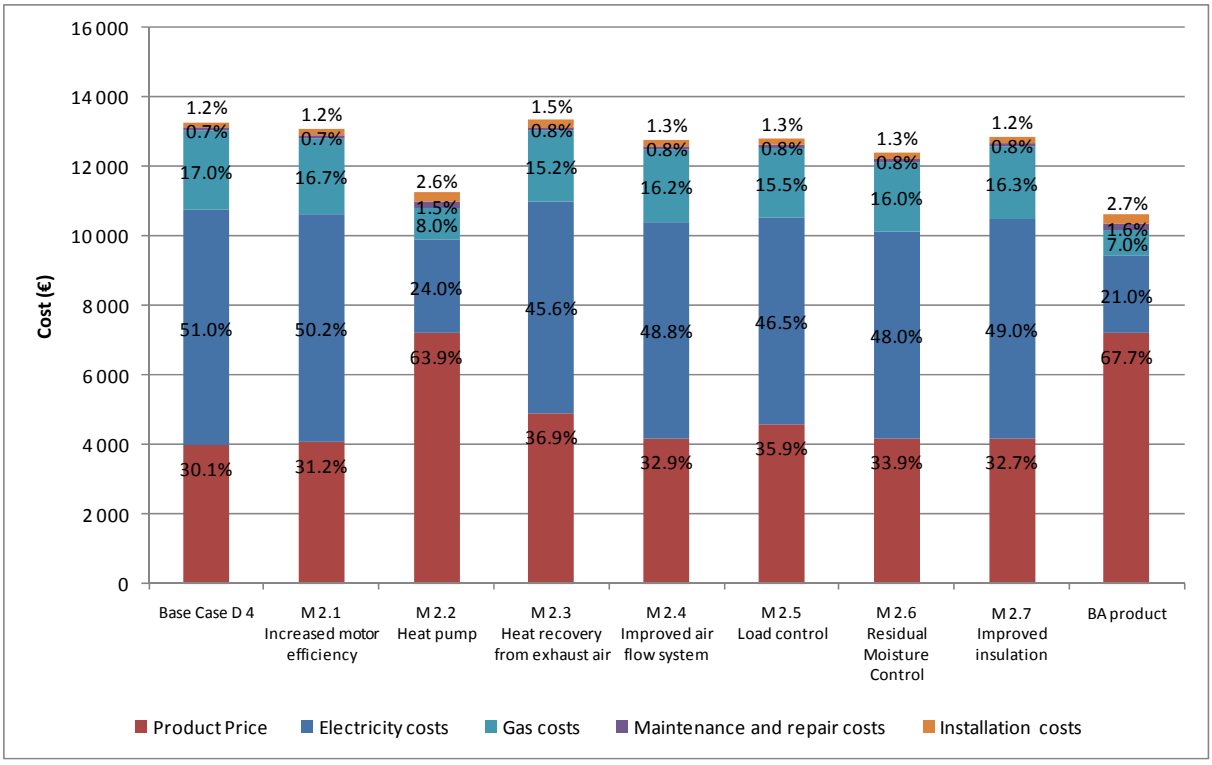


Figure 39 Life cycle costs breakdown by improvement option for Base Case D 4

4.12 Base Case D 5: Professional tumble dryer (15–40 kg)

The option M 2.2 heat pump and the BA product lead to the LLCC. They reduce 24% the LCC, and 60% the electricity and gas costs. All other options reduce the LCC as well, included option M 2.3 Heat recovery from exhaust air.

Table 43 Life cycle costs by improvement option for Base Case D 5

Life cycle indicators per unit	Unit	Base Case D 5	M 2.1 In-creased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insula-tion	BA product
Economic indicators										
Purchase price	**€**	7 125	7 268	12 825	8 835	7 553	8 123	7 766	7 553	12 825
	% change with BC	0%	2%	80%	24%	6%	14%	9%	6%	80%
Installation costs	**€**	285	285	513	353	302	285	285	285	513
	% change with BC	0%	0%	80%	24%	6%	0%	0%	0%	80%
Electricity costs	**€**	12 953	12 694	5 181	11 787	11 528	11 658	11 658	12 176	5 181
	% change with BC	0%	-2%	-60%	-9%	-11%	-10%	-10%	-6%	-60%
Maintenance and repair costs	**€**	161	165	290	200	171	184	176	171	290
	% change with BC	0%	2%	80%	24%	6%	14%	9%	6%	80%
Gas costs	**€**	8 935	8 757	3 574	8 131	7 952	8 042	8 042	8 399	3 574
	% change with BC	0%	-2%	-60%	-9%	-11%	-10%	-10%	-6%	-60%
Life cycle cost	**€**	29 460	29 168	22 384	29 307	27 506	28 291	27 927	28 584	22 384
	% change with BC	0%	-1%	-24%	-1%	-7%	-4%	-5%	-3%	-24%

Figure 40 presents the breakdown of the LCC for the base case and all improvement options.

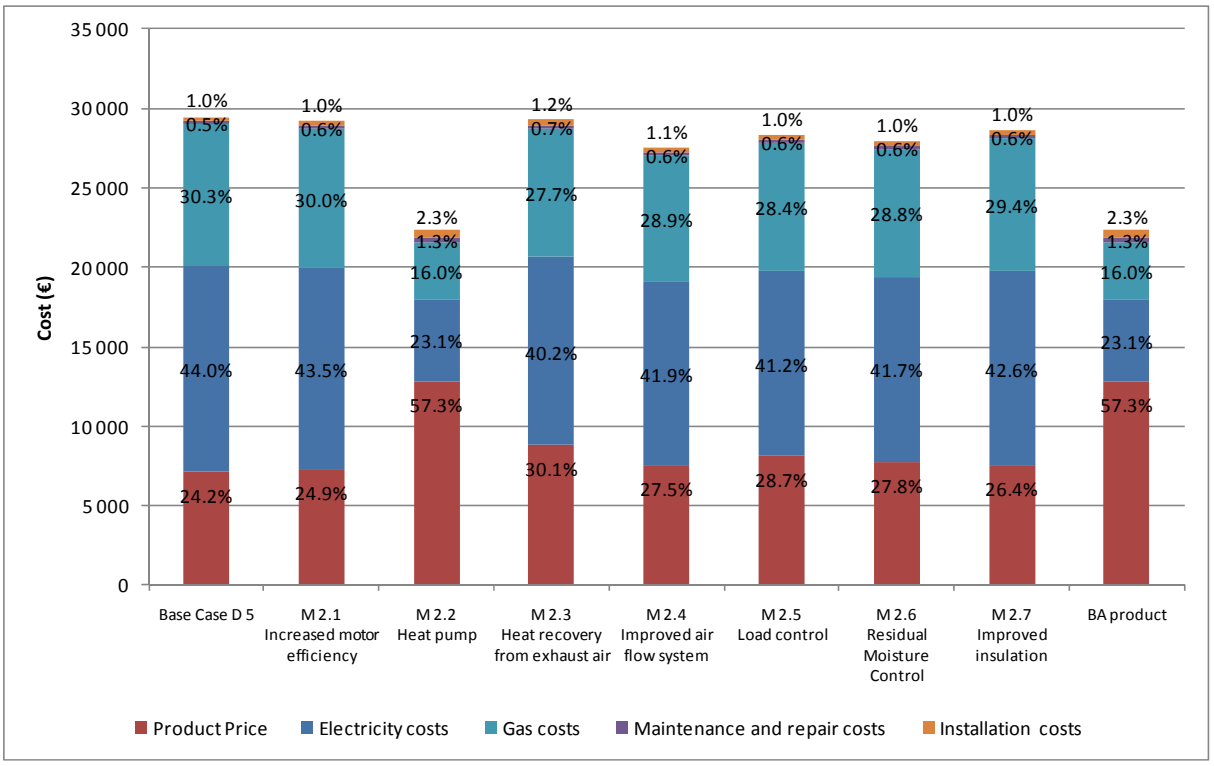


Figure 40 Life cycle costs breakdown by improvement option for Base Case D 5

4.13 Base Case D 6: Professional tumble dryer (>40 kg)

Option M 2.2 Heat pump and the BA product represent the LLCC for this base case. They reduce the LCC by 27% and the energy costs by 60% while the purchase costs increase by 80%. Option M 2.3 Heat recovery from exhaust air is the only improvement option not being economically beneficial (+3%).

Table 44 Life cycle costs by improvement option for Base Case D 6

Life cycle indicators per unit	Unit	Base Case D 6	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
Economic indicators										
Purchase price	**€**	21 500	21 930	38 700	29 455	23 220	23 865	24 725	23 435	38 700
	% change with BC	0%	2%	80%	37%	8%	11%	15%	9%	80%
Installation costs	**€**	860	860	1 548	1 178	860	860	860	860	1 548
	% change with BC	0%	0%	80%	37%	0%	0%	0%	0%	80%
Electricity costs	**€**	36 191	35 829	14 476	33 295	34 381	34 381	34 381	35 467	14 476
	% change with BC	0%	-1%	-60%	-8%	-5%	-5%	-5%	-2%	-60%
Maintenance and repair costs	**€**	2 973	3 032	5 351	4 073	3 210	3 300	3 419	3 240	5 351
	% change with BC	0%	2%	80%	37%	8%	11%	15%	9%	80%
Gas costs	**€**	46 038	45 577	18 415	42 355	43 736	43 736	43 736	45 117	18 415
	% change with BC	0%	-1%	-60%	-8%	-5%	-5%	-5%	-2%	-60%
Life cycle cost	**€**	107 561	107 228	78 490	110 356	105 407	106 141	107 120	108 119	78 490
	% change with BC	0%	0%	-27%	3%	-2%	-1%	0%	1%	-27%

Figure 41 presents the breakdown of the LCC for the base case and all improvement options. In comparison with the other base cases, gas costs now represent a substantial share of the LCC (between 23.5% for the BA product and 42.8% for the base case), which is larger than the electricity share.

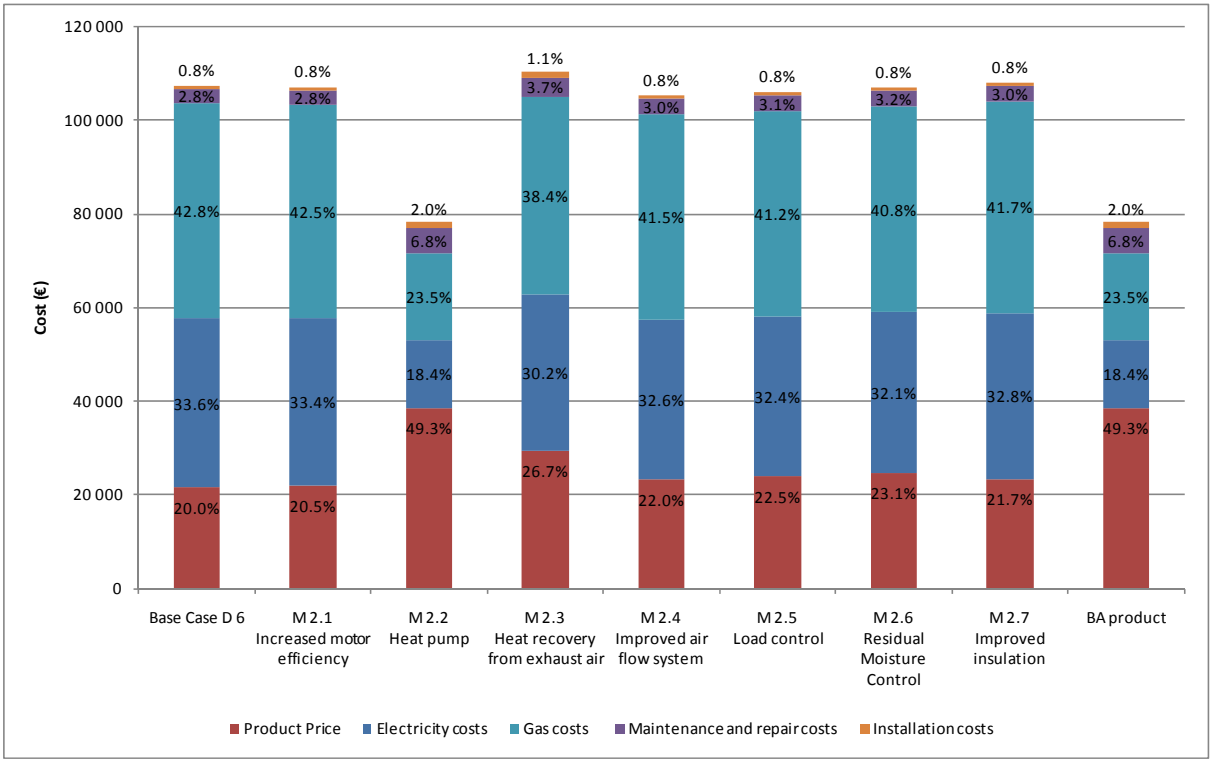


Figure 41 Life cycle costs breakdown by improvement option for Base Case D 6

4.14 Base Case D 7: Industrial pass-through (transfer) tumble dryer

The BA product option represents the LLCC for this base case. It reduces 14% the LCC and 25% the energy costs. Option M 2.1 Increased motor efficiency gives the highest LCC, while M 2.3 heat recovery from exhaust air reduces the LCC by 8% compared to the base case.

Table 45 Life cycle costs by improvement option for Base Case D 7

Life cycle indicators per unit	Unit	Base Case D 7	M 2.1 Increased motor concept	M 2.3 Heat recovery from exhaust air	M 2.7 Improved insulation	BA product
Economic indicators						
Purchase price	**€**	62 500	66 250	72 500	68 125	88 125
	% change with BC	0%	6%	16%	9%	41%
Installation costs	**€**	5 625	5 625	6 525	5 625	7 931
	% change with BC	0%	0%	16%	0%	41%
Electricity costs	**€**	96 802	95 834	85 185	93 898	72 601
	% change with BC	0%	-1%	-12%	-3%	-25%
Maintenance and repair costs	**€**	8 641	9 160	10 024	9 419	12 184
	% change with BC	0%	6%	16%	9%	41%
Gas costs	**€**	306 057	302 997	269 330	296 875	229 543
	% change with BC	0%	-1%	-12%	-3%	-25%
Life cycle cost	**€**	479 625	479 865	443 565	473 942	410 385
	% change with BC	0%	0%	-8%	-1%	-14%

Figure 42 presents the breakdown of the LCC for the base case and all improvement options. Gas costs are also particularly important for this base case which is considered with a 100% “alternative” heating (see Task 5).

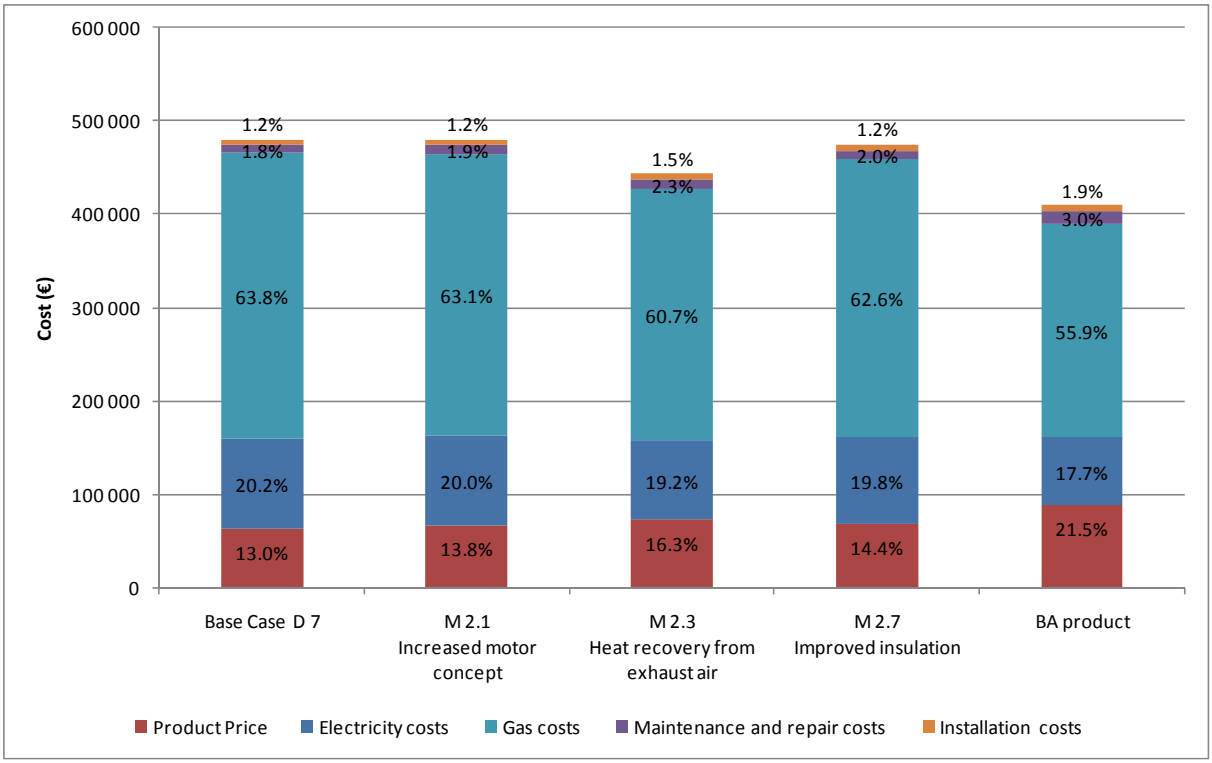


Figure 42 Life cycle costs breakdown by improvement option for Base Case D 7

4.15 Payback periods

Table 46 and Table 47 present the payback periods in years of the different improvement options implemented, for professional laundry appliances. In the estimation of these periods, maintenance and repair costs were kept constant in the calculations of the life cycle costs (and not proportional to the lifetime considered), since they were estimated by a percentage of the purchase price in Task 5, rather than on the basis of the product lifetime.

The payback period represents the year when the additional investment done when buying a more expensive appliance (all improvement options result in increases of the purchase price of the professional laundry appliances) is counterbalanced by the reduced operating costs of the appliance (in particular here, energy, water and detergent costs), when summing all costs in a life cycle approach.

Regarding professional washing machines, options M 1.4 Load control and M 1.5 Further control systems have quite low payback periods for all base cases. On the other hand,

options M 1.1 Increased motor efficiency and M 1.2 heat exchanger present very long periods, except for base case WM 7 and the heat exchanger (one year). For the remaining options, the situation is intermediate and the period depends on the base case considered (from one to 17 years for the BA products, 7 to 15 years for M 1.3 Water recovery).

Table 46 Payback periods (in years) of the improvement options for professional washing machines

Base case	Lifetime considered in previous analysis	M 1.1 Increased motor efficiency	M 1.2 Heat exchanger	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construction	BA product
WM 1	8	>20	14	15	4	4	17	17
WM 2	12	>20	11	11	3	1	4	5
WM 3	14	>20	14	12	4	1	5	7
WM 4	15	>20	>20	4	3	4	-	6
WM 5	11	>20	-	-	1	1	-	-
WM 6	14	>20	>20	7	5	9	-	15
WM 7	13	>20	1	-	-	-	-	1

Regarding professional laundry dryers, the options generally present lower payback periods. Except for the heat recovery system which in similar situation as the heat exchanger for washing machine (all periods high except for base case D 7), all other options have payback times of less than 8 years for most of the base cases. Given the average estimated lifetimes (all under 8 years), most options are logically economically beneficial over the lifetime of the product, as shown in the previous costs analysis.

Table 47 Payback periods (in years) of the improvement options for professional dryers

Base case	Lifetime considered in prev. analysis	M 2.1 Increased motor efficiency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Improved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Improved insulation	BA product
D1	8	6	6	-	3	4	4	4	9
D2	8	7	5	15	4	4	4	4	9
D3	15	-	10	>20	3	-	-	5	14
D4	13	4	8	15	4	7	3	4	7
D5	14	4	6	13	3	6	4	4	6
D6	13	7	5	>20	6	8	12	20	5
D7	13	15	-	3	-	-	-	7	4

5 Analysis of LLCC and BAT

In this sub-task we will combine environmental impacts and costs. The objective is to identify, amongst the options analysed, the Least Life Cycle Cost (LLCC) option and the Best Available Technology (BAT). This task will include:

- Ranking the identified design options by LCC (e.g. option 1, option 2, option 3)
- Considering the possible trade-offs (positive or negative side effects of the envisaged options/individual design measures);
- Estimating the accumulative improvement and cost effects of implementing the ranked options simultaneously (e.g. option 1, option 1+2, option 1+2+3, etc.);
- Ranking the cumulative design options, drawing an LCC-curve (Y1-axis = energy consumption, Y2-axis = LLCC, X-axis = options) and identifying the Least Life Cycle Cost (LLCC) point and the BAT point. The improvement potential resulting from the ranking will be discussed, such as the appropriateness of setting minimum requirements at the LLCC point, to use the environmental performance of the BAT point or benchmarks set in other countries as a benchmark or if manufacturers will make use of this ranking to evaluate alternative design solutions and the achieved environmental performance of the product.

The figures in the following subsection show on the one hand the total primary energy consumed over the whole life cycle of the products and the life cycle costs on the other hand. Primary energy was chosen here as the most important and representative environmental indicator, given the importance of the use phase and the electricity consumption during this phase:

- Although implementing the improvement options often increases the quantity of waste generated (mostly non-hazardous), this impact category is directly related to the quantity of material that is contained in the product and the major environmental impacts that are due to this waste management (e.g. incineration) are also accounted for in other emissions impact categories. Thus, this category gives an interesting indicator but should not be considered as a priority. Besides, the implementation of some features (heat pumps, heat exchangers, etc.) requires the manufacture of additional materials resulting in higher PAH (especially aluminium), POP and heavy metal emissions (especially stainless steel). However, because of the high recycling rates of the metals, it is estimated that the higher emissions they may cause are not of primary importance in these life cycle assessments.
- Acidification is another important environmental indicator and an overview of the environmental results tables shows that its change is very similar (almost the same) as that of Global Warming Potential. Primary energy consumption is estimated to be representative and in line with these two indicators.

5.1 Base Case WM 1: Semi-professional washer extractor

Figure 43 shows that the LLCC for WM 1 is M 1.4 Load control, while energy consumption is reduced most with the BA product.



Figure 43 Economic and environmental analysis for Base Case WM 1

5.2 Base Case WM 2: Professional washer extractor <15kg

Figure 44 shows that the LLCC for WM 2 is M 1.4 Load control whereas the energy is reduced the most with the BA product.

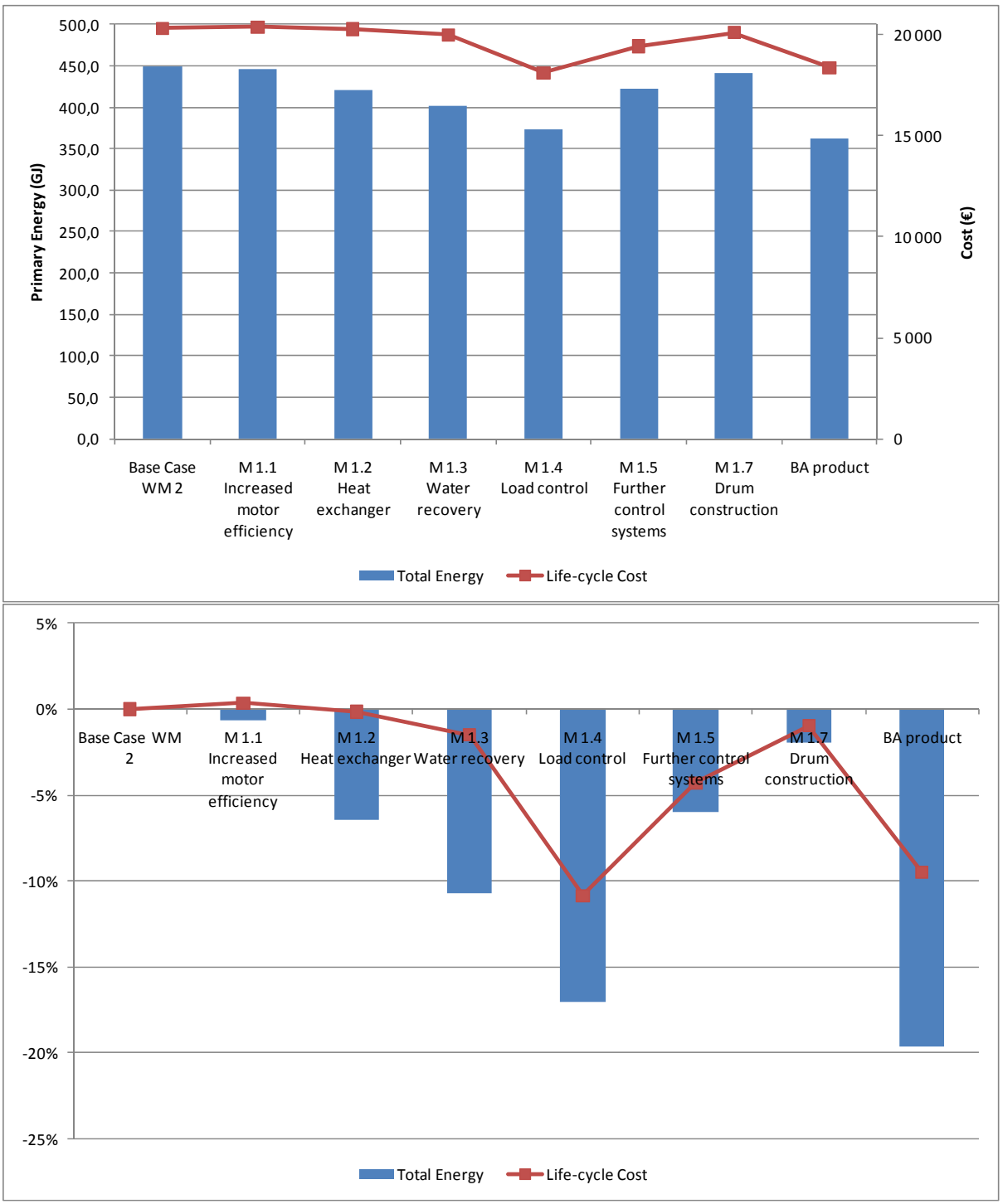


Figure 44 Economic and environmental analysis for Base Case WM 2

5.3 Base Case WM 3: Professional washer extractor 15–40 kg

Figure 45 shows that the LLCC for WM 3 is M 1.4 Load control whereas the maximum energy consumption is achieved with the BA product.

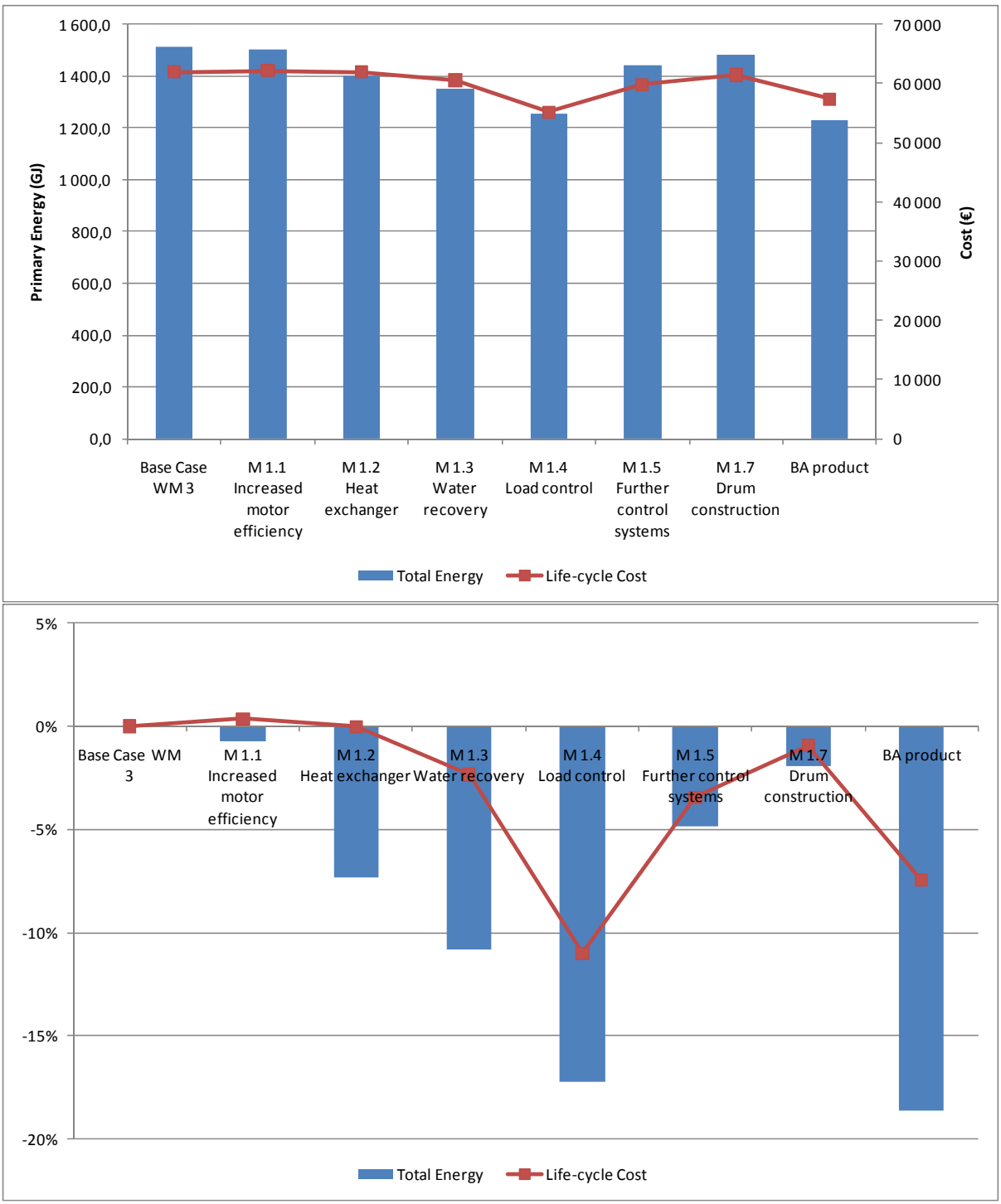


Figure 45 Economic and environmental analysis for Base Case WM 3

5.4 Base Case WM 4: Professional washer extractor >40kg

Figure 46 shows that the LLCC for WM 4 is M 1.3 Water recovery. This option also shows the highest reduction in the energy consumption (BAT).

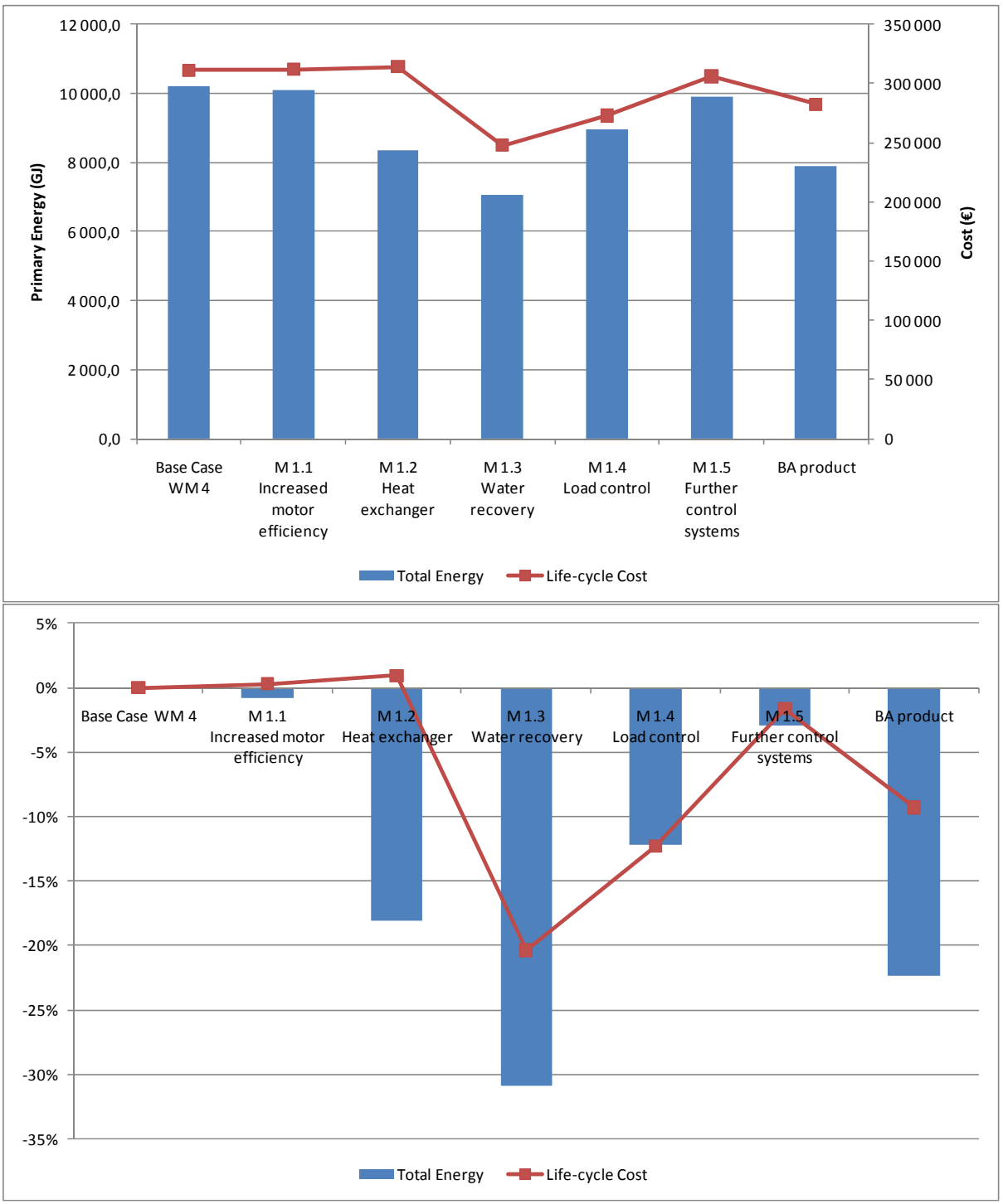


Figure 46 Economic and environmental analysis for Base Case WM 4

5.5 Base Case WM 5: Professional washer dryer

Figure 47 shows that the LLCC for WM 5 is M 1.4 Load control. This option also shows the highest reduction of the energy consumption (BAT).

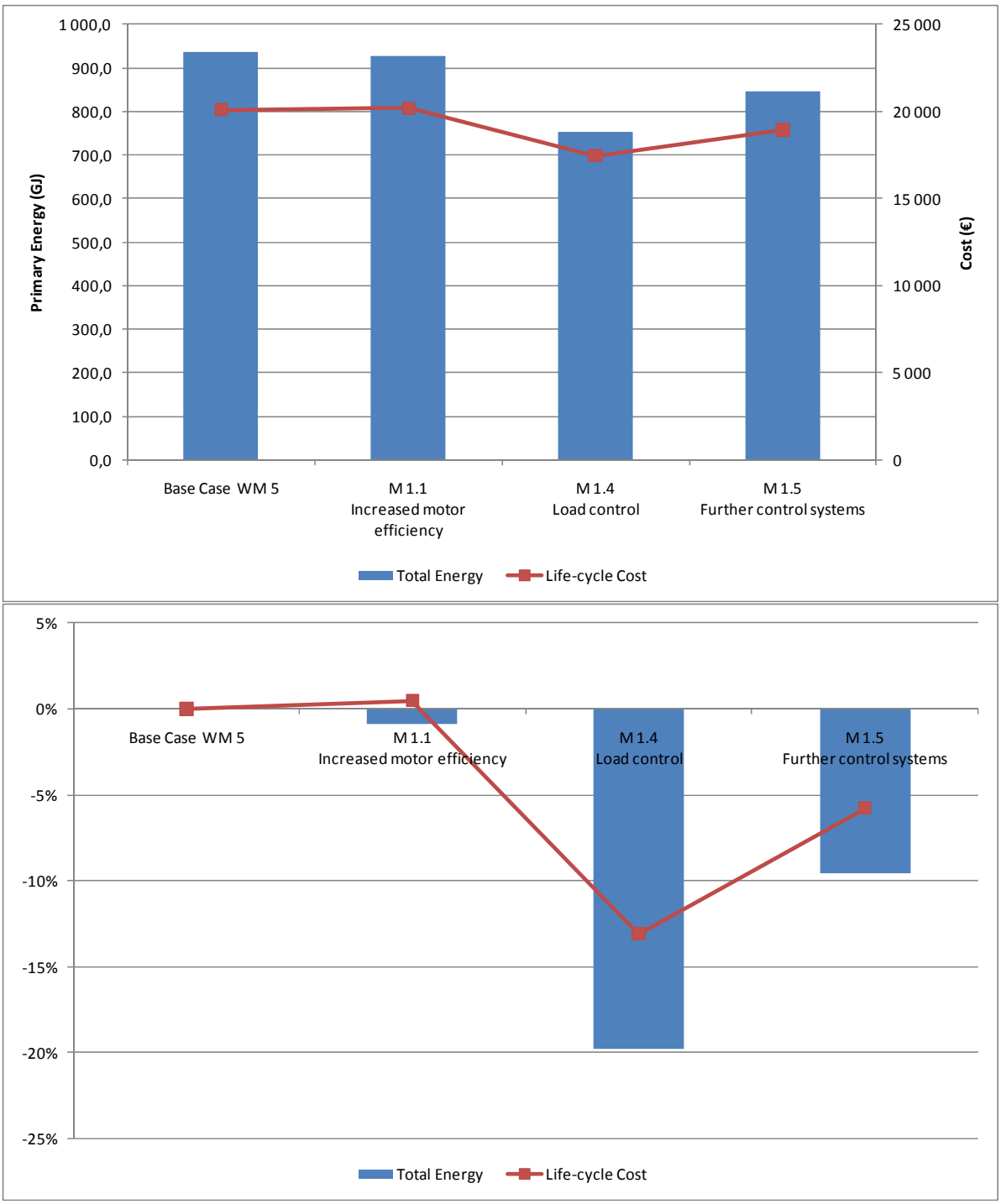


Figure 47 Economic and environmental analysis for Base Case WM 5

5.6 Base Case WM 6: Professional Barrier Washer

Figure 48 shows that the LLCC for WM 6 is M 1.3 Water recovery. This option also shows the highest reduction in the energy consumption (BAT).

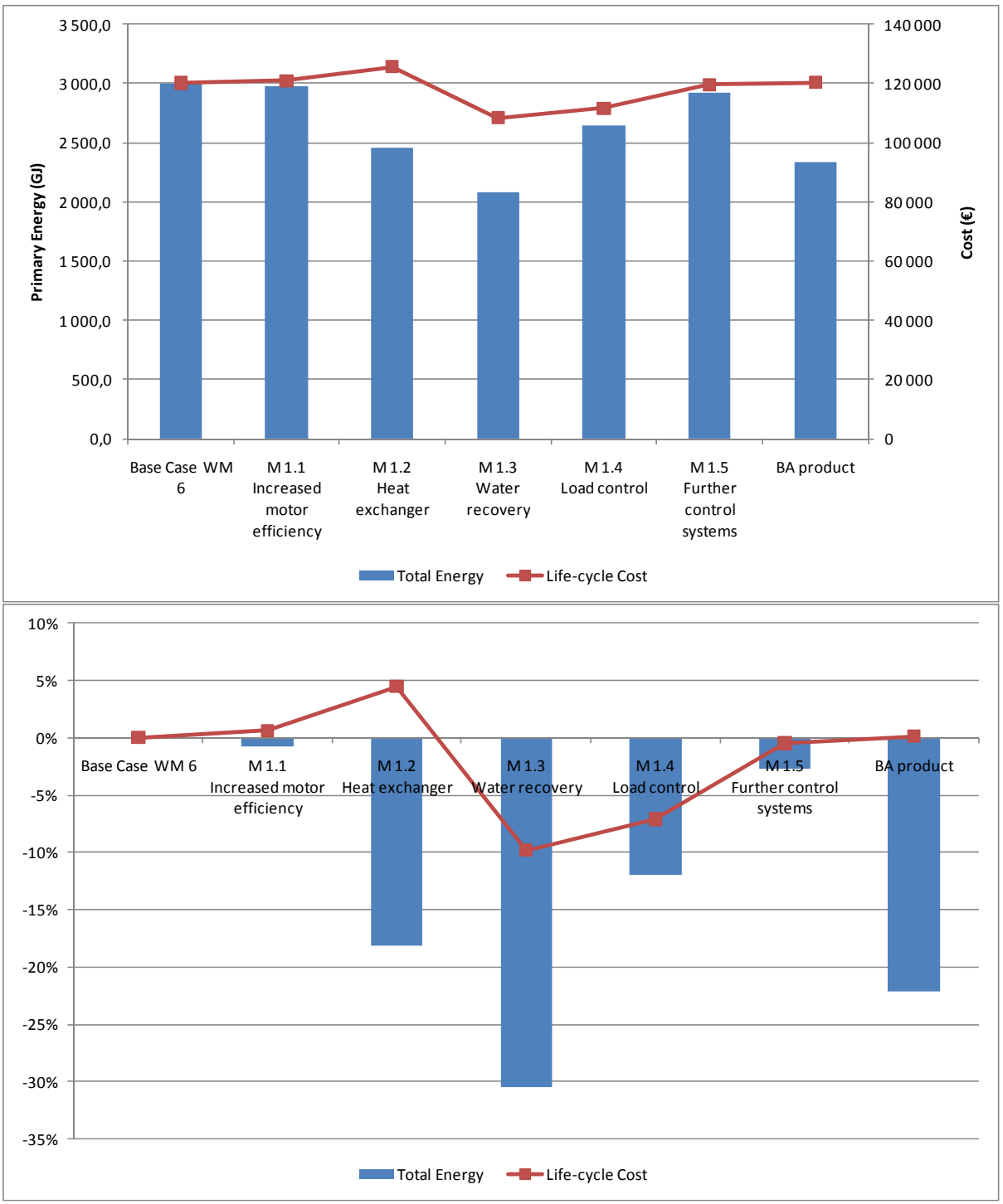


Figure 48 Economic and environmental analysis for Base Case WM 6

5.7 Base Case WM 7: Washing tunnel machine

The figure below shows that the LLCC for WM 7 is the BA product. This option also shows the highest reduction in the energy consumption (BAT).

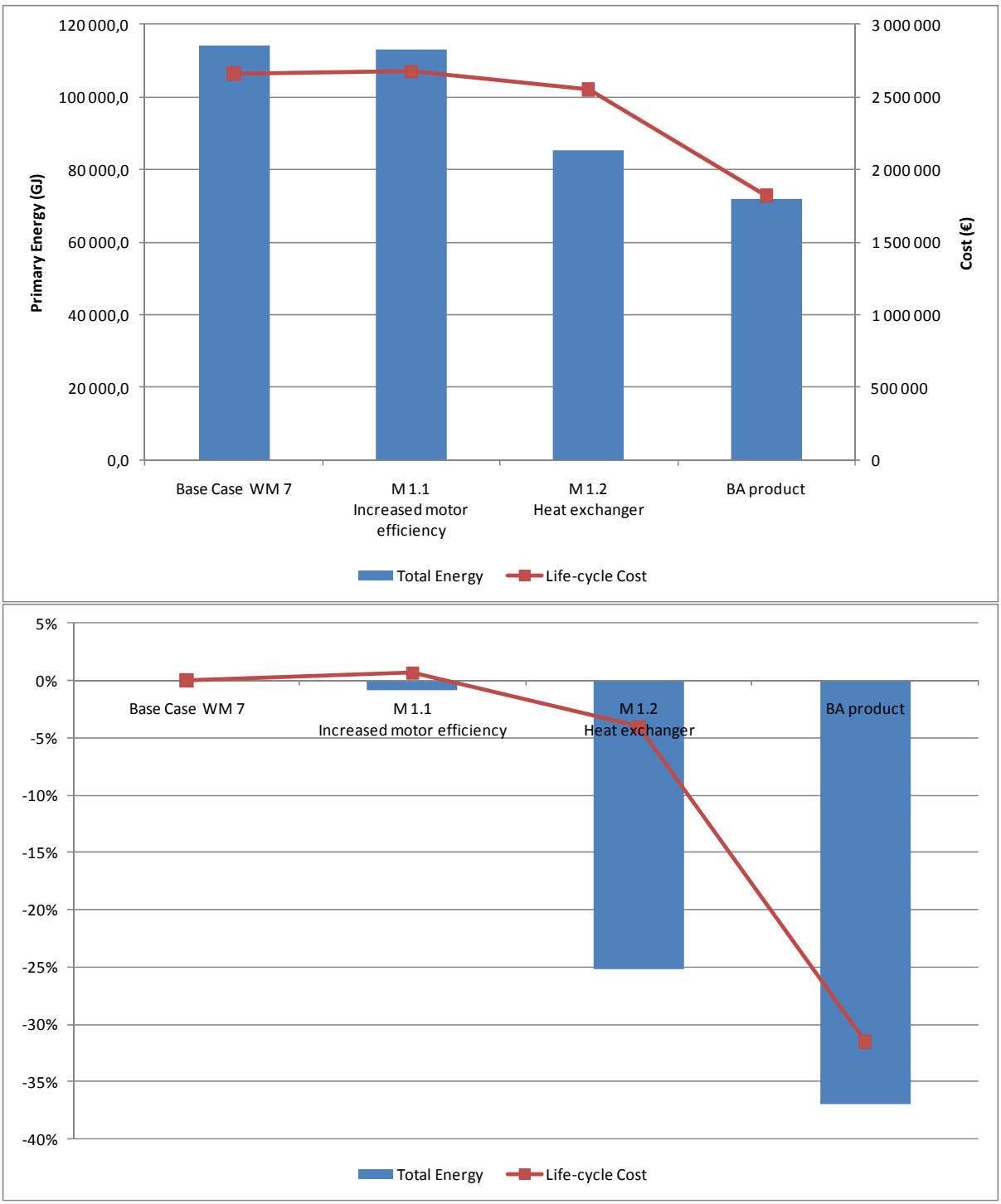


Figure 49 Economic and environmental analysis for Base Case WM 7

5.8 Base Case D 1: Semi-professional dryer, condenser

As shown in the figure below, the LLCC is the option M 2.2 Heat pump, while the BAT is the BA product.

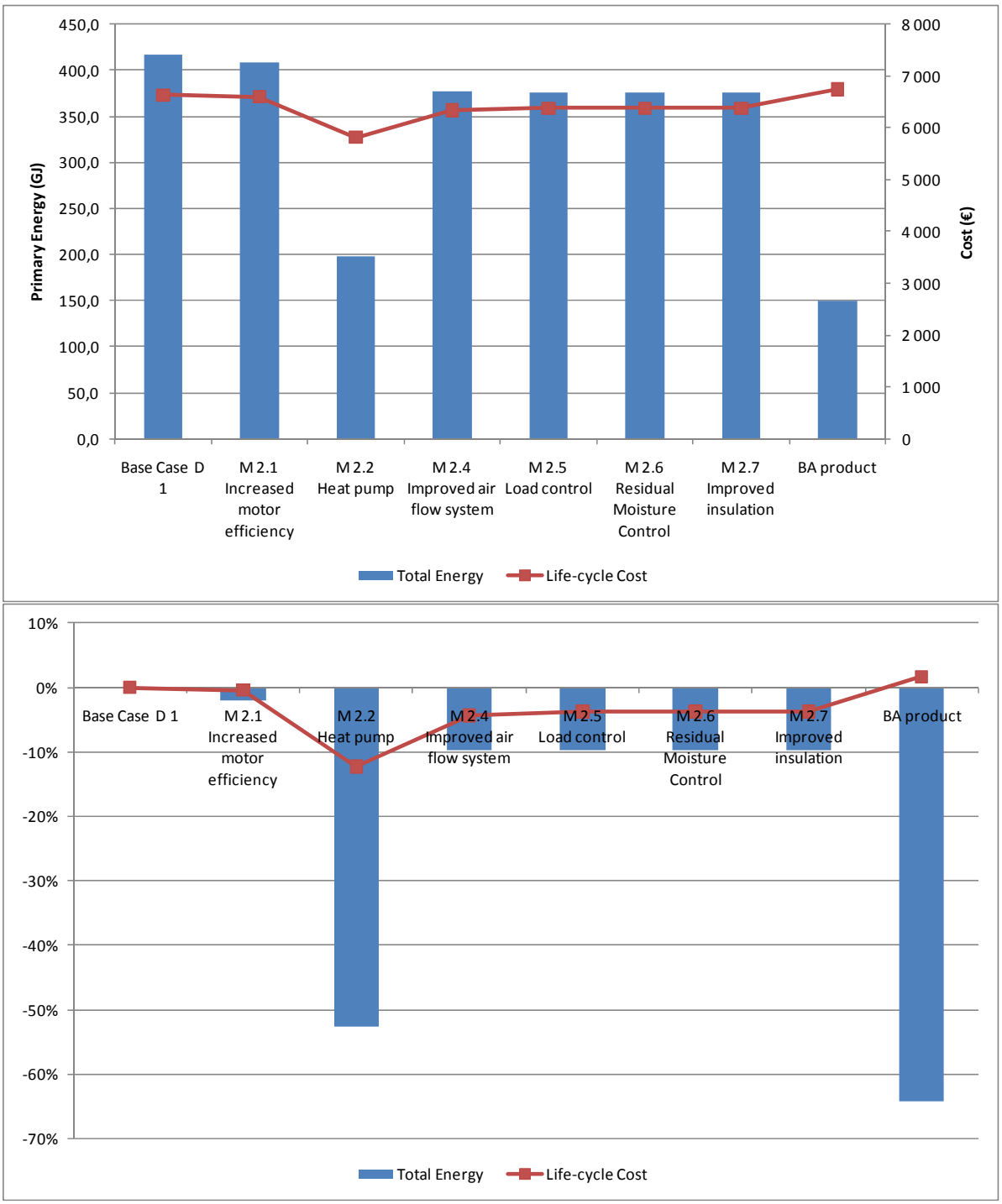


Figure 50 Economic and environmental analysis for Base Case D 1

5.9 Base Case D 2: Semi-professional dryer, air vented

As shown in the figure below, the option M 2.2 Heat pump represents both the LLCC and the BAT.

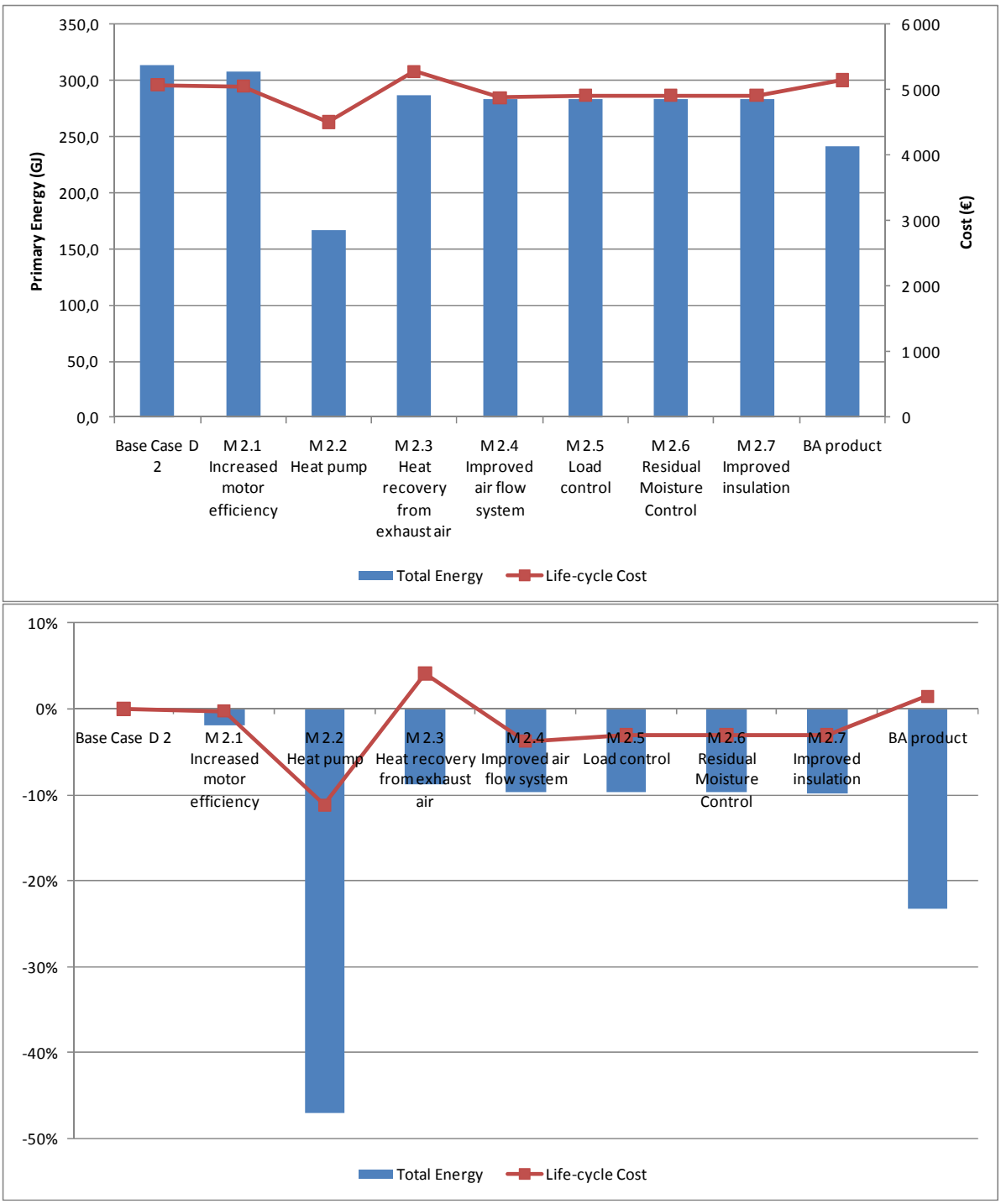


Figure 51 Economic and environmental analysis for Base Case D 2

5.10 Base Case D 3: Professional Cabinet dryer

As shown in the figure below, the LLCC is the option M 2.2 Heat pump, while the BAT is the BA product.

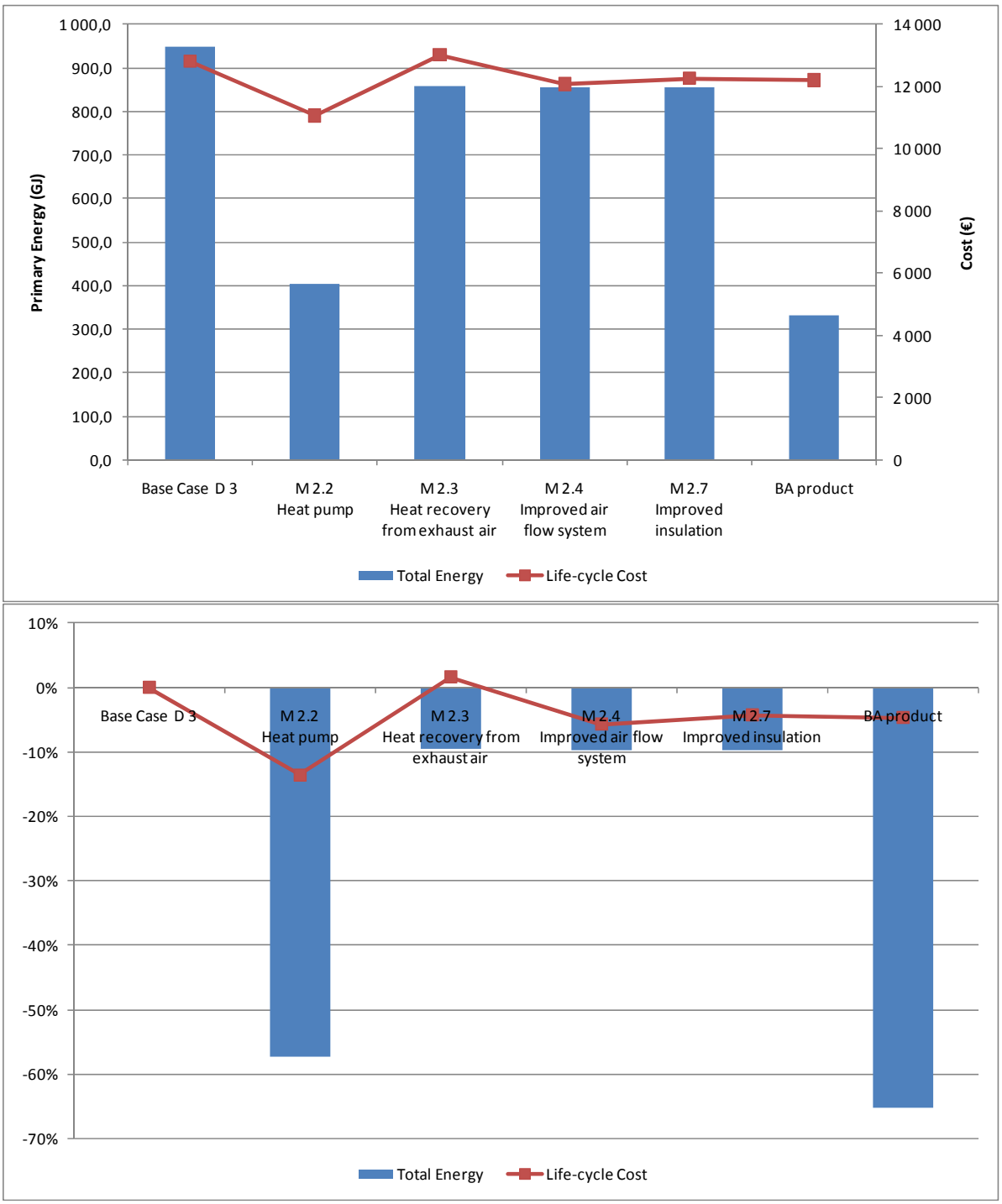


Figure 52 Economic and environmental analysis for Base Case D 3

5.11 Base Case D 4: Professional tumble dryer (<15 kg)

As shown in the figure below, the BA product represents both the LLCC and the BAT.

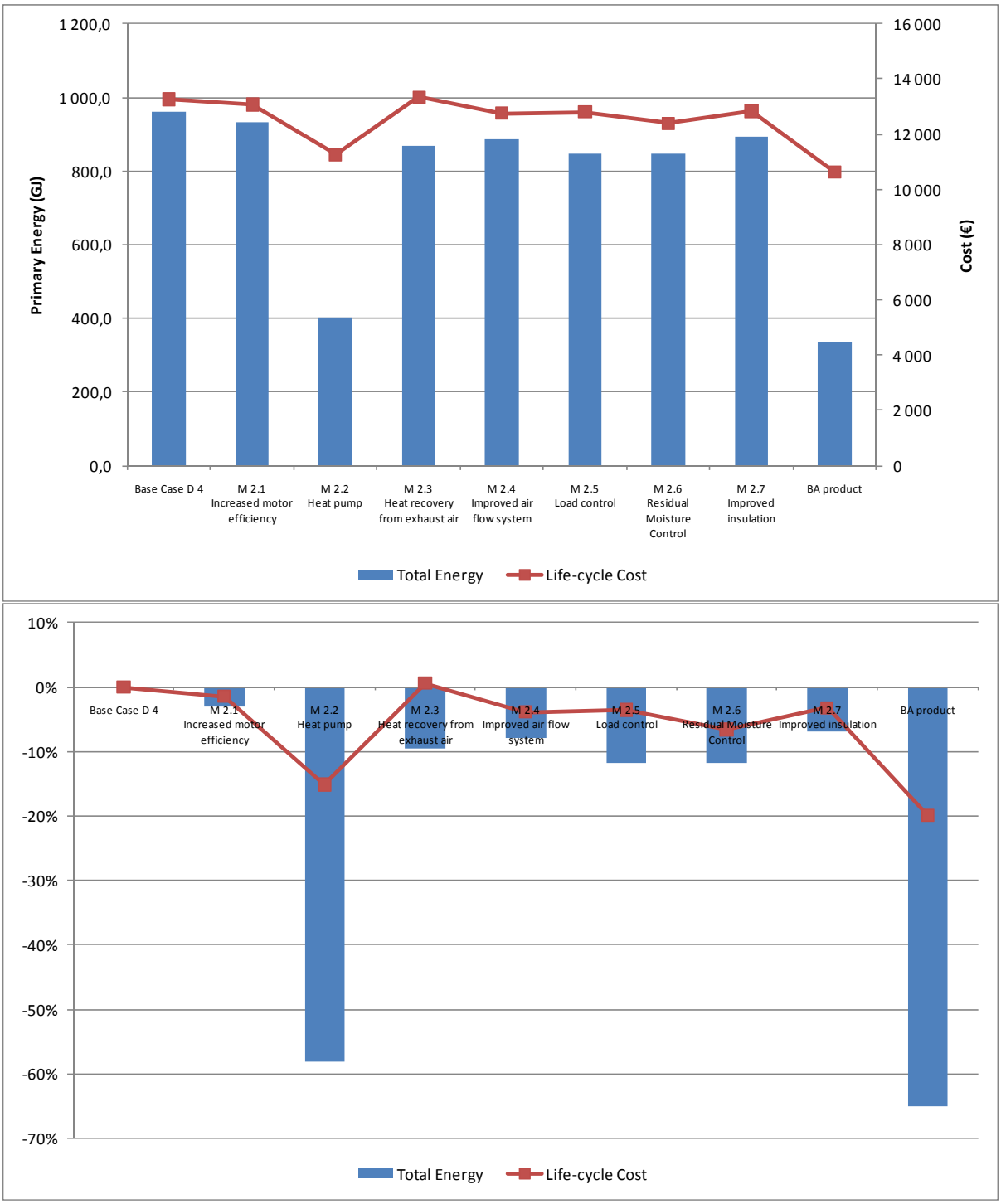


Figure 53 Economic and environmental analysis for Base Case D 4

5.12 Base Case D 5: Professional tumble dryer (15–40 kg)

As shown in the figure below, the option M 2.2 Heat pump represents both the LLCC (with the BA product) and the BAT.

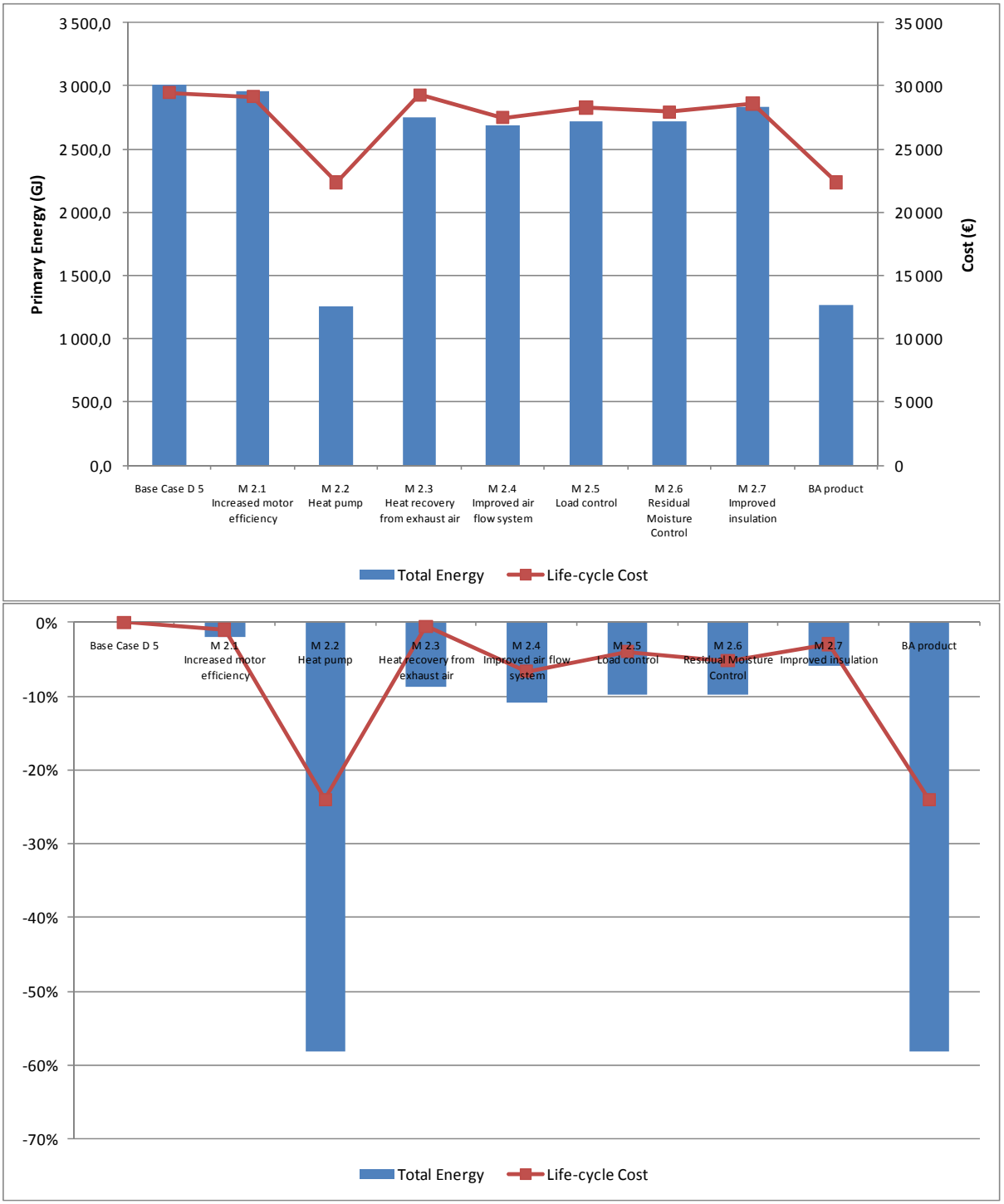


Figure 54 Economic and environmental analysis for Base Case D 5

5.13 Base Case D 6: Professional tumble dryer (>40 kg)

As shown in the figure below, the option M 2.2 Heat pump represents both the LLCC (with the BA product) and the BAT.

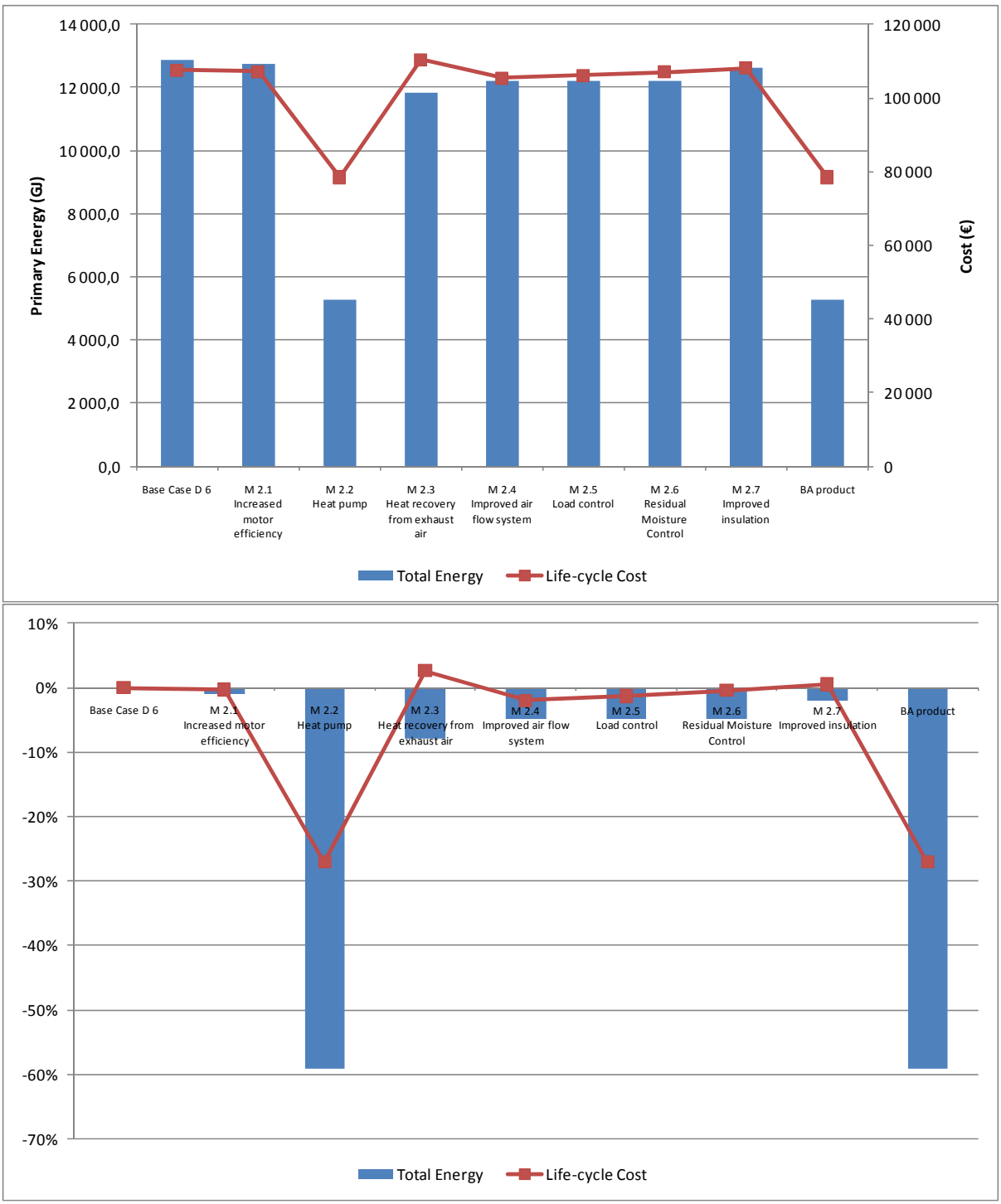


Figure 55 Economic and environmental analysis for Base Case D 6

5.14 Base Case D 7: Industrial pass-through (transfer) tumble dryer

In the case of this base case, the BAT and LLCC is represented by the BA product option.

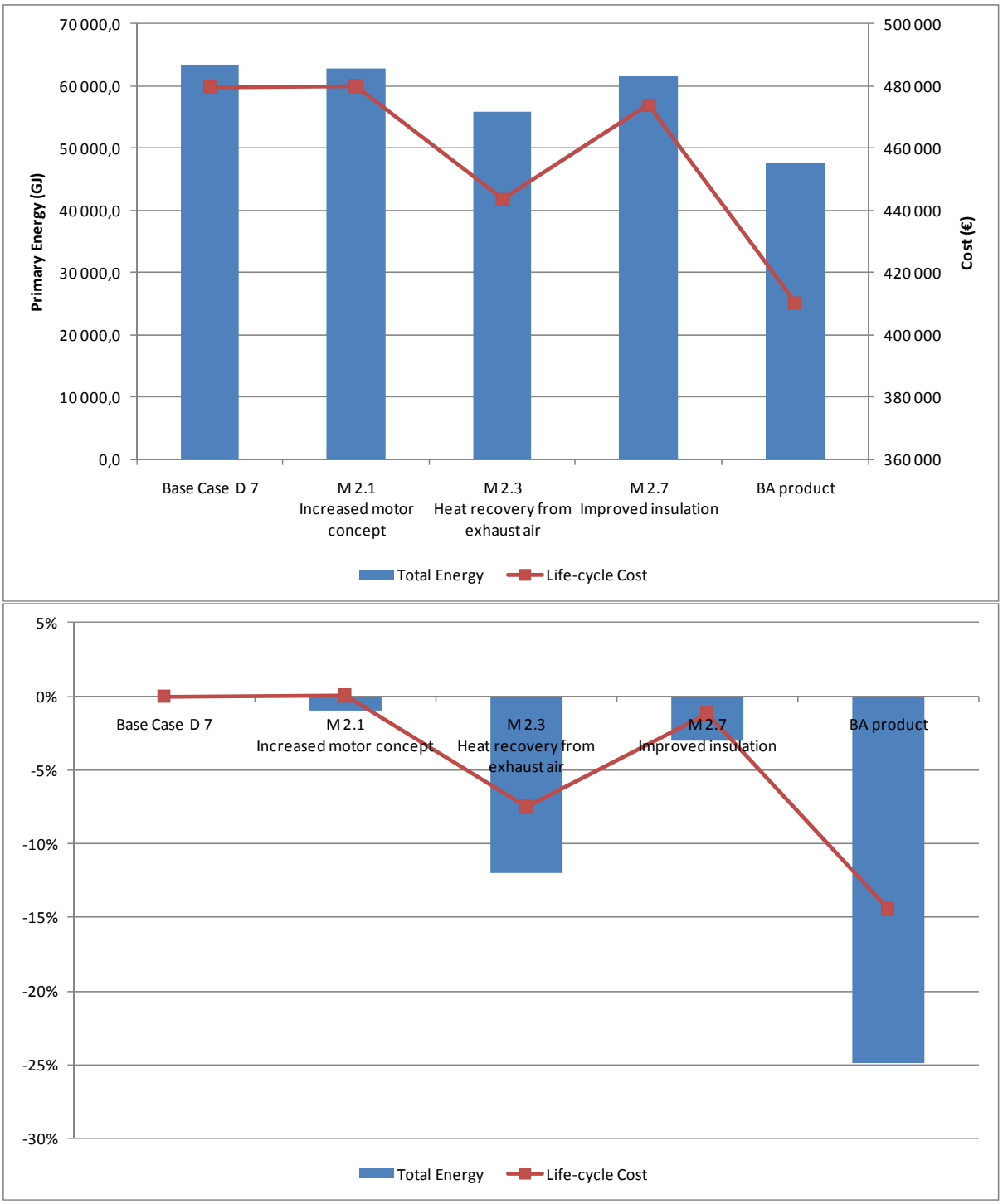


Figure 56 Economic and environmental analysis for Base Case D 7

5.15 Summary of the LLCC and BAT options identified

Table 48 summarises the results of the environmental and economic analysis of the improvement options by presenting the LLCC and BAT options identified for each base case.

Table 48 LLCC and BAT options by base case

	LLCC option	BAT option
WM 1 Semi-professional washer extractor	M 1.4 Load control	BA product
WM 2 Professional washer extractor (<15kg)	M 1.4 Load control	BA product
WM 3 Professional washer extractor (15 - 40 kg)	M 1.4 Load control	BA product
WM 4 Professional washer extractor (>40kg)	M 1.3 Water recovery	M 1.3 Water recovery
WM 5 Professional washer dryer	M 1.4 Load control	M 1.4 Load control
WM 6 Professional Barrier Washer	M 1.3 Water recovery	M 1.3 Water recovery
WM 7 Washing tunnel machine	BA product	BA product
D 1 Semi-professional dryer, condenser	M 2.2 Heat pump	BA product
D 2 Semi-professional dryer, air vented	M 2.2 Heat pump	M 2.2 Heat pump
D 3 Professional cabinet dryer	M 2.2 Heat pump	BA product
D 4 Professional tumble dryer (<15 kg)	BA Product	BA Product
D 5 Professional tumble dryer (15 - 40 kg)	M 2.2 Heat pump	M 2.2 Heat pump
D 6 Professional tumble dryer (>40 kg)	M 2.2 Heat pump	M 2.2 Heat pump
D 7 Pass-through (transfer) tumble dryer	BA product	BA product

6 Long-term targets (BNAT) and systems analysis

Not all possible improvement options were considered in the preceding sections. Some are still prohibitively expensive or not yet widely available. Such options can be described as BNAT and considered as long-term targets. The term BNAT indicates long-term possibilities and helps to define the exact scope and nature of any potential eco-design measures.

Predicting the technological status over such a long period (a horizon of 2020/2025) in a very innovative sector is not possible with a high level of accuracy. Technology roadmaps tend to have a time horizon of 10–12 years at most, describing mid-term targets but often without specifying which particular technologies will be used to achieve those targets.

The BNAT identified in Task 6 are:

- Polymer beads: currently under development and expected to be introduced in the market in 2011/2012. By contact and friction of polymer beads introduced in a specific washing machine, the stains are more easily removed and this process can result in large savings in energy, water and detergent. It represents however a totally different washing approach than the conventional laundry.
- Microwave dryer: this technology is expected to be used in the future. It is based on the use of microwave to heat the remaining water.
- Vacuum dryer: by reducing pressure in the dryer drum, it is possible to evaporate the water at a lower temperature. As a drawback, energy reduction in the water evaporation process might be compensated by an increase in energy use to create the vacuum.
- Smart portal display (changes to appliances operation): the aim is to harmonise the available power on the grid with the demand. Therefore an energy demand manager starts the washing machine within a predefined time interval.[15]

It should be noted that, for competition reasons, manufacturers are rather reluctant to talk about inventions, ideas and strategies which are not yet available on the market. Competition between the manufacturers is quite fierce and the circle of leading manufacturers is rather small. For this reason the information received from manufacturers may not be complete.

[15] University of Bonn, Synergy Potential of Smart Domestic Appliances in Renewable Energy Systems, Prof.Dr. R. Stamminger (Stamminger 2009)

7 Conclusions

The most energy-demanding process in washing machines is water heating. Any action to improve or reduce the related energy consumption will have a significant impact. The environmental impacts and life cycle costs of these machines can also be significantly reduced by using alternative, more efficient energy sources such as gas, for heating the water or air of the washing machines or dryers which was illustrated in Task 5.

In terms of water pollution, any reduction in detergent used will reduce the eutrophication potential. Stronger chemical products are not seen as an alternative option in the EU.

Laundry dryers can also be improved by using alternative technological options, especially heat pumps, which seem economical for most base cases.

According to the analysis presented in this task, there is room for improvement that would not entail additional lifecycle costs to consumers. However, the options providing the highest improvement are often the ones with higher purchase costs. This could damage the competitiveness of these machines, in the case of customers not following a Life Cycle Cost approach for their purchasing decision. This issue should be considered during the development of any EU policy measure.

8 Annex: Additional questionnaire to stakeholders

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

- EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

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Final Report, Part:
Washing Machines and Dryers

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For reasons of better readability, two Task 8 reports were prepared.

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

The Task 8 report on *professional dishwashers*
is published separately.

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1 Introduction: objective of Task 8

This task summarises the previous tasks and looks at suitable policy means to achieve the potential reduction in environmental impacts identified. Among the policy options to be considered are implementing Least Life Cycle Cost (LLCC) as a minimum level and Best Available Technology (BAT) as a promotional target, using legislative or voluntary agreements, labelling, public procurement and other incentives.

The policy options considered and the conclusions are the opinions of the project team and do not represent the views of the European Commission. Unlike Tasks 1-7, which will serve as the baseline data for future work to be conducted by the European Commission (Impact Assessment, further discussion in the Consultation Forum and possible development of implementing measures), Task 8 simply serves as a summary of policy implications as seen by the project team. Some parts of this chapter may be analysed in greater detail at the Impact Assessment stage.

The task draws up scenarios for the period 2010-2030, quantifying the improvements that can be achieved with respect to a Business-as-Usual (BAU) scenario and comparing the outcomes with EU energy and environmental targets.

It estimates the impact on consumers and industry as described in Annex 2 of the Directive, explicitly describing and taking into account the typical design cycle (platform change) in a product sector as well as the cost of redesign necessary to apply the policy recommendations of Task 8. Finally, in a sensitivity analysis of the main parameters, it studies the robustness of the outcomes.

In addition, an analysis of which significant impacts may have to be measured under possible implementing measures and what measurement methods would need to be developed or adapted is provided.

2 Policy and scenario analysis

This section presents suggestions of policy options and a scenario analysis for the period 2010-2030. The scenarios quantify the improvements that can be achieved in comparison with a BAU (Business-As-Usual) scenario and compare the outcomes with EU environmental targets.

2.1 Scope

The policy analysis should identify policy options, considering the outcomes of all previous tasks. Notably, the options should:

- Be based on the exact product definitions in Task 1 as modified/confirmed by the other tasks;
- Provide Eco-design requirements, such as minimum (or maximum) requirements, considering the sensitivity analysis carried out in this task;
- Be complemented, where appropriate, with (dynamic) labelling and benchmark categories linked to possible incentives relating to public procurement or direct and indirect fiscal instruments;
- Where appropriate, apply existing standards or propose needs/generic requirements for harmonised standards to be developed;
- Provide measurement requirements, including test standards and/or methods;
- Consider possible self-regulation, such as voluntary agreements or sectoral benchmark initiatives;

2.2 Generic eco-design requirements

Generic eco-design requirements aim at improving the environmental performance of products, focusing on significant environmental aspects thereof without setting limit values. According to Ecodesign Directive 2009/125/EC they method must be applied when it is not appropriate to set limit values for the product group under examination.

Generic eco-design requirements for professional laundry appliances may enable the customer to know more about the products on the market in order to allow easier comparison.

2.2.1 Need for the definition of a standard programme

Similarly to the recent Regulation for household washing machines (N 1015/2010)[1], also for professional washing machines (and dryers) a ‘standard programme’ should be defined. Thus, for the calculation of the energy consumption and other parameters for professional laundry machines, a typical cycle which cleans and dries typically soiled laundry (hereafter standard washing cycle / standard drying cycle) shall be used within each washing machine and dryer category. This cycle shall be clearly understandable by the user and *as much as possible representative for the real-life conditions within the key customer segments for each product category*. Further, it shall be clearly identifiable on the programme selection device of the professional appliance or the display of the appliance, if any, or both, and named ‘standard programme’ and shall be set as the default cycle for professional laundry machines equipped with automatic programme selection or any function for automatically selecting a cleaning or drying programme or maintaining the selection of a programme.

[1] No Regulation for household dryers has been adopted in the EU yet (status: May 2011).

2.2.2 Information requirements

Further, the **booklet of instructions** should provide information on:

- the standard cleaning or drying cycle referred to as 'standard programme', which would be the most energy and water (only for dryers) efficient programme for normally soiled or to be dried laundry.
- Power consumption of the operating, low-power and off modes.
- Indicative information on the main characteristics of the different programmes available (energy and water efficiency, drying efficiency, temperature, time, etc.).
- Recommendations on the types of detergents suitable, depending on the washing temperature and cleaning / hygienic needs.

This information would not be sufficient to achieve large savings on its own. Taking into account the fact that professional washing machines and dryers might also be operated by untrained personnel, the development of **user guided programme menus** directly indicating the above information could further support changing the user behaviour. Making information about energy consumption available on the internet and in sales brochures would be another approach (e.g. basic information on resource efficient cleaning and drying processes). In parallel, harmonised information could be provided by the European Commission, such as:

a) Examples for best practice.

b) Overview on consumption values and benchmarks of appliances currently being on the market (based on a standardised measurement method).

c) Life cycle costs calculator which can be individually adapted according to the in-situ parameters.

However, precondition for implementing these generic eco-design requirements is a harmonised measurement standard which is currently not available. It would considerably help manufacturers in establishing the ecological profile of their products in a harmonised and understandable way (cf. Section 2.3.1).

In addition, household washing machines are supposed to offer end-users a low-temperature cycle at 20°C. Given the large energy savings potential of such a program, which relies only on user behaviour and not on technical improvement of the machines, it would be relevant to have a compulsory low temperature (20°C or 30°C) program for some professional washing machines, at least for machines used in semi-commercial customer segments like Apartment Household Laundry (AHL) and Coin & Card Laundry (CCL), e.g. for categories WM1 and WM2 (Semi-professional washer extractor, professional washer extractor <15 kg) and D1, D2 and D4 (Semi-professional dryers, air-vented / condenser, professional tumble dryer <15 kg).

2.2.3 Detergent consumption

As shown in Task 5, detergent consumption can have important environmental impacts, especially eutrophication potential. In this study, detergents have been treated for the most part indirectly, since detergent consumption is linked to water consumption. Improvement options such as automatic detergent dispensing were not considered to be among the most relevant for professional washing machines. Besides, the washing process is a complex balance between the duration of the process, the cleaning capacity of the detergent used, the mechanical action and the temperature of the process. In the context of this study, a typical process temperature, a typical time and a typical detergent have been estimated in order to be able to study the machines from energy and water performance perspectives.

Nevertheless, different detergent types may have different levels of environmental impact. Some new detergents may allow a slightly lower washing temperature, and thus lower energy consumption, than regular detergents. In general, lower temperatures either imply larger doses or another composition and ingredients of detergents in order to maintain the wash performance. A larger dose of detergent in turn implies greater water consumption; another composition might imply further environmental impacts. A new measurement standard and performance requirements should take these relationships into account.

It is commonly considered that misuse of detergent is more likely to involve over-dosage than under-dosage (at least for smaller machines) and would thus exacerbate negative environmental impacts.

Optimum detergent dosage depends on a range of factors including detergent formulation, water hardness, temperature, as well as filling and soiling. Although consumer behaviour is partly beyond the scope of eco-design, **better information on optimum dosage** could be provided to users. Further, eco-design requirements for automatic detergent feeders could include a visual means to verify that detergents are delivered or a visual or audible alarm to signal if detergents are not available for delivery to the respective washing system.

Finally, it should be noted that especially for large professional washing machines, the detergent service and supply (cleaners system) is provided by third party companies. Thus, **green procurement requirements for detergents** could also be included in the criteria to award the service contract to the best companies.

2.3 Specific eco-design requirements

Specific eco-design requirements aim at improving a selected environmental aspect of the product. According to Ecodesign Directive 2009/125/EC, they may take the form of requirements for reduced consumption of a given resource, such as a limit on the use of a resource in the various stages of an product's life cycle, as appropriate (such as a limit on water consumption in the use phase or on the quantities of a given material incorporated in the product or a requirement for minimum quantities of recycled material).

Generally, in the white goods sector energy (and water) efficiency has increased substantially in the past thirty years thanks to implementation of the most easy and straightforward technical solutions. The required effort and investment per unit of energy efficiency gained are now becoming larger and manufacturers may now tend to slow down their efforts in innovation and research because of this, especially in the household appliances sector. For professional appliances, the possible improvement potential seems to be more unclear as currently no standardised comparison between two different machines is possible in the EU. However, a common measurement standard is prerequisite for the implementation of efficiency requirements and labelling programmes, which would allow the end user to benefit from a relevant methodology providing him with reliable data and fair assessment of product performance. Therefore, the influence of the customers on the market development would be highly increased as their choices would be eased and justified by this initiative.

2.3.1 Need for the development of harmonised standards and definitions

Standard measurement methods are necessary to enable the setting of performance requirements. Today, there are no standards officially and widely used in the EU for the product categories in the scope of Lot 24, part professional washing machines and dryers. This lack of standards is also a reason why consumption data was hard to obtain and remains uncertain within this study. Discussions are currently ongoing at the EU level within the CENELEC Technical Committee TC 59X.

A harmonised testing methodology should take into account and define several parameters (ideally reflecting the requirements of the main customer segments in which the product categories are applied to):

- Ambient temperature and humidity;
- Water temperature and hardness;
- Energy source for heating water / air;
- Input water temperature and other chemical and physical characteristics of the water;
- Residual moisture of laundry before drying process;
- Rated washing / drying capacity (maximum amount of load that can be washed/dried in one washing/drying cycle, in kg laundry per hour or per cycle); filling ratio;
- Type (formulation) and dosage of detergent and laundry aid;
- Standard laundry in terms of type, amount and soiling;
- Definition of a test cycle (inter alia selection of programme).

Relevant parameters to measure when establishing standards for professional washing machines and dryers include:

- Cleaning / drying / spin extraction performance and, if necessary, hygienic performance; for washing machines additionally rinsing performance;
- Energy and/or water consumption per kg laundry or on a per cycle basis;
- Energy demand in low-power modes (left-on, and if applicable: off mode); if possible, the termination of low-power modes should follow the definitions of Commission Regulation (EC) No. 1275/2008 on Standby.
- Detergent/rinse aid consumption (defined quality);
- Cycle time (more important for professional appliances than for household ones);
- Noise level[2];
- Damage to textiles;
- The standard cycle conditions should reflect the real-life use conditions: energy and water consumption in partial load / discontinuous operation; possibly consumption in other than 'standard' program.

Standard conditions should represent real-life conditions as precisely as possible. However, as there is a great variation in the user behaviour of professional washing machines and dryers within the categories as well as customer segments identified, the energy and water consumption in day-to-day operation may still differ from that under standard test conditions.

The fact that multiple parameters have to be taken into account is crucial as some of them may conflict with each other. For instance, water efficiency could be improved by reducing the rinsing/drying performance, leading to non-satisfactory results of the washing process. Therefore, if levels of resources and consumables consumption are to be set, they should be associated with corresponding cleaning or drying performance levels.

In the commercial and industrial sectors, customers have different needs and the appliances are often customised to the demand of the customer. The goal of the standardisation process would ideally be to find one or several standard programme(s) that can be run on the machine to test it and measure its performance level, even if the washing programme wanted and used by the customer is different.

Along with the standards measurement methods, a tolerance level (taking into account the uncertainties of the measurement methods) should be properly defined according to the product category specificities. Working group TC59X has mentioned the importance of tolerance as reproducibility of tests is one of the major issue of professional laundry appliances testing.

[2] Only in the case it is not yet covered under safety legislation.

2.3.2 Labelling requirements

Based on a harmonised measurement standard which would need to be developed first (see previous section), an energy labelling scheme could promote a voluntary shift in the market. Unlike performance requirements (which aim at removing the worst-performing products from the market), a label would help the consumers to pull the market towards the best-performing products via their purchase decisions. It should therefore be seen as a complementary tool to minimum requirements. To be fully effective, such a scheme should be mandatory so that all products on the market can be fairly compared.

In the context of professional laundry appliances, it would be more appropriate for the smaller machines considered in this study: the more customers are influenced by the presence of labels at the time of purchase, the more effective the initiative is. Customers of larger industrial machines tend to have a more sophisticated understanding and are already provided with a more detailed level of information at the time of purchase, while retailers have even more incentive to provide high efficiency machines than retailers of smaller machines. This does not, however, mean that a labelling programme could not be implemented for heavy duty machines.

In the case of washing machines, energy consumption is intricately linked with water and detergent consumption and washing performance. Although energy consumption is the most appropriate basis for classification, any labelling scheme should take a holistic approach either by setting reference water and detergent consumption and reference washing performance associated with the energy consumption measured, or by providing clear and transparent information for all these other variables as is currently done for household washing machines (the label indicates the energy and water consumption and the washing performance, see Figure 1). For dryers the situation is similar, as energy consumption is linked to drying efficiency. Therefore, the label should display all relevant parameters to allow a fair and direct comparison between two products.

Council Directive 92/75/EEC on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances was recast in 2010 and replaced by Directive 2010/30/EU, which now covers energy-related products. Implementing Directives under this Energy Labelling Directive have already been adopted for household washing machines, household washer-dryers and household tumble dryers.

Washing machines

For household washing machines, Regulation No 1061/2010 recently replaced Directive 95/12/EC (which will be repealed from 20 December 2011), in particular by updating the performance levels and introducing more ambitious levels (A^{+}, A^{++}, A^{+++}). It only deals with electric appliances (that can possibly be powered by batteries).

The following notes define the information to be included on the label (see Figure 1):

1. Supplier's name and name of model;
2. The energy efficiency class of the washing machine, determined in accordance with harmonised standards. The indicator letter should be placed at the same level as the relevant arrow;
3. Weighted annual energy consumption;
4. Weighted annual water consumption;
5. Rated capacity, in kg, for the standard programme;
6. Drying efficiency;
7. Noise emissions in dB.

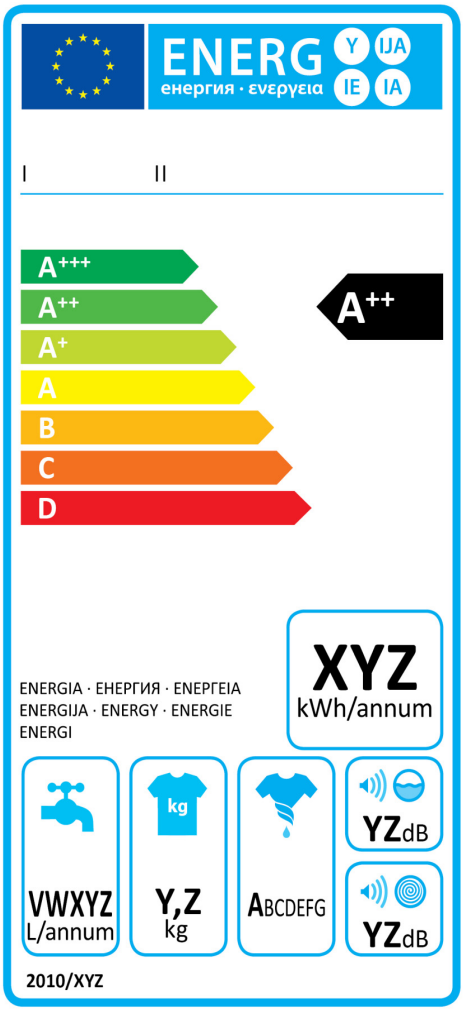


Figure 1 Household washing machines label

Household washer-dryers are covered by a separate Labelling Directive (96/60/EC). The following notes define the information to be included on the label (see Figure 2):

1. Supplier's name and name of model;
2. The energy efficiency class of the machine, determined in accordance with harmonised standards.
3. Energy consumption by cycle (for washing and drying, and for washing only);
4. Washing performance class;
5. Rated capacity, in kg, for washing, and for drying;
6. Water consumption
7. Noise emissions in dB.

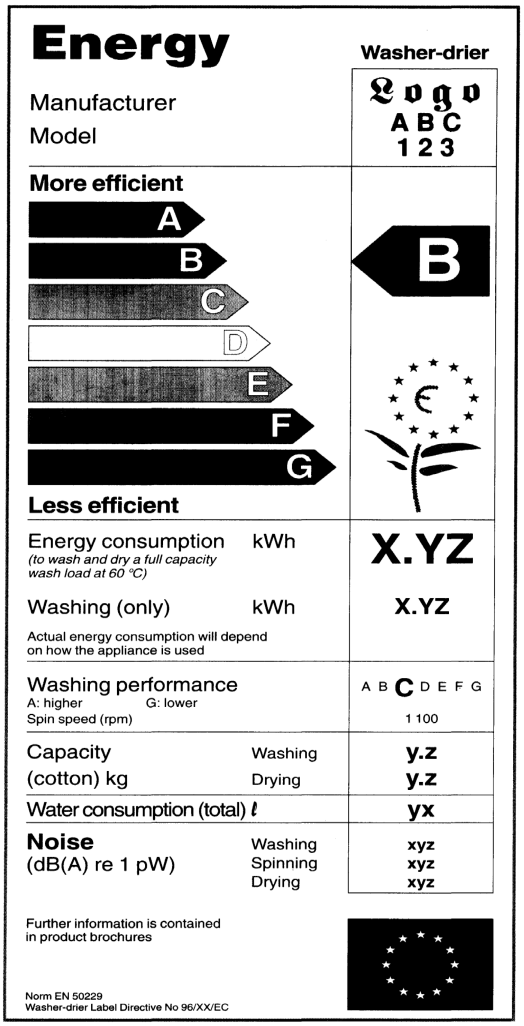


Figure 2 Household washer driers label

The label for professional washing machines could be similar in most respects to the one used for household appliances. When drafting the labelling regulation it should be discussed whether a single labelling scheme could be applicable for all types of professional washing machines (for instance washer extractors, washer dryers, tunnel washing machines) in order to allow comparison of products. This also includes the consideration if a single labelling scheme could cover machines with different heating options: A key difference with the current situation of domestic appliances is that the domestic labelling scheme only concerns electric washing machines as these are the most common products found on the market. However, for professional appliances, the situation is different as other heating options are used more widely (e.g. direct gas, steam). For example, taking primary energy (instead of electricity consumption) as an indicator could be an alternative way to define the energy efficiency classes[3].

Along with the pictograms on the label more detailed information should be provided in the product fiche / technical information of the professional washing machines and dryers and shall be included in the product brochure or other literature provided with the product (cf. also Section 2.2).

Dryers

Household tumble dryers are covered by the implementing Directive (95/13/EC) but only electrical appliances are concerned by this legislation. The European Commission is in the process of reviewing this energy label.

The following notes define the information to be included on the label (see Figure 3):

1. Supplier's name and name of model;
2. The energy efficiency class of the washing machine, determined in accordance with harmonised standards.
3. Energy consumption by cycle;
4. Rated capacity of cotton, in kg;
5. Type of product: air vented or condensing;
6. Noise emissions in dB.

The household tumble driers labelling scheme has been less influential compared to that of household washing machines. According to the preparatory study on domestic driers (Lot 16), most dryers on the market used the same technology resulting in rather similar levels of energy efficiency (class C) for a long time, thus the label could not have a significant influence on the purchase choice of consumers. The development of new technologies (heat pump dryers, efficiency class A, and gas dryers) led to a significant diversification of the

[3] Efficiency factors for the different heating processes should then be estimated at the EU level.

efficiency spectrum. However, the current efficiency classes are not representative enough of the best available products. For example:

- gas dryers are not covered by the label at all;
- heat pump dryers perform well beyond the A class limit but their purchase prices are much more expensive so that the additional investment may not look interesting by only looking at the efficiency classes that are currently defined (without looking at the energy consumption value). Therefore, customers may avoid them, not being aware of the important energy savings.

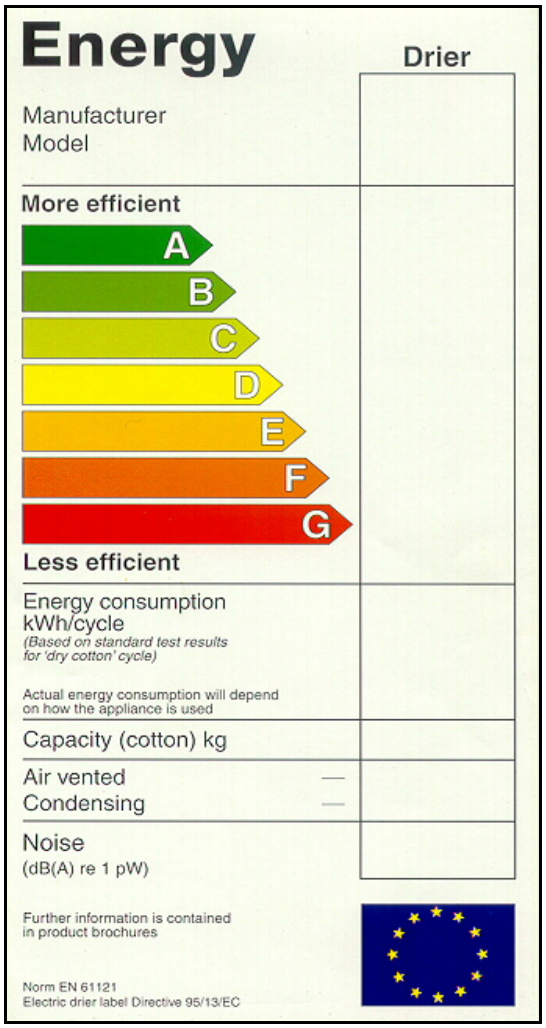


Figure 3 Household tumble driers label

The European Commission is in the process of reviewing this energy label. The figure below shows an example of the proposed new energy label for condenser driers.

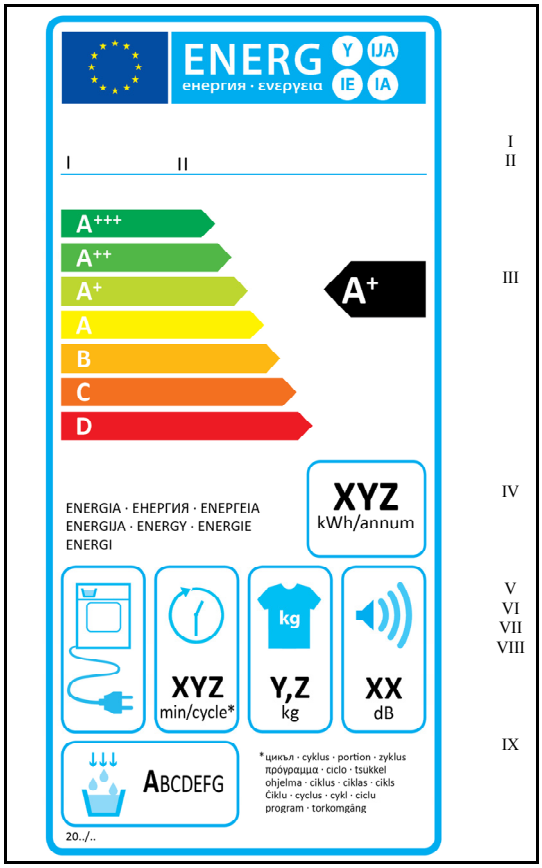


Figure 4 Proposed new energy label for condenser driers

Information to be provided includes:

I. supplier's name or trade mark;

II. supplier's model identifier, meaning the code, usually alphanumeric, which distinguishes a specific household tumble drier model from other models with the same trade mark or supplier's name;

III. the energy efficiency class;

IV. weighted annual energy consumption (AEC) in kWh/year;

V. information on the type of household tumble drier;

VI. programme time of the standard cotton programme at full load in minutes and rounded to the nearest minute;

VII. rated capacity, in kg, for the standard cotton programme at full load;

VIII. airborne acoustic noise emissions, during the drying phase, for the standard cotton programme at full load, expressed in dB(A) re 1 pW;

IX. the condensation efficiency class.

The label itself for professional dryers could be similar in most respects to that used for household appliances. When drafting the labelling regulation it should be discussed whether a single labelling scheme could be applicable for all types of professional dryers (for instance tumble dryers, cabinet dryers, condenser or air vented dryers, pass-through dryers) in order to allow comparison of products. This also includes the consideration if a single labelling scheme could cover machines with different heating options: A key difference with the current situation of domestic appliances is that the domestic labelling scheme only concerns electric dryers as these are the most common products found on the market. However, for professional appliances, the situation is different as other heating options are used more widely (e.g. direct gas, steam). For instance, the label “Energy Saving Trust Recommended” implemented in the UK for gas-fired domestic tumble dryers can be put on products with a primary energy consumption and carbon emission equal to or better than the equivalent primary energy consumption and carbon emission of electric tumble dryers in EU Energy Label B.

Along with the pictograms on the label more detailed information should be provided in the product fiche / technical information of the professional washing machines and dryers and shall be included in the product brochure or other literature provided with the product (cf. also Section 2.2).

2.3.3 Benchmarking

According to Ecodesign Directive 2009/125/EC, in addition to the legally binding requirements, indicative benchmarks for best available technologies should be identified to ensure the wide availability and easy accessibility of information on the lifecycle and environmental performance of professional washing machines and dryers.

The technical, environmental and economic analysis of preparatory study Lot 24 has already identified the best-performing products and technology available on the market (cf. Task 6). However, due to lack of standardised performance measurement data, this analysis should be renewed as soon as a harmonized measurement standard is applied. Thus, at the time of entry into force of a Regulation on professional washing machines and dryers, data on best available technology on the market in terms of their energy efficiency, energy and water consumption, cleaning and drying efficiency and airborne acoustical noise emissions should be available and being published in the Annexes of the Eco-design Regulation.

Benchmarks are non-binding for manufacturers but would allow the evaluation of the efficiency, consumption and environmental performance achieved by a new product against the best-performing products available on the EU market.

2.3.4 Energy and Water Requirements

Currently no eco-design requirements on energy efficiency exist in the EU for professional washing machines or dryers. Eco-design requirements have been recently adopted for

household washing machines under the Regulation No. 1015/2010, but not for household driers yet.

Very few initiatives have been launched in third countries either. Only the United States with energy efficiency requirements for commercial clothes washers (they will be applicable from January 8, 2013), and Canada with a voluntary Energy Star labelling programme also for commercial clothes washers, have implemented programmes so far. No measures for commercial dryers have been found.

Eco-design requirements may be a relevant option to remove the least efficient appliances. Indicative levels are suggested in this section, based on the analysis made in previous tasks. However, because of the current lack of available and harmonised data on product performance, **these suggested levels should be considered with caution and discussed again once harmonised measurement methods have been defined, as suggested in Section 2.2.1.** For example, cleaning performance was not assessed in the framework of the study but will be a key parameter to measure in a standardised process, in order to allow fair comparison of products. As average EU parameters were estimated to carry out the environmental and economic analysis, the results may not be representative for all situations (see sensitivity analysis). **Finally, as an additional delay will be required before the finalisation of the standards, the market may continue to evolve and more ambitious targets could be set when the levels of eco-design requirements are decided.**

The current definition and quantification of performance requirements may have to be completed or amended in accordance with future harmonised standards. Indeed, the washing process itself is a complex balance between parameters that compete with each other (e.g. energy efficiency and cleaning performance). In the framework of this study, only basic quantification of the energy aspect has been possible so the levels for eco-design requirements suggested will refer to these. In reality, more parameters will be needed (see Section 2.2.1 for more details).

Eco-design requirements could be considered in the form of “Tier 1” and “Tier 2” requirements. Tier 1 would apply from 2014 onwards, assuming a standard measurement method can be developed by the relevant organisation (CENELEC) by 2012/2013. Tier 2 would apply from 2017 onwards, and would enable more ambitious targets to be kept as a long-term goal (e.g. heat pump efficiency levels for dryers). According to the Ecodesign Directive, eco-deisgn requirements should not exceed the LLCC level, to avoid creating difficulties for consumers (in terms of monetary impacts) and for manufacturers (in terms of both technical and monetary impacts). However, by 2017 new technologies will become available so that today’s BAT level may no longer be BAT in 2017, and may benefit from a different economic situation (e.g. higher energy rates, lower purchase prices). BAT should therefore be kept as a long-term target, for instance by benchmarking BAT products in the future Eco-design Regulation.

The proposals for eco-design requirements have been made based on the LLCC and BAT analysis in Task 7. All the eco-design requirements suggested are economically and environmentally beneficial in comparison with the base case products. When the gap in performance was estimated to be too large to set LLCC as Tier 1 (2014), LLCC was set in Tier 2 with an intermediary step: this is the case for WM 4-6-7 and all dryers. This is based on the consultants' opinion and could be discussed further during the Consultation Forum with all relevant stakeholders.

Table 1 summarises the suggested eco-design requirements for professional laundry appliances.

Table 1 Proposals for eco-design requirements by product category[4]

Base case	Capacity per cycle	Tier 1 (2014)	Tier 2 (2017)
WM 1 - Semi-professional washer extractor	6	M 1.4 Load control (LLCC) 0.13 kWh 7.2 L	-
WM 2 - Professional washer extractor (<15 kg)	10	M 1.4 Load control (LLCC) 0.141 kWh 9.4 L	-
WM 3 - Professional washer extractor (15-40 kg)	24	M 1.4 Load control (LLCC) 0.175 kWh 10.2 L	-
WM 4 - Professional washer extractor (>40 kg)	90	M 1.4 Load control 0.310 kWh 10.9 L	M 1.3 Water recovery (LLCC, BAT) 0.244 kWh 8.9 L
WM 5 - Professional washer dryer	6	M 1.5 Further control systems 0.72 kWh 9 L	M 1.4 Load control (LLCC, BAT) 0.64 kWh 7.1 L
WM 6 - Professional barrier washer	32	M 1.4 Load control 0.345 kWh 12.5 L	M 1.3 Water recovery (LLCC, BAT) 0.275 kWh 10.1 L
WM 7 - Washing tunnel machine	1 500 (kg per hour)	M 1.2 Heat exchanger 0.27 kWh 6 L	BA product (LLCC, BAT) 0.22 kWh 3 L

[4] Energy and water consumption are given in operation mode for by kg of laundry

Base case	Capacity per cycle	Tier 1 (2014)	Tier 2 (2017)
D 1 - Semi-professional dryer, condenser	6	M 2.5 Load control 0.54 kWh	M 2.2 Heat pump (LLCC) 0.27 kWh
D 2 - Semi-professional dryer, air vented	6	M 2.5 Load control 0.51 kWh	M 2.2 Heat pump (LLCC, BAT) 0.28 kWh
D 3 - Professional cabinet dryer	8	M 2.4 Improved air flow system 0.63 kWh	M 2.2 Heat pump (LLCC) 0.28 kWh
D 4 - Professional tumble dryer (<15 kg)	10	M 2.6 Residual moisture control 0.485 kWh	BA product (LLCC, BAT) 0.20 kWh
D 5 - Professional tumble dryer (15–40 kg)	23	M 2.4 Improved air flow system 0.58 kWh	M 2.2 Heat pump (LLCC, BAT) 0.275 kWh
D 6 - Professional tumble dryer (>40 kg)	70	M 2.4 Improved air flow system 0.81 kWh	M 2.2 Heat pump (LLCC, BAT) 0.35 kWh
D 7 - Pass-through (transfer) tumble dryer	400 (kg/hour)	M 2.3 Heat recovery from exhaust air 0.71 kWh	BA product (LLCC, BAT) 0.6 kWh

The performance levels indicated should be extrapolated for products with different capacities, according to rules that will need to be defined in the relevant standards. **The energy and water parameters in the table are quantified thanks to the parameters that were available within this study but in practice the harmonised standardisation process may result in other ways to measure product consumption and performance parameters.**

As specified in the framework of the Ecodesign Directive, the approach to checking compliance with the eco-design requirements is based on self-declaration in the case of domestic laundry appliances, and the same approach shall be adopted for professional appliances. The information required should be measured according to harmonised standards. Once the harmonised standard has been defined, a detailed market review of the various categories should be done to assess whether the eco-design requirements proposed are still relevant or should be amended.

2.3.5 Verification procedure for market surveillance purposes

Member States shall apply a verification procedure when performing the market surveillance checks for compliance of products with the according requirements. In order to facilitate compliance checks, manufacturers shall provide information in the technical documentation in so far as this information relates to the requirements laid down in the Regulation.

For comparison: for household washing machines, the verification procedure for the purposes of checking conformity with the requirements, defines that authorities of the

Member State shall test a single household washing machine. If the measured parameters do not meet the values declared in the technical documentation file by the manufacturer within the tolerance range set out in the eco-design regulation, the measurements shall be carried out on three more household washing machines. The arithmetic mean of the measured values of these three household washing machines shall meet the requirements within the tolerance ranges defined in the regulation.

A similar approach is deemed relevant to the case of professional washing machines and dryers: The usual procedure so far would be self-declaration with market surveillance. Framework Directive 2010/30/EG and the according implementation measures include that Member States shall test products and might require conformity in case of non-compliance; in case of recurrence the product might be taken off the market. However, practical experience e.g. from Germany[5] repeatedly shows that there are still great problems with the correct implementation of the energy labelling directive due to a lack of governmental controls and sanctions.

Based on this experience, suppliers of professional washing machines and dryers could also be required to establish a more demanding approach. According to stakeholders' feedback, for domestic appliances a voluntary agreement (VA) enabling mutual testing between competitors is appropriate and works well; thus it could be adapted for professional appliances as well.

Basis would be sufficient technical documentation to assess the accuracy of the provided information (e.g. general description of the product, internal or independent tests reports). The information required should be measured according to harmonised standards. However, these standards are still under development at the time of the study at hand (see 2.3.1). Once the harmonised standard has been defined, a detailed market review of the various categories should be done to assess whether the minimum performance standards proposed are still relevant or should be amended.

2.3.6 Criteria for Green public procurement

Public procurement accounts for a large share of EU GDP and has a key role to play in market transformation by favouring products with the least environmental impact. Both environmental and cost criteria are important in any purchasing decision, and care must be taken that neither criterion is given undue weight. In the context of this study, an appropriate approach might be to propose more ambitious requirements for public procurement (oriented to the benchmarks, see 2.3.3) than the general eco-design requirements (see 2.3.4). As stated in Task 2, government institutions, including the armed services, prisons, schools, and

[5] According to tests of Deutsche Umwelthilfe, the provided tags and data tapes are often false or even not at all attached to the appliances. This concerns mainly air conditioning appliances being provided as special offer in the summer months in and built-in appliances (white goods) offered in kitchen studios and furniture stores (source: http://www.duh.de/energielabel.html).

hospitals, bought about 11% of the professional laundry equipment production in the United States in the late 1990s. Thus, all public customers (e.g. hospitals) could help drive the market towards more efficient appliances, as they represent a significant share of the markets concerned.

Therefore, Table 2 below presents suggested levels that could be set as GPP targets, being more ambitious than the basic requirements proposed in Section 2.3.4. For base cases WM 4-5-6-7 and dryer base cases, the Tier 2 target of the basic eco-design requirements could be set in Tier 1 for the GPP eco-design requirements. For these base cases, all the targets represent the LLCC option identified in Task 7. For the base cases WM 1-2-3, the LLCC option is already set in Tier 1 in the basic eco-design requirements but there is still room for improvement potential: the BA products are performing better regarding water and energy consumption, even if not resulting in the lowest life cycle costs. Therefore, it is suggested to implement BA product levels in Tier 1 to enable these additional energy and water savings, and to help drive the market towards the most efficient appliances.

Table 2 Proposals for GPP eco-design requirements by product category[6]

Base case	Capacity per cycle	Tier 1 (2014)
WM 1 - Semi-professional washer extractor	6	BA product 0.11 kWh 5.7 L
WM 2 - Professional washer extractor (<15 kg)	10	BA product 0.136 kWh 9.2 L
WM 3 - Professional washer extractor (15–40 kg)	24	BA product 0.170 kWh 10.1 L
WM 4 - Professional washer extractor (>40 kg)	90	M 1.3 Water recovery (LLCC, BAT) 0.244 kWh 8.9 L
WM 5 - Professional washer dryer	6	M 1.4 Load control (LLCC, BAT) 0.64 kWh 7.1 L
WM 6 - Professional barrier washer	32	M 1.3 Water recovery (LLCC, BAT) 0.275 kWh 10.1 L
WM 7 - Washing tunnel machine	1 500 (kg per hour)	BA product (LLCC, BAT) 0.22 kWh 3 L

[6] Energy and water consumption are given in operation mode for by kg of laundry

Base case	Capacity per cycle	Tier 1 (2014)
D 1 - Semi-professional dryer, condenser	6	M 2.2 Heat pump (LLCC) 0.27 kWh
D 2 - Semi-professional dryer, air vented	6	M 2.2 Heat pump (LLCC, BAT) 0.28 kWh
D 3 - Professional cabinet dryer	8	M 2.2 Heat pump (LLCC) 0.28 kWh
D 4 - Professional tumble dryer (<15 kg)	10	BA product (LLCC, BAT) 0.20 kWh
D 5 - Professional tumble dryer (15–40 kg)	23	M 2.2 Heat pump (LLCC, BAT) 0.275 kWh
D 6 - Professional tumble dryer (>40 kg)	70	M 2.2 Heat pump (LLCC, BAT) 0.35 kWh
D 7 - Pass-through (transfer) tumble dryer	400 (kg/hour)	BA product (LLCC, BAT) 0.6 kWh

2.4 Policy scenario analysis

An excel tool allowing estimates of the impacts of different scenarios was created and used in order to build the scenario analysis (2010-2020, 2010-2025 and 2010-2030) in this section. Two separate documents were developed to deal separately with washing machines and dryers. The tool was designed quite simply and relies on the following assumptions:

- The stock and sales estimates were obtained with an assumed annual growth rate of 1% for all base cases, except for WM 6 Professional Barrier Washer (growth rate of 2%). Initial stock (year 2009) was extracted from the market data presented in Task 2.
- The tool displays the expenditure (in €) and the primary energy (in J) related to the consumption of the products, following different policy options. The primary energy displayed is not limited to the use phase, but takes into account the energy required over the whole life time (including manufacturing, distribution and end-of-life phases). The model is kept simple because the global energy consumption is allocated uniformly over the life time of the product even though in theory, this is only true for the use phase. Given the low shares of other life cycle phases in energy consumption (see Task 5), this assumption is considered acceptable for the purposes of this analysis as a more “realistic” modelling exercise would make an insignificant difference to the overall results.

- Primary energy consumption was estimated as the most relevant and representative indicator to be modelled in the tool (see Task 7).
- Expenditure measures the yearly costs associated with the entire market. It consists of the amount of money spent to buy the products (purchase price), which is taken into account when the washing machines/dryer is bought and of the operating costs (energy, water, detergent costs, maintenance and repair) which are split over the life time of the appliance.
- The model is built on a discrete basis (data given for each year).

In subsections below, three scenarios are built: a Business-as-Usual (BAU) scenario, which assumes that the products on the market do not include any improvement options over the outlook period; a Best Available technology (BAT) scenario, which assumes that the BAT options are implemented in the near future for all product categories (ideally, that could be the target in the long term); a Least Life Cycle Cost (LLCC) scenario, which assumes that the LLCC options are implemented in the near future. The BAT, LLCC and the two-tier eco-design requirement scenarios are also compared to the BAU scenario, in order to have an estimate of the improvement potential of the improvement options on a large scale. Most of the description in the sections below refers to 2025 for comparison.

The following inputs regarding the market data are used within the modelling tool:

Table 3 Market inputs of the policy analysis model

Category	Stock		Growth	Life time
	2009	2025	(% per year)	(years)
WM 1 - Semi-professional washer extractor	193 139	226 471	1	8
WM 2 - Professional washing extractor (<15 kg)	557 280	653 455	1	13
WM 3 - Professional washing extractor (15–40 kg)	81 379	95 423	1	14
WM 4 - Professional washing extractor (>40 kg)	2 799	3 282	1	15
WM 5 - Professional washer dryer	2 093	2 454	1	11
WM 6 - Professional barrier Washer	10 471	14 374	2	14
WM 7 - Washing tunnel machine	3 063	3 592	1	13
D 1 - Semi-professional dryer, condenser	24 722	28 988	1	8
D 2 - Semi- professional dryer, air vented	33 219	38 952	1	8
D 3 - Professional Cabinet dryer	149 737	175 578	1	15
D 4 - Professional air tumble dryer (<15 kg)	195 967	229 787	1	13
D 5 - Professional air tumble dryer (15–40 kg)	45 939	53 867	1	14
D 6 - Professional air tumble dryer (>40 kg)	3 674	4 308	1	13
D 7 - Industrial pass-through (transfer) tumble dryer	14 697	17 233	1	13

The replacement rate of products has been estimated to be inversely proportional to the life time. For example, 12.5% (1/8) of the stock of base cases WM 1, D 1 or D 2 is replaced each year. Table 4 and Table 5 present the market data over time that result from the inputs.

Table 4 Washing machine market data of the policy analysis model

Year	Units	WM1	WM2	WM3	WM4	WM5	WM6	WM7
2009	Stock	193 139	557 280	81 379	2 799	2 093	10 471	3 063
	Sales	26 074	48 440	6 627	215	211	957	266
	Replaced	24 142	42 868	5 813	187	190	748	236
2010	Stock	195 070	562 853	82 193	2 827	2 114	10 680	3 094
	Sales	26 335	48 925	6 693	217	213	976	269
	Replaced	24 384	43 296	5 871	188	192	763	238
2011	Stock	197 021	568 481	83 015	2 855	2 135	10 894	3 125
	Sales	26 598	49 414	6 760	219	215	996	272
	Replaced	24 628	43 729	5 930	190	194	778	240
2012	Stock	198 991	574 166	83 845	2 884	2 156	11 112	3 156
	Sales	26 864	49 908	6 827	221	218	1 016	274
	Replaced	24 874	44 167	5 989	192	196	794	243
2013	Stock	200 981	579 908	84 683	2 913	2 178	11 334	3 187
	Sales	27 132	50 407	6 896	223	220	1 036	277
	Replaced	25 123	44 608	6 049	194	198	810	245
2014	Stock	202 991	585 707	85 530	2 942	2 200	11 561	3 219
	Sales	27 404	50 911	6 965	226	222	1 057	280
	Replaced	25 374	45 054	6 109	196	200	826	248
2015	Stock	205 021	591 564	86 385	2 971	2 222	11 792	3 251
	Sales	27 678	51 421	7 034	228	224	1 078	283
	Replaced	25 628	45 505	6 170	198	202	842	250
2016	Stock	207 071	597 480	87 249	3 001	2 244	12 028	3 284
	Sales	27 955	51 935	7 105	230	226	1 100	285
	Replaced	25 884	45 960	6 232	200	204	859	253
2017	Stock	209 142	603 454	88 122	3 031	2 266	12 268	3 317
	Sales	28 234	52 454	7 176	232	229	1 122	288
	Replaced	26 143	46 420	6 294	202	206	876	255
2018	Stock	211 233	609 489	89 003	3 061	2 289	12 514	3 350
	Sales	28 516	52 979	7 247	235	231	1 144	291
	Replaced	26 404	46 884	6 357	204	208	894	258
2019	Stock	213 346	615 584	89 893	3 092	2 312	12 764	3 383
	Sales	28 802	53 508	7 320	237	233	1 167	294
	Replaced	26 668	47 353	6 421	206	210	912	260

Year	Units	WM1	WM2	WM3	WM4	WM5	WM6	WM7
2020	Stock	215 479	621 740	90 792	3 123	2 335	13 019	3 417
	Sales	29 090	54 044	7 393	239	236	1 190	297
	Replaced	26 935	47 826	6 485	208	212	930	263
2021	Stock	217 634	627 957	91 700	3 154	2 358	13 280	3 451
	Sales	29 381	54 584	7 467	242	238	1 214	300
	Replaced	27 204	48 304	6 550	210	214	949	265
2022	Stock	219 810	634 237	92 617	3 186	2 382	13 545	3 486
	Sales	29 674	55 130	7 542	244	240	1 238	303
	Replaced	27 476	48 787	6 615	212	217	968	268
2023	Stock	222 008	640 579	93 543	3 217	2 406	13 816	3 521
	Sales	29 971	55 681	7 617	247	243	1 263	306
	Replaced	27 751	49 275	6 682	214	219	987	271
2024	Stock	224 228	646 985	94 478	3 250	2 430	14 093	3 556
	Sales	30 271	56 238	7 693	249	245	1 288	309
	Replaced	28 029	49 768	6 748	217	221	1 007	274
2025	Stock	226 471	653 455	95 423	3 282	2 454	14 374	3 592
	Sales	30 574	56 800	7 770	252	248	1 314	312
	Replaced	28 309	50 266	6 816	219	223	1 027	276
2026	Stock	228 735	659 989	96 378	3 315	2 479	14 662	3 628
	Sales	30 879	57 368	7 848	254	250	1 341	315
	Replaced	28 592	50 768	6 884	221	225	1 047	279
2027	Stock	231 023	666 589	97 341	3 348	2 504	14 955	3 664
	Sales	31 188	57 942	7 926	257	253	1 367	318
	Replaced	28 878	51 276	6 953	223	228	1 068	282
2028	Stock	233 333	673 255	98 315	3 381	2 529	15 254	3 700
	Sales	31 500	58 521	8 006	259	255	1 395	322
	Replaced	29 167	51 789	7 022	225	230	1 090	285
2029	Stock	235 666	679 988	99 298	3 415	2 554	15 559	3 737
	Sales	31 815	59 107	8 086	262	258	1 423	325
	Replaced	29 458	52 307	7 093	228	232	1 111	287
2030	Stock	238 023	686 787	100 291	3 449	2 579	15 871	3 775
	Sales	32 133	59 698	8 167	264	260	1 451	328
	Replaced	29 753	52 830	7 164	230	234	1 134	290

Table 5 Dryer market data of the policy analysis model

Year	Units	D1	D2	D3	D4	D5	D6	D7
2009	Stock	24 722	33 219	149 737	195 967	45 939	3 674	14 697
	Sales	3 337	4 485	11 480	17 034	3 741	319	1 278
	Replaced	3 090	4 152	9 982	15 074	3 281	283	1 131
2010	Stock	24 969	33 551	151 234	197 927	46 398	3 711	14 844
	Sales	3 371	4 529	11 595	17 204	3 778	323	1 290
	Replaced	3 121	4 194	10 082	15 225	3 314	285	1 142
2011	Stock	25 219	33 887	152 747	199 906	46 862	3 748	14 992
	Sales	3 405	4 575	11 711	17 376	3 816	326	1 303
	Replaced	3 152	4 236	10 183	15 377	3 347	288	1 153
2012	Stock	25 471	34 226	154 274	201 905	47 331	3 785	15 142
	Sales	3 439	4 620	11 828	17 550	3 854	329	1 316
	Replaced	3 184	4 278	10 285	15 531	3 381	291	1 165
2013	Stock	25 726	34 568	155 817	203 924	47 804	3 823	15 294
	Sales	3 473	4 667	11 946	17 726	3 893	332	1 329
	Replaced	3 216	4 321	10 388	15 686	3 415	294	1 176
2014	Stock	25 983	34 914	157 375	205 963	48 282	3 861	15 447
	Sales	3 508	4 713	12 065	17 903	3 932	336	1 343
	Replaced	3 248	4 364	10 492	15 843	3 449	297	1 188
2015	Stock	26 243	35 263	158 949	208 023	48 765	3 900	15 601
	Sales	3 543	4 760	12 186	18 082	3 971	339	1 356
	Replaced	3 280	4 408	10 597	16 002	3 483	300	1 200
2016	Stock	26 505	35 615	160 538	210 103	49 253	3 939	15 757
	Sales	3 578	4 808	12 308	18 263	4 011	342	1 370
	Replaced	3 313	4 452	10 703	16 162	3 518	303	1 212
2017	Stock	26 770	35 971	162 144	212 204	49 745	3 978	15 915
	Sales	3 614	4 856	12 431	18 445	4 051	346	1 383
	Replaced	3 346	4 496	10 810	16 323	3 553	306	1 224
2018	Stock	27 038	36 331	163 765	214 326	50 243	4 018	16 074
	Sales	3 650	4 905	12 555	18 630	4 091	349	1 397
	Replaced	3 380	4 541	10 918	16 487	3 589	309	1 236
2019	Stock	27 308	36 694	165 403	216 469	50 745	4 058	16 235
	Sales	3 687	4 954	12 681	18 816	4 132	353	1 411
	Replaced	3 414	4 587	11 027	16 651	3 625	312	1 249
2020	Stock	27 582	37 061	167 057	218 634	51 253	4 099	16 397
	Sales	3 724	5 003	12 808	19 004	4 173	356	1 425
	Replaced	3 448	4 633	11 137	16 818	3 661	315	1 261

Year	Units	D1	D2	D3	D4	D5	D6	D7
2021	Stock	27 857	37 432	168 727	220 821	51 765	4 140	16 561
	Sales	3 761	5 053	12 936	19 194	4 215	360	1 440
	Replaced	3 482	4 679	11 248	16 986	3 698	318	1 274
2022	Stock	28 136	37 806	170 415	223 029	52 283	4 181	16 727
	Sales	3 798	5 104	13 065	19 386	4 257	363	1 454
	Replaced	3 517	4 726	11 361	17 156	3 734	322	1 287
2023	Stock	28 417	38 184	172 119	225 259	52 806	4 223	16 894
	Sales	3 836	5 155	13 196	19 580	4 300	367	1 468
	Replaced	3 552	4 773	11 475	17 328	3 772	325	1 300
2024	Stock	28 701	38 566	173 840	227 512	53 334	4 265	17 063
	Sales	3 875	5 206	13 328	19 776	4 343	371	1 483
	Replaced	3 588	4 821	11 589	17 501	3 810	328	1 313
2025	Stock	28 988	38 952	175 578	229 787	53 867	4 308	17 233
	Sales	3 913	5 259	13 461	19 974	4 386	374	1 498
	Replaced	3 624	4 869	11 705	17 676	3 848	331	1 326
2026	Stock	29 278	39 341	177 334	232 085	54 406	4 351	17 406
	Sales	3 953	5 311	13 596	20 174	4 430	378	1 513
	Replaced	3 660	4 918	11 822	17 853	3 886	335	1 339
2027	Stock	29 571	39 735	179 108	234 405	54 950	4 395	17 580
	Sales	3 992	5 364	13 732	20 375	4 474	382	1 528
	Replaced	3 696	4 967	11 941	18 031	3 925	338	1 352
2028	Stock	29 867	40 132	180 899	236 749	55 499	4 439	17 756
	Sales	4 032	5 418	13 869	20 579	4 519	386	1 543
	Replaced	3 733	5 017	12 060	18 211	3 964	341	1 366
2029	Stock	30 166	40 533	182 708	239 117	56 054	4 483	17 933
	Sales	4 072	5 472	14 008	20 785	4 564	390	1 559
	Replaced	3 771	5 067	12 181	18 394	4 004	345	1 379
2030	Stock	30 467	40 939	184 535	241 508	56 615	4 528	18 112
	Sales	4 113	5 527	14 148	20 993	4 610	394	1 574
	Replaced	3 808	5 117	12 302	18 578	4 044	348	1 393

2.4.1 Business-as-Usual scenario

The BAU scenario considers that the base case remains the only product sold on the market in the future: no improvement option or any other type of improvement are introduced to the market or purchased. In this model, it is consequently assumed that there is no phenomenon of continuous improvement of the products. This scenario is taken as a reference in order to compare the results with those of the BAT and LLCC scenarios.

Figure 5, Figure 6, Figure 7 and Figure 8 show the breakdown by base case of the energy consumption and the expenditure over the period 2010-2025. Concerning washing

machines, WM 7 have the largest share (43%) in energy consumption while WM 2 machines have the largest share in expenditure (40%). For dryers, D 7 machines have by far the largest shares for both energy consumption and expenditure (64% and 52%).

Table 6 and Table 7 present all the outcomes of the model. In 2025, professional washing machines would require 73.8 PJ of primary energy, and the total consumption over the period 2010-2025 represents 1 094 PJ. Regarding expenditure, 2 665 m€ are expected to be spent for professional washing machines in 2025, and 39.5 b€[7] over the period 2010-2025.

Regarding professional dryers, they would require 131 PJ of primary energy in 2025, and the total consumption over the period 2010-2025 represents 1 947 PJ. Regarding expenditure, 1 250 m€ are expected to be spent for professional dryers in 2025, and 18.6 b€[8] over the period 2010-2025.

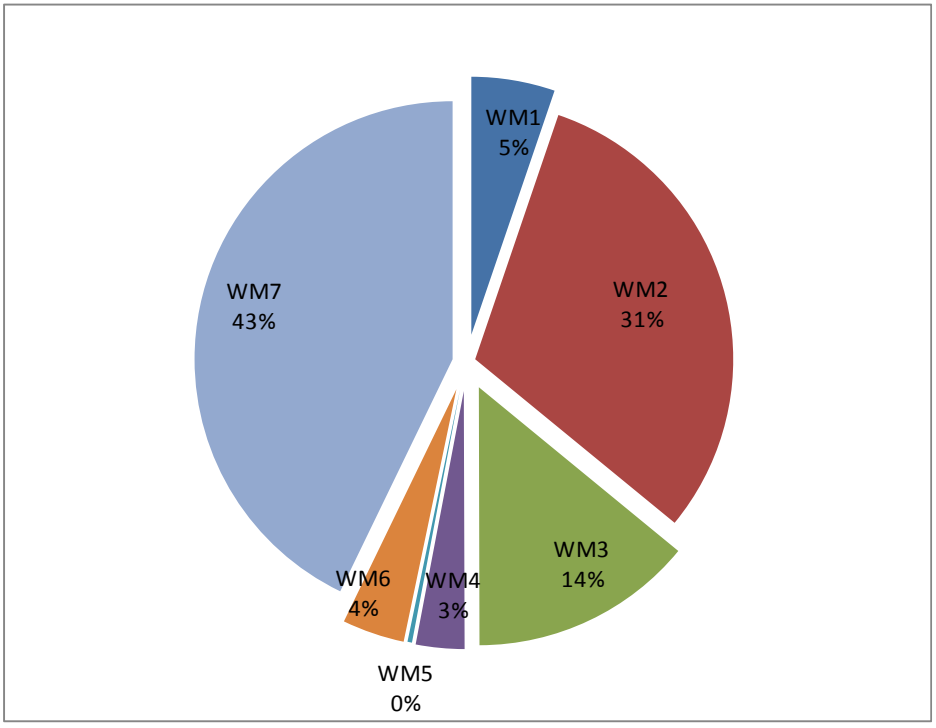


Figure 5 Breakdown of primary energy consumption of the washing machine base cases over the period 2010-2025

7 Billion Euros

8 Billion Euros

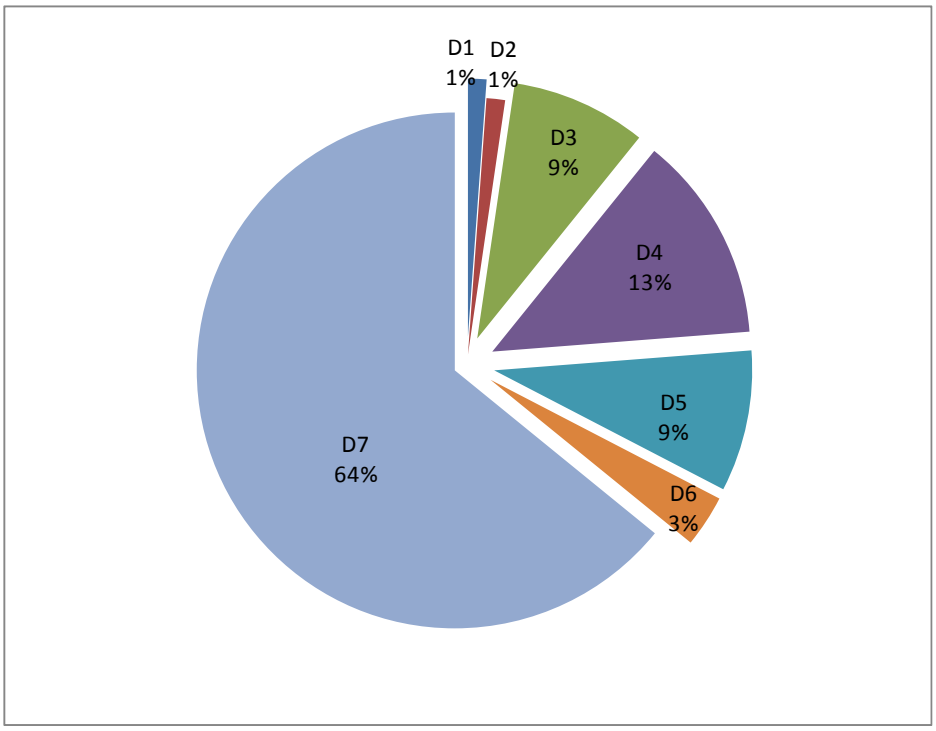


Figure 6 Breakdown of primary energy consumption of the dryer base cases over the period 2010-2025

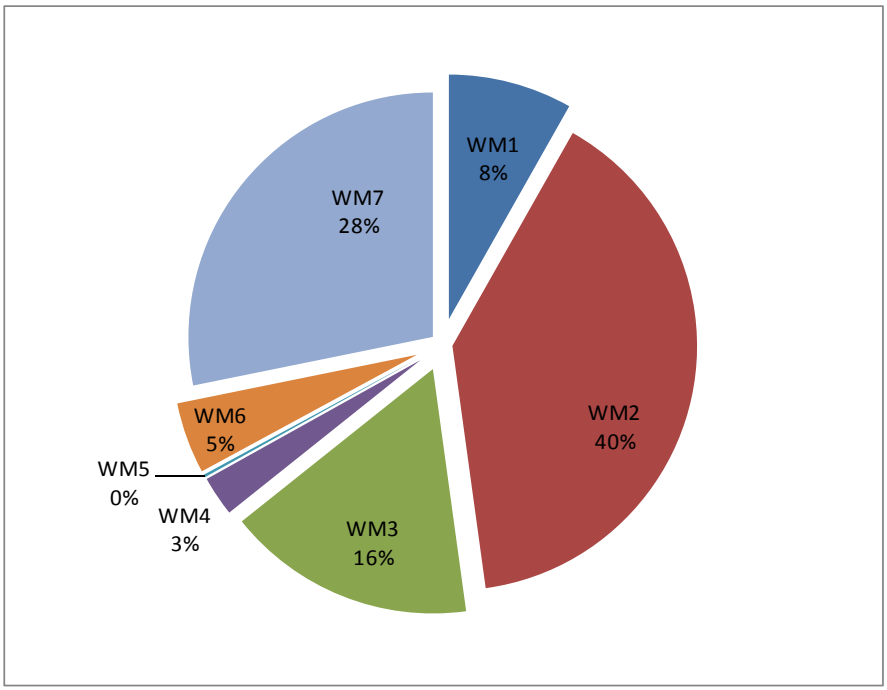


Figure 7 Breakdown of total expenditure of the washing machine base cases over the period 2010-2025

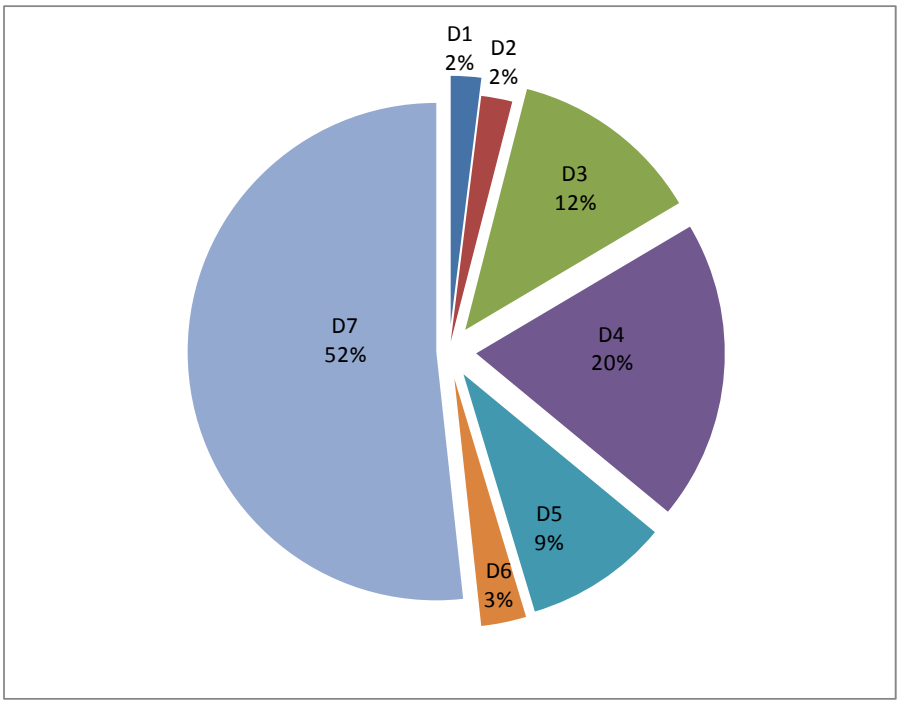


Figure 8 Breakdown of total expenditure of the dryer base cases over the period 2010-2025

Table 6 BAU scenario outcomes for washing machines: market data, energy consumption and expenditure

Year	Units	WM1	WM2	WM3	WM4	WM5	WM6	WM7	Total
2009	Stock (units)	193 139	557 280	81 379	2 799	2 093	10 471	3 063	850 224
	Sales (units)	26 074	48 440	6 627	215	211	957	266	82 790
	Energy (TJ)	3 280.8	19 276.4	8 801.3	1 902.1	178.3	2 243.0	26 882.5	62 564.5
	Expenditure (m€)	185.6	897.9	372.7	59.7	4.0	98.0	638.5	2 256.3
2010	Stock (units)	195 070	562 853	82 193	2 827	2 114	10 680	3 094	858 831
	Sales (units)	26 335	48 925	6 693	217	213	976	269	83 628
	Energy (TJ)	3 313.7	19 469.2	8 889.3	1 921.1	180.1	2 287.8	27 151.4	63 212.6
	Expenditure (m€)	187.4	906.8	376.4	60.3	4.0	99.9	644.9	2 279.8
2011	Stock (units)	197 021	568 481	83 015	2 855	2 135	10 894	3 125	867 526
	Sales (units)	26 598	49 414	6 760	219	215	996	272	84 474
	Energy (TJ)	3 346.8	19 663.9	8 978.2	1 940.3	181.9	2 333.6	27 422.9	63 867.6
	Expenditure (m€)	189.3	915.9	380.2	60.9	4.1	101.9	651.3	2 303.6
2012	Stock (units)	198 991	574 166	83 845	2 884	2 156	11 112	3 156	876 310
	Sales (units)	26 864	49 908	6 827	221	218	1 016	274	85 328
	Energy (TJ)	3 380.3	19 860.5	9 068.0	1 959.7	183.7	2 380.3	27 697.1	64 529.6
	Expenditure (m€)	191.2	925.1	384.0	61.5	4.1	104.0	657.8	2 327.7
2013	Stock (units)	200 981	579 908	84 683	2 913	2 178	11 334	3 187	885 184
	Sales (units)	27 132	50 407	6 896	223	220	1 036	277	86 192
	Energy (TJ)	3 414.1	20 059.2	9 158.6	1 979.3	185.6	2 427.9	27 974.1	65 198.7
	Expenditure (m€)	193.1	934.3	387.8	62.1	4.2	106.0	664.4	2 352.0
2014	Stock (units)	202 991	585 707	85 530	2 942	2 200	11 561	3 219	894 150
	Sales (units)	27 404	50 911	6 965	226	222	1 057	280	87 064
	Energy (TJ)	3 448.2	20 259.7	9 250.2	1 999.1	187.4	2 476.4	28 253.8	65 875.0
	Expenditure (m€)	195.0	943.7	391.7	62.8	4.2	108.2	671.1	2 376.6

Year	Units	WM1	WM2	WM3	WM4	WM5	WM6	WM7	Total
2015	Stock (units)	205 021	591 564	86 385	2 971	2 222	11 792	3 251	903 207
	Sales (units)	27 678	51 421	7 034	228	224	1 078	283	87 945
	Energy (TJ)	3 482.7	20 462.3	9 342.7	2 019.1	189.3	2 526.0	28 536.4	66 558.5
	Expenditure (m€)	197.0	953.1	395.6	63.4	4.2	110.3	677.8	2 401.4
2016	Stock (units)	207 071	597 480	87 249	3 001	2 244	12 028	3 284	912 357
	Sales (units)	27 955	51 935	7 105	230	226	1 100	285	88 836
	Energy (TJ)	3 517.5	20 667.0	9 436.2	2 039.3	191.2	2 576.5	28 821.7	67 249.3
	Expenditure (m€)	198.9	962.6	399.6	64.0	4.3	112.5	684.5	2 426.5
2017	Stock (units)	209 142	603 454	88 122	3 031	2 266	12 268	3 317	921 601
	Sales (units)	28 234	52 454	7 176	232	229	1 122	288	89 735
	Energy (TJ)	3 552.7	20 873.6	9 530.5	2 059.7	193.1	2 628.0	29 109.9	67 947.6
	Expenditure (m€)	200.9	972.3	403.6	64.7	4.3	114.8	691.4	2 451.9
2018	Stock (units)	211 233	609 489	89 003	3 061	2 289	12 514	3 350	930 939
	Sales (units)	28 516	52 979	7 247	235	231	1 144	291	90 644
	Energy (TJ)	3 588.2	21 082.4	9 625.8	2 080.3	195.0	2 680.6	29 401.0	68 653.3
	Expenditure (m€)	202.9	982.0	407.6	65.3	4.4	117.1	698.3	2 477.6
2019	Stock (units)	213 346	615 584	89 893	3 092	2 312	12 764	3 383	940 374
	Sales (units)	28 802	53 508	7 320	237	233	1 167	294	91 561
	Energy (TJ)	3 624.1	21 293.2	9 722.1	2 101.1	197.0	2 734.2	29 695.0	69 366.7
	Expenditure (m€)	205.0	991.8	411.7	66.0	4.4	119.4	705.3	2 503.5
2020	Stock (units)	215 479	621 740	90 792	3 123	2 335	13 019	3 417	949 905
	Sales (units)	29 090	54 044	7 393	239	236	1 190	297	92 489
	Energy (TJ)	3 660.3	21 506.1	9 819.3	2 122.1	198.9	2 788.9	29 992.0	70 087.7
	Expenditure (m€)	207.0	1 001.7	415.8	66.6	4.4	121.8	712.3	2 529.7
2021	Stock (units)	217 634	627 957	91 700	3 154	2 358	13 280	3 451	959 534
	Sales (units)	29 381	54 584	7 467	242	238	1 214	300	93 425
	Energy (TJ)	3 696.9	21 721.2	9 917.5	2 143.3	200.9	2 844.7	30 291.9	70 816.5
	Expenditure (m€)	209.1	1 011.7	420.0	67.3	4.5	124.2	719.5	2 556.3

Year	Units	WM1	WM2	WM3	WM4	WM5	WM6	WM7	Total
2022	Stock (units)	219 810	634 237	92 617	3 186	2 382	13 545	3 486	969 263
	Sales (units)	29 674	55 130	7 542	244	240	1 238	303	94 372
	Energy (TJ)	3 733.9	21 938.4	10 016.7	2 164.8	202.9	2 901.5	30 594.8	71 553.1
	Expenditure (m€)	211.2	1 021.9	424.2	68.0	4.5	126.7	726.7	2 583.1
2023	Stock (units)	222 008	640 579	93 543	3 217	2 406	13 816	3 521	979 091
	Sales (units)	29 971	55 681	7 617	247	243	1 263	306	95 328
	Energy (TJ)	3 771.3	22 157.8	10 116.8	2 186.4	205.0	2 959.6	30 900.8	72 297.6
	Expenditure (m€)	213.3	1 032.1	428.4	68.6	4.6	129.3	733.9	2 610.2
2024	Stock (units)	224 228	646 985	94 478	3 250	2 430	14 093	3 556	989 020
	Sales (units)	30 271	56 238	7 693	249	245	1 288	309	96 294
	Energy (TJ)	3 809.0	22 379.4	10 218.0	2 208.3	207.0	3 018.8	31 209.8	73 050.2
	Expenditure (m€)	215.4	1 042.4	432.7	69.3	4.6	131.8	741.3	2 637.6
2025	Stock (units)	226 471	653 455	95 423	3 282	2 454	14 374	3 592	999 051
	Sales (units)	30 574	56 800	7 770	252	248	1 314	312	97 270
	Energy (TJ)	3 847.1	22 603.2	10 320.2	2 230.4	209.1	3 079.1	31 521.9	73 810.9
	Expenditure (m€)	217.6	1 052.8	437.0	70.0	4.7	134.5	748.7	2 665.3
2026	Stock (units)	228 735	659 989	96 378	3 315	2 479	14 662	3 628	1 009 185
	Sales (units)	30 879	57 368	7 848	254	250	1 341	315	98 256
	Energy (TJ)	3 885.5	22 829.2	10 423.4	2 252.7	211.2	3 140.7	31 837.1	74 579.8
	Expenditure (m€)	219.8	1 063.3	441.4	70.7	4.7	137.2	756.2	2 693.3
2027	Stock (units)	231 023	666 589	97 341	3 348	2 504	14 955	3 664	1 019 424
	Sales (units)	31 188	57 942	7 926	257	253	1 367	318	99 252
	Energy (TJ)	3 924.4	23 057.5	10 527.6	2 275.2	213.3	3 203.5	32 155.5	75 357.0
	Expenditure (m€)	222.0	1 074.0	445.8	71.4	4.8	139.9	763.7	2 721.6
2028	Stock (units)	233 333	673 255	98 315	3 381	2 529	15 254	3 700	1 029 767
	Sales (units)	31 500	58 521	8 006	259	255	1 395	322	100 258
	Energy (TJ)	3 963.6	23 288.1	10 632.9	2 297.9	215.4	3 267.6	32 477.0	76 142.6
	Expenditure (m€)	224.2	1 084.7	450.2	72.1	4.8	142.7	771.4	2 750.2

Year	Units	WM1	WM2	WM3	WM4	WM5	WM6	WM7	Total
2029	Stock (units)	235 666	679 988	99 298	3 415	2 554	15 559	3 737	1 040 218
	Sales (units)	31 815	59 107	8 086	262	258	1 423	325	101 274
	Energy (TJ)	4 003.3	23 520.9	10 739.2	2 320.9	217.6	3 333.0	32 801.8	76 936.7
	Expenditure (m€)	226.4	1 095.6	454.7	72.9	4.9	145.6	779.1	2 779.1
2030	Stock (units)	238 023	686 787	100 291	3 449	2 579	15 871	3 775	1 050 775
	Sales (units)	32 133	59 698	8 167	264	260	1 451	328	102 301
	Energy (TJ)	4 043.3	23 756.1	10 846.6	2 344.1	219.7	3 399.6	33 129.8	77 739.4
	Expenditure (m€)	228.7	1 106.5	459.3	73.6	4.9	148.5	786.9	2 808.3
2010-2020	**Energy (TJ)**	**38 328.5**	**225 197.2**	**102 821.0**	**22 221.2**	**2 083.1**	**27 840.2**	**314 055.4**	**732 546.5**
2010-2020	**Expenditure (m€)**	**2 167.8**	**10 489.4**	**4 353.9**	**697.6**	**46.6**	**1 215.9**	**7 459.2**	**26 430.2**
2010-2025	**Energy (TJ)**	**57 186.7**	**335 997.1**	**153 410.2**	**33 154.3**	**3 108.0**	**42 643.9**	**468 574.6**	**1 094 074.7**
2010-2025	**Expenditure (m€)**	**3 234.4**	**15 650.2**	**6 496.1**	**1 040.8**	**69.5**	**1 862.4**	**11 129.2**	**39 482.6**
2010-2030	**Energy (TJ)**	**77 006.7**	**452 448.8**	**206 579.9**	**44 645.2**	**4 185.2**	**58 988.3**	**630 975.9**	**1 474 830.1**
2010-2030	**Expenditure (m€)**	**4 355.4**	**21 074.4**	**8 747.5**	**1 401.6**	**93.6**	**2 576.2**	**14 986.4**	**53 235.0**

Table 7 BAU scenario outcomes for dryers: market data, energy consumption and expenditure

Year	Units	D1	D2	D3	D4	D5	D6	D7	Total
2009	Stock (units)	24 722	33 219	149 737	195 967	45 939	3 674	14 697	467 955
	Sales (units)	3 337	4 485	11 480	17 034	3 741	319	1 278	41 674
	Energy (TJ)	1 288.9	1 304.1	9 474.7	14 477.3	9 891.7	3 633.9	71 641.2	111 711.6
	Expenditure (m€)	21.0	21.6	133.1	207.8	99.9	31.2	551.4	1 066.1
2010	Stock (units)	24 969	33 551	151 234	197 927	46 398	3 711	14 844	472 635
	Sales (units)	3 371	4 529	11 595	17 204	3 778	323	1 290	42 090
	Energy (TJ)	1 301.7	1 317.1	9 569.5	14 622.0	9 990.6	3 670.2	72 357.6	112 828.8
	Expenditure (m€)	21.2	21.8	134.4	209.9	100.9	31.5	556.9	1 076.7
2011	Stock (units)	25 219	33 887	152 747	199 906	46 862	3 748	14 992	477 361
	Sales (units)	3 405	4 575	11 711	17 376	3 816	326	1 303	42 511
	Energy (TJ)	1 314.8	1 330.3	9 665.1	14 768.3	10 090.5	3 706.9	73 081.2	113 957.1
	Expenditure (m€)	21.4	22.0	135.8	212.0	101.9	31.8	562.5	1 087.5
2012	Stock (units)	25 471	34 226	154 274	201 905	47 331	3 785	15 142	482 135
	Sales (units)	3 439	4 620	11 828	17 550	3 854	329	1 316	42 936
	Energy (TJ)	1 327.9	1 343.6	9 761.8	14 915.9	10 191.4	3 744.0	73 812.0	115 096.6
	Expenditure (m€)	21.6	22.3	137.1	214.1	103.0	32.1	568.1	1 098.4
2013	Stock (units)	25 726	34 568	155 817	203 924	47 804	3 823	15 294	486 956
	Sales (units)	3 473	4 667	11 946	17 726	3 893	332	1 329	43 366
	Energy (TJ)	1 341.2	1 357.0	9 859.4	15 065.1	10 293.3	3 781.4	74 550.1	116 247.6
	Expenditure (m€)	21.8	22.5	138.5	216.3	104.0	32.5	573.8	1 109.3
2014	Stock (units)	25 983	34 914	157 375	205 963	48 282	3 861	15 447	491 825
	Sales (units)	3 508	4 713	12 065	17 903	3 932	336	1 343	43 799
	Energy (TJ)	1 354.6	1 370.6	9 958.0	15 215.8	10 396.3	3 819.2	75 295.6	117 410.1
	Expenditure (m€)	22.0	22.7	139.9	218.4	105.0	32.8	579.5	1 120.4

Year	Units	D1	D2	D3	D4	D5	D6	D7	Total
2015	Stock (units)	26 243	35 263	158 949	208 023	48 765	3 900	15 601	496 744
	Sales (units)	3 543	4 760	12 186	18 082	3 971	339	1 356	44 237
	Energy (TJ)	1 368.1	1 384.3	10 057.6	15 367.9	10 500.2	3 857.4	76 048.6	118 584.2
	Expenditure (m€)	22.3	22.9	141.3	220.6	106.1	33.1	585.3	1 131.6
2016	Stock (units)	26 505	35 615	160 538	210 103	49 253	3 939	15 757	501 711
	Sales (units)	3 578	4 808	12 308	18 263	4 011	342	1 370	44 680
	Energy (TJ)	1 381.8	1 398.1	10 158.2	15 521.6	10 605.2	3 896.0	76 809.1	119 770.0
	Expenditure (m€)	22.5	23.2	142.7	222.8	107.2	33.4	591.2	1 143.0
2017	Stock (units)	26 770	35 971	162 144	212 204	49 745	3 978	15 915	506 728
	Sales (units)	3 614	4 856	12 431	18 445	4 051	346	1 383	45 126
	Energy (TJ)	1 395.6	1 412.1	10 259.7	15 676.8	10 711.3	3 935.0	77 577.2	120 967.7
	Expenditure (m€)	22.7	23.4	144.1	225.1	108.2	33.8	597.1	1 154.4
2018	Stock (units)	27 038	36 331	163 765	214 326	50 243	4 018	16 074	511 795
	Sales (units)	3 650	4 905	12 555	18 630	4 091	349	1 397	45 578
	Energy (TJ)	1 409.6	1 426.2	10 362.3	15 833.6	10 818.4	3 974.3	78 353.0	122 177.4
	Expenditure (m€)	22.9	23.6	145.6	227.3	109.3	34.1	603.1	1 165.9
2019	Stock (units)	27 308	36 694	165 403	216 469	50 745	4 058	16 235	516 913
	Sales (units)	3 687	4 954	12 681	18 816	4 132	353	1 411	46 034
	Energy (TJ)	1 423.7	1 440.5	10 466.0	15 991.9	10 926.6	4 014.0	79 136.5	123 399.2
	Expenditure (m€)	23.2	23.9	147.0	229.6	110.4	34.5	609.1	1 177.6
2020	Stock (units)	27 582	37 061	167 057	218 634	51 253	4 099	16 397	522 083
	Sales (units)	3 724	5 003	12 808	19 004	4 173	356	1 425	46 494
	Energy (TJ)	1 437.9	1 454.9	10 570.6	16 151.8	11 035.8	4 054.2	79 927.8	124 633.1
	Expenditure (m€)	23.4	24.1	148.5	231.9	111.5	34.8	615.2	1 189.4
2021	Stock (units)	27 857	37 432	168 727	220 821	51 765	4 140	16 561	527 303
	Sales (units)	3 761	5 053	12 936	19 194	4 215	360	1 440	46 959
	Energy (TJ)	1 452.3	1 469.4	10 676.3	16 313.4	11 146.2	4 094.7	80 727.1	125 879.5
	Expenditure (m€)	23.6	24.4	150.0	234.2	112.6	35.1	621.4	1 201.3

Year	Units	D1	D2	D3	D4	D5	D6	D7	Total
2022	Stock (units)	28 136	37 806	170 415	223 029	52 283	4 181	16 727	532 576
	Sales (units)	3 798	5 104	13 065	19 386	4 257	363	1 454	47 428
	Energy (TJ)	1 466.8	1 484.1	10 783.1	16 476.5	11 257.7	4 135.7	81 534.4	127 138.3
	Expenditure (m€)	23.9	24.6	151.5	236.5	113.7	35.5	627.6	1 213.3
2023	Stock (units)	28 417	38 184	172 119	225 259	52 806	4 223	16 894	537 902
	Sales (units)	3 836	5 155	13 196	19 580	4 300	367	1 468	47 903
	Energy (TJ)	1 481.5	1 499.0	10 890.9	16 641.2	11 370.2	4 177.0	82 349.7	128 409.7
	Expenditure (m€)	24.1	24.8	153.0	238.9	114.9	35.9	633.8	1 225.4
2024	Stock (units)	28 701	38 566	173 840	227 512	53 334	4 265	17 063	543 281
	Sales (units)	3 875	5 206	13 328	19 776	4 343	371	1 483	48 382
	Energy (TJ)	1 496.3	1 514.0	10 999.8	16 807.7	11 483.9	4 218.8	83 173.2	129 693.8
	Expenditure (m€)	24.4	25.1	154.5	241.3	116.0	36.2	640.2	1 237.7
2025	Stock (units)	28 988	38 952	175 578	229 787	53 867	4 308	17 233	548 714
	Sales (units)	3 913	5 259	13 461	19 974	4 386	374	1 498	48 865
	Energy (TJ)	1 511.3	1 529.1	11 109.8	16 975.7	11 598.8	4 261.0	84 005.0	130 990.7
	Expenditure (m€)	24.6	25.3	156.1	243.7	117.2	36.6	646.6	1 250.0
2026	Stock (units)	29 278	39 341	177 334	232 085	54 406	4 351	17 406	554 201
	Sales (units)	3 953	5 311	13 596	20 174	4 430	378	1 513	49 354
	Energy (TJ)	1 526.4	1 544.4	11 220.9	17 145.5	11 714.8	4 303.6	84 845.0	132 300.6
	Expenditure (m€)	24.8	25.6	157.6	246.1	118.4	36.9	653.0	1 262.5
2027	Stock (units)	29 571	39 735	179 108	234 405	54 950	4 395	17 580	559 743
	Sales (units)	3 992	5 364	13 732	20 375	4 474	382	1 528	49 848
	Energy (TJ)	1 541.7	1 559.8	11 333.1	17 317.0	11 831.9	4 346.6	85 693.5	133 623.6
	Expenditure (m€)	25.1	25.8	159.2	248.6	119.5	37.3	659.6	1 275.2
2028	Stock (units)	29 867	40 132	180 899	236 749	55 499	4 439	17 756	565 341
	Sales (units)	4 032	5 418	13 869	20 579	4 519	386	1 543	50 346
	Energy (TJ)	1 557.1	1 575.4	11 446.5	17 490.1	11 950.2	4 390.1	86 550.4	134 959.8
	Expenditure (m€)	25.3	26.1	160.8	251.1	120.7	37.7	666.2	1 287.9

Year	Units	D1	D2	D3	D4	D5	D6	D7	Total
2029	Stock (units)	30 166	40 533	182 708	239 117	56 054	4 483	17 933	570 994
	Sales (units)	4 072	5 472	14 008	20 785	4 564	390	1 559	50 850
	Energy (TJ)	1 572.6	1 591.2	11 560.9	17 665.0	12 069.7	4 434.0	87 415.9	136 309.4
	Expenditure (m€)	25.6	26.4	162.4	253.6	121.9	38.1	672.8	1 300.8
2030	Stock (units)	30 467	40 939	184 535	241 508	56 615	4 528	18 112	576 704
	Sales (units)	4 113	5 527	14 148	20 993	4 610	394	1 574	51 358
	Energy (TJ)	1 588.4	1 607.1	11 676.5	17 841.7	12 190.4	4 478.3	88 290.1	137 672.5
	Expenditure (m€)	25.8	26.6	164.0	256.1	123.2	38.4	679.6	1 313.8
2010-2020	**Energy (TJ)**	**15 057.0**	**15 234.6**	**110 688.3**	**169 130.8**	**115 559.6**	**42 452.7**	**836 948.8**	**1 305 071.7**
2010-2020	**Expenditure (m€)**	**245.0**	**252.5**	**1 554.8**	**2 428.1**	**1 167.6**	**364.4**	**6 442.0**	**12 454.3**
2010-2025	**Energy (TJ)**	**22 465.3**	**22 730.2**	**165 148.3**	**252 345.3**	**172 416.3**	**63 339.9**	**1 248 738.3**	**1 947 183.5**
2010-2025	**Expenditure (m€)**	**365.6**	**376.7**	**2 319.8**	**3 622.7**	**1 742.0**	**543.6**	**9 611.5**	**18 581.9**
2010-2030	**Energy (TJ)**	**30 251.4**	**30 608.2**	**222 386.3**	**339 804.5**	**232 173.4**	**85 292.6**	**1 681 533.1**	**2 622 049.6**
2010-2030	**Expenditure (m€)**	**492.3**	**507.2**	**3 123.8**	**4 878.3**	**2 345.8**	**732.0**	**12 942.7**	**25 022.1**

2.4.2 Least Life Cycle Cost scenario

The Least Life Cycle Cost (LLCC) scenario considers that all LLCC improvement options are implemented for each base case, as described in Task 7. The market modelling includes that from 2014, all products sold are equivalent to these LLCC options and no more base case products are sold (the market shift takes place in one single step). Table 8 reminds the LLCC options that were identified for each base case in Task 7.

Table 8 LLCC improvement option for each base case

Base case	LLCC Improvement option
WM 1 - Semi-professional washer extractor	M 1.4 Load control
WM 2 - Professional washing extractor (<15 kg)	M 1.4 Load control
WM 3 - Professional washing extractor (15–40 kg)	M 1.4 Load control
WM 4 - Professional washing extractor (>40 kg)	M 1.3 Water recovery
WM 5 - Professional washer dryer	M 1.4 Load control
WM 6 - Professional barrier Washer	M 1.3 Water recovery
WM 7 - Washing tunnel machine	BA product
D 1 - Semi-professional dryer, condenser	M 2.2 Heat pump
D 2 - Semi- professional dryer, air vented	M 2.2 Heat pump
D 3 - Professional Cabinet dryer	M 2.2 Heat pump
D 4 - Professional air tumble dryer (<15 kg)	BA Product
D 5 - Professional air tumble dryer (15–40 kg)	M 2.2 Heat pump
D 6 - Professional air tumble dryer (>40 kg)	M 2.2 Heat pump
D 7 - Industrial pass-through (transfer) tumble dryer	BA product

Table 9 and Table 10 present the outcomes of this scenario modelling. In 2025, the professional washing machine market would require 56.3 PJ of primary energy (-23.7% compared to BAU), and would represent 2.31 b€ (-13.3% compared to BAU). Over the period 2010-2025, the total primary energy consumption would be 990 PJ (-9.5% compared to BAU) and the total expenditure 38.1 b€ (-3.6% compared to BAU).

In 2025, the professional dryer market would require 87.6 PJ of primary energy (-33.1% compared to BAU), and would represent 1.12 b€ (-10.7% compared to BAU). Over the period 2010-2025, the total primary energy consumption would be 1 689 PJ (-13.3% compared to BAU) and the total expenditure 18.8 b€ (+1.3% compared to BAU).

Table 9 LLCC scenario outcomes and comparison with BAU scenario for washing machines: market data, energy consumption and expenditure

Year	Indicator	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
	Product price (€/unit)	2 670	3 097	5 000	5 800	15 250	17 690	58 750	76 375	8 000	8 160	38 250	49 725	390 000	507 000			
2009	Stock (units)	193 139	0	557 280	0	81 379	0	2 799	0	2 093	0	10 471	0	3 063	0	850 224	0.0	0.0%
	Sales (units)	26 074	0	48 440	0	6 627	0	215	0	211	0	957	0	266	0	82 790	0.0	0.0%
	Energy (TJ)	3 280.8	0.0	19 276.4	0.0	8 801.3	0.0	1 902.1	0.0	178.3	0.0	2 243.0	0.0	26 882.5	0.0	62 564.5	0.0	0.0%
	Expenditure (m€)	185.6	0.0	897.9	0.0	372.7	0.0	59.7	0.0	4.0	0.0	98.0	0.0	638.5	0.0	2 256.3	0.0	0.0%
2010	Stock (units)	195 070	0	562 853	0	82 193	0	2 827	0	2 114	0	10 680	0	3 094	0	858 831	0.0	0.0%
	Sales (units)	26 335	0	48 925	0	6 693	0	217	0	213	0	976	0	269	0	83 628	0.0	0.0%
	Energy (TJ)	3 313.7	0.0	19 469.2	0.0	8 889.3	0.0	1 921.1	0.0	180.1	0.0	2 287.8	0.0	27 151.4	0.0	63 212.6	0.0	0.0%
	Expenditure (m€)	187.4	0.0	906.8	0.0	376.4	0.0	60.3	0.0	4.0	0.0	99.9	0.0	644.9	0.0	2 279.8	0.0	0.0%
2011	Stock (units)	197 021	0	568 481	0	83 015	0	2 855	0	2 135	0	10 894	0	3 125	0	867 526	0.0	0.0%
	Sales (units)	26 598	0	49 414	0	6 760	0	219	0	215	0	996	0	272	0	84 474	0.0	0.0%
	Energy (TJ)	3 346.8	0.0	19 663.9	0.0	8 978.2	0.0	1 940.3	0.0	181.9	0.0	2 333.6	0.0	27 422.9	0.0	63 867.6	0.0	0.0%
	Expenditure (m€)	189.3	0.0	915.9	0.0	380.2	0.0	60.9	0.0	4.1	0.0	101.9	0.0	651.3	0.0	2 303.6	0.0	0.0%
2012	Stock (units)	198 991	0	574 166	0	83 845	0	2 884	0	2 156	0	11 112	0	3 156	0	876 310	0.0	0.0%
	Sales (units)	26 864	0	49 908	0	6 827	0	221	0	218	0	1 016	0	274	0	85 328	0.0	0.0%
	Energy (TJ)	3 380.3	0.0	19 860.5	0.0	9 068.0	0.0	1 959.7	0.0	183.7	0.0	2 380.3	0.0	27 697.1	0.0	64 529.6	0.0	0.0%
	Expenditure (m€)	191.2	0.0	925.1	0.0	384.0	0.0	61.5	0.0	4.1	0.0	104.0	0.0	657.8	0.0	2 327.7	0.0	0.0%
2013	Stock (units)	200 981	0	579 908	0	84 683	0	2 913	0	2 178	0	11 334	0	3 187	0	885 184	0.0	0.0%
	Sales (units)	27 132	0	50 407	0	6 896	0	223	0	220	0	1 036	0	277	0	86 192	0.0	0.0%
	Energy (TJ)	3 414.1	0.0	20 059.2	0.0	9 158.6	0.0	1 979.3	0.0	185.6	0.0	2 427.9	0.0	27 974.1	0.0	65 198.7	0.0	0.0%
	Expenditure (m€)	193.1	0.0	934.3	0.0	387.8	0.0	62.1	0.0	4.2	0.0	106.0	0.0	664.4	0.0	2 352.0	0.0	0.0%

Year	Indicator	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2014	Stock (units)	202 991	0	585 707	0	85 530	0	2 942	0	2 200	0	11 561	0	3 219	0	894 150	**0.0**	**0.0%**
	Sales (units)	0	27 404	0	50 911	0	6 965	0	226	0	222	0	1 057	0	280	87 064	**0.0**	**0.0%**
	Energy (TJ)	3 448.2	0.0	20 259.7	0.0	9 250.2	0.0	1 999.1	0.0	187.4	0.0	2 476.4	0.0	28 253.8	0.0	65 875.0	**0.0**	**0.0%**
	Expenditure (m€)	121.9	84.9	689.1	295.3	285.5	123.2	49.5	17.2	2.4	1.8	67.7	52.6	561.9	141.9	2 494.9	**118.3**	**5.0%**
2015	Stock (units)	177 617	27 404	540 653	50 911	79 421	6 965	2 746	226	2 000	222	10 735	1 057	2 972	280	903 207	**0.0**	**0.0%**
	Sales (units)	0	27 678	0	51 421	0	7 034	0	228	0	224	0	1 078	0	283	87 945	**0.0**	**0.0%**
	Energy (TJ)	3 017.2	392.1	18 701.3	1 460.6	8 589.5	623.2	1 865.8	106.0	170.4	15.2	2 299.6	157.4	26 080.4	1 548.6	65 027.2	**-1 531.3**	**-2.3%**
	Expenditure (m€)	106.6	99.2	636.1	346.4	265.1	143.1	46.2	20.0	2.2	2.0	62.9	58.0	518.7	171.6	2 478.1	**76.7**	**3.2%**
2016	Stock (units)	151 990	55 082	495 148	102 332	73 250	13 999	2 548	453	1 798	446	9 893	2 135	2 721	562	912 357	**0.0**	**0.0%**
	Sales (units)	0	27 955	0	51 935	0	7 105	0	230	0	226	0	1 100	0	285	88 836	**0.0**	**0.0%**
	Energy (TJ)	2 581.8	788.1	17 127.3	2 935.8	7 922.2	1 252.6	1 731.2	213.0	153.2	30.5	2 119.1	318.0	23 885.3	3 112.6	64 170.8	**-3 078.5**	**-4.6%**
	Expenditure (m€)	91.2	113.7	582.6	398.0	244.5	163.1	42.9	22.8	2.0	2.2	58.0	63.6	475.0	201.6	2 461.1	**34.6**	**1.4%**
2017	Stock (units)	126 106	83 036	449 188	154 267	67 018	21 103	2 348	683	1 594	673	9 034	3 235	2 469	848	921 601	**0.0**	**0.0%**
	Sales (units)	0	28 234	0	52 454	0	7 176	0	232	0	229	0	1 122	0	288	89 735	**0.0**	**0.0%**
	Energy (TJ)	2 142.2	1 188.1	15 537.5	4 425.7	7 248.2	1 888.3	1 595.3	321.1	135.8	46.0	1 935.1	481.8	21 668.3	4 692.3	63 305.6	**-4 642.0**	**-6.8%**
	Expenditure (m€)	75.7	128.3	528.5	450.1	223.7	183.4	39.5	25.6	1.8	2.4	52.9	69.3	431.0	231.9	2 444.0	**-7.9**	**-0.3%**
2018	Stock (units)	99 963	111 270	402 768	206 721	60 724	28 279	2 145	916	1 388	901	8 157	4 356	2 214	1 136	930 939	**0.0**	**0.0%**
	Sales (units)	0	28 516	0	52 979	0	7 247	0	235	0	231	0	1 144	0	291	90 644	**0.0**	**0.0%**
	Energy (TJ)	1 698.1	1 592.1	13 931.8	5 930.5	6 567.4	2 530.4	1 458.0	430.3	118.2	61.6	1 747.4	648.9	19 429.1	6 287.8	62 431.6	**-6 221.8**	**-9.1%**
	Expenditure (m€)	60.0	143.1	473.9	502.8	202.7	203.9	36.1	28.4	1.5	2.6	47.8	75.2	386.4	262.5	2 426.8	**-50.8**	**-2.1%**
2019	Stock (units)	73 559	139 787	355 884	259 700	54 367	35 526	1 941	1 150	1 180	1 132	7 263	5 501	1 956	1 427	940 374	**0.0**	**0.0%**
	Sales (units)	0	28 802	0	53 508	0	7 320	0	237	0	233	0	1 167	0	294	91 561	**0.0**	**0.0%**
	Energy (TJ)	1 249.5	2 000.2	12 310.1	7 450.4	5 879.8	3 178.9	1 319.3	540.5	100.5	77.4	1 555.9	819.3	17 167.4	7 899.3	61 548.6	**-7 818.1**	**-11.3%**
	Expenditure (m€)	44.2	158.0	418.7	555.9	181.5	224.6	32.7	31.3	1.3	2.9	42.5	81.1	341.4	293.4	2 409.3	**-94.2**	**-3.8%**

Year	Indicator	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2020	Stock (units)	46 891	168 589	308 532	313 208	47 946	42 846	1 735	1 388	969	1 366	6 352	6 668	1 696	1 721	949 905	**0.0**	**0.0%**
	Sales (units)	0	29 090	0	54 044	0	7 393	0	239	0	236	0	1 190	0	297	92 489	**0.0**	**0.0%**
	Energy (TJ)	796.5	2 412.3	10 672.2	8 985.5	5 185.4	3 833.9	1 179.2	651.9	82.6	93.3	1 360.6	993.1	14 883.2	9 526.8	60 656.6	**-9 431.1**	**-13.5%**
	Expenditure (m€)	28.1	173.0	363.0	609.6	160.0	245.4	29.2	34.1	1.1	3.1	37.2	87.2	296.0	324.6	2 391.7	**-138.0**	**-5.5%**
2021	Stock (units)	19 956	197 678	260 706	367 251	41 461	50 239	1 527	1 627	757	1 601	5 422	7 858	1 433	2 019	959 534	**0.0**	**0.0%**
	Sales (units)	0	29 381	0	54 584	0	7 467	0	242	0	238	0	1 214	0	300	93 425	**0.0**	**0.0%**
	Energy (TJ)	339.0	2 828.5	9 017.9	10 535.9	4 484.0	4 495.4	1 037.7	764.4	64.5	109.4	1 161.4	1 170.4	12 576.1	11 170.7	59 755.4	**-11 061.0**	**-15.6%**
	Expenditure (m€)	12.0	188.2	306.7	663.9	138.4	266.5	25.7	37.1	0.8	3.3	31.8	93.3	250.1	356.1	2 373.9	**-182.3**	**-7.1%**
2022	Stock (units)	0	219 810	212 401	421 835	34 911	57 706	1 317	1 869	543	1 839	4 473	9 072	1 167	2 319	969 263	**0.0**	**0.0%**
	Sales (units)	0	29 674	0	55 130	0	7 542	0	244	0	240	0	1 238	0	303	94 372	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 145.2	7 347.0	12 101.8	3 775.6	5 163.5	894.9	878.0	46.2	125.7	958.2	1 351.3	10 246.0	12 831.0	58 864.5	**-12 688.6**	**-17.7%**
	Expenditure (m€)	0.0	200.0	249.9	718.6	116.5	287.8	22.2	40.0	0.6	3.5	26.2	99.6	203.8	387.9	2 356.8	**-226.3**	**-8.8%**
2023	Stock (units)	0	222 008	163 614	476 965	28 295	65 248	1 104	2 113	326	2 080	3 506	10 311	899	2 622	979 091	**0.0**	**0.0%**
	Sales (units)	0	29 971	0	55 681	0	7 617	0	247	0	243	0	1 263	0	306	95 328	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 176.7	5 659.4	13 683.4	3 060.2	5 838.4	750.5	992.8	27.8	142.1	751.0	1 535.8	7 892.5	14 507.9	58 018.3	**-14 279.3**	**-19.8%**
	Expenditure (m€)	0.0	202.0	192.5	774.0	94.4	309.4	18.6	43.0	0.4	3.7	20.5	106.1	157.0	420.1	2 341.7	**-268.5**	**-10.3%**
2024	Stock (units)	0	224 228	114 338	532 646	21 613	72 865	890	2 360	108	2 322	2 519	11 574	628	2 928	989 020	**0.0**	**0.0%**
	Sales (units)	0	30 271	0	56 238	0	7 693	0	249	0	245	0	1 288	0	309	96 294	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 208.4	3 955.0	15 280.9	2 337.5	6 519.9	604.8	1 108.7	9.2	158.7	539.6	1 723.9	5 515.6	16 201.5	57 163.5	**-15 886.7**	**-21.7%**
	Expenditure (m€)	0.0	204.0	134.5	829.9	72.1	331.1	15.0	46.0	0.1	4.0	14.8	112.6	109.7	452.6	2 326.4	**-311.2**	**-11.8%**
2025	Stock (units)	0	226 471	64 570	588 884	14 865	80 558	673	2 609	0	2 454	1 512	12 862	355	3 237	999 051	**0.0**	**0.0%**
	Sales (units)	0	30 574	0	56 800	0	7 770	0	252	0	248	0	1 314	0	312	97 270	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 240.5	2 233.5	16 894.2	1 607.7	7 208.3	457.6	1 225.7	0.0	167.7	323.9	1 915.8	3 114.8	17 912.1	56 301.8	**-17 509.0**	**-23.7%**
	Expenditure (m€)	0.0	206.1	76.0	886.3	49.6	353.0	11.3	49.0	0.0	4.1	8.9	119.3	61.9	485.4	2 311.0	**-354.3**	**-13.3%**

Year	Indicator	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2026	Stock (units)	0	228 735	14 305	645 685	8 049	88 329	455	2 860	0	2 479	485	14 176	79	3 549	1 009 185	**0.0**	**0.0%**
	Sales (units)	0	30 879	0	57 368	0	7 848	0	254	0	250	0	1 341	0	315	98 256	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 272.9	494.8	18 523.8	870.5	7 903.6	308.9	1 343.9	0.0	169.4	104.0	2 111.6	690.0	19 639.8	55 433.1	**-19 146.6**	**-25.7%**
	Expenditure (m€)	0.0	208.1	16.8	943.3	26.9	375.2	7.6	52.1	0.0	4.1	2.8	126.1	13.7	518.5	2 295.5	**-397.8**	**-14.8%**
2027	Stock (units)	0	231 023	0	666 589	1 165	96 176	234	3 115	0	2 504	0	14 955	0	3 664	1 019 424	**0.0**	**0.0%**
	Sales (units)	0	31 188	0	57 942	0	7 926	0	257	0	253	0	1 367	0	318	99 252	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 305.6	0.0	19 123.5	126.0	8 605.8	158.7	1 463.4	0.0	171.1	0.0	2 227.6	0.0	20 275.6	55 457.2	**-19 899.8**	**-26.4%**
	Expenditure (m€)	0.0	210.2	0.0	966.4	3.9	397.6	3.9	55.2	0.0	4.2	0.0	130.7	0.0	531.7	2 303.9	**-417.7**	**-15.3%**
2028	Stock (units)	0	233 333	0	673 255	0	98 315	10	3 371	0	2 529	0	15 254	0	3 700	1 029 767	**0.0**	**0.0%**
	Sales (units)	0	31 500	0	58 521	0	8 006	0	259	0	255	0	1 395	0	322	100 258	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 338.7	0.0	19 314.7	0.0	8 797.1	7.0	1 584.0	0.0	172.8	0.0	2 272.1	0.0	20 478.4	55 964.8	**-20 177.8**	**-26.5%**
	Expenditure (m€)	0.0	212.3	0.0	976.1	0.0	404.7	0.2	58.3	0.0	4.2	0.0	133.4	0.0	537.1	2 326.2	**-423.9**	**-15.4%**
2029	Stock (units)	0	235 666	0	679 988	0	99 298	0	3 415	0	2 554	0	15 559	0	3 737	1 040 218	**0.0**	**0.0%**
	Sales (units)	0	31 815	0	59 107	0	8 086	0	262	0	258	0	1 423	0	325	101 274	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 372.1	0.0	19 507.9	0.0	8 885.1	0.0	1 604.7	0.0	174.5	0.0	2 317.6	0.0	20 683.2	56 545.0	**-20 391.7**	**-26.5%**
	Expenditure (m€)	0.0	214.5	0.0	985.8	0.0	408.8	0.0	59.0	0.0	4.3	0.0	136.0	0.0	542.4	2 350.8	**-428.3**	**-15.4%**
2030	Stock (units)	0	238 023	0	686 787	0	100 291	0	3 449	0	2 579	0	15 871	0	3 775	1 050 775	**0.0**	**0.0%**
	Sales (units)	0	32 133	0	59 698	0	8 167	0	264	0	260	0	1 451	0	328	102 301	**0.0**	**0.0%**
	Energy (TJ)	0.0	3 405.8	0.0	19 702.9	0.0	8 974.0	0.0	1 620.7	0.0	176.2	0.0	2 363.9	0.0	20 890.0	57 133.6	**-20 605.8**	**-26.5%**
	Expenditure (m€)	0.0	216.6	0.0	995.7	0.0	412.9	0.0	59.6	0.0	4.3	0.0	138.7	0.0	547.8	2 375.6	**-432.7**	**-15.4%**
2010-2020	**Energy (TJ)**	**28 388.3**	**8 373.0**	**187 592.8**	**31 188.4**	**86 736.8**	**13 307.3**	**18 948.5**	**2 262.8**	**1 679.3**	**323.9**	**22 923.7**	**3 418.6**	**261 613.1**	**33 067.5**	**699 823.9**	**-32 722.7**	**-4.5%**
	Expenditure (m€)	**1 288.7**	**900.1**	**7 374.0**	**3 158.1**	**3 091.3**	**1 286.7**	**521.0**	**179.3**	**28.6**	**17.1**	**780.8**	**487.0**	**5 628.9**	**1 627.3**	**26 368.9**	**-61.3**	**-0.2%**
2010-2025	**Energy (TJ)**	**28 727.3**	**23 972.3**	**215 805.6**	**99 684.7**	**102 001.8**	**42 532.8**	**22 693.9**	**7 232.4**	**1 827.0**	**1 027.4**	**26 657.8**	**11 115.9**	**300 958.1**	**105 690.6**	**989 927.4**	**-104 147.3**	**-9.5%**
	Expenditure (m€)	**1 300.7**	**1 900.5**	**8 333.7**	**7 030.7**	**3 562.5**	**2 834.6**	**613.7**	**394.4**	**30.5**	**35.7**	**883.0**	**1 018.1**	**6 411.4**	**3 729.4**	**38 078.7**	**-1 403.9**	**-3.6%**

Year	Indicator	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2010-2030	Energy (TJ)	28 727.3	40 667.4	216 300.4	195 857.4	102 998.3	85 698.4	23 168.5	14 849.1	1 827.0	1 891.3	26 761.8	22 408.6	301 648.1	207 657.6	1 270 461.1	-204 369.0	-13.9%
	Expenditure (m€)	1 300.7	2 962.3	8 350.5	11 897.9	3 593.2	4 833.7	625.5	678.6	30.5	56.8	885.8	1 683.1	6 425.2	6 407.0	49 730.6	-3 504.4	-6.6%

Table 10 LLCC scenario outcomes and comparison with BAU scenario for dryers: market data, energy consumption and expenditure

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA Product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
	Product price (€/unit)	1 970	3 546	1 680	2 688	3 500	7 000	4 000	7 200	7 125	12 825	21 500	38 700	62 500	88 125			
2009	Stock (units)	24 722	0	33 219	0	149 737	0	195 967	0	45 939	0	3 674	0	14 697	0	467 955	0.0	0.0%
	Sales (units)	3 337	0	4 485	0	11 480	0	17 034	0	3 741	0	319	0	1 278	0	41 674	0.0	0.0%
	Energy (TJ)	1 288.9	0.0	1 304.1	0.0	9 474.7	0.0	14 477.3	0.0	9 891.7	0.0	3 633.9	0.0	71 641.2	0.0	111 711.6	0.0	0.0%
	Expenditure (m€)	21.0	0.0	21.6	0.0	133.1	0.0	207.8	0.0	99.9	0.0	31.2	0.0	551.4	0.0	1 066.1	0.0	0.0%
2010	Stock (units)	24 969	0	33 551	0	151 234	0	197 927	0	46 398	0	3 711	0	14 844	0	472 635	0.0	0.0%
	Sales (units)	3 371	0	4 529	0	11 595	0	17 204	0	3 778	0	323	0	1 290	0	42 090	0.0	0.0%
	Energy (TJ)	1 301.7	0.0	1 317.1	0.0	9 569.5	0.0	14 622.0	0.0	9 990.6	0.0	3 670.2	0.0	72 357.6	0.0	112 828.8	0.0	0.0%
	Expenditure (m€)	21.2	0.0	21.8	0.0	134.4	0.0	209.9	0.0	100.9	0.0	31.5	0.0	556.9	0.0	1 076.7	0.0	0.0%
2011	Stock (units)	25 219	0	33 887	0	152 747	0	199 906	0	46 862	0	3 748	0	14 992	0	477 361	0.0	0.0%
	Sales (units)	3 405	0	4 575	0	11 711	0	17 376	0	3 816	0	326	0	1 303	0	42 511	0.0	0.0%
	Energy (TJ)	1 314.8	0.0	1 330.3	0.0	9 665.1	0.0	14 768.3	0.0	10 090.5	0.0	3 706.9	0.0	73 081.2	0.0	113 957.1	0.0	0.0%
	Expenditure (m€)	21.4	0.0	22.0	0.0	135.8	0.0	212.0	0.0	101.9	0.0	31.8	0.0	562.5	0.0	1 087.5	0.0	0.0%
2012	Stock (units)	25 471	0	34 226	0	154 274	0	201 905	0	47 331	0	3 785	0	15 142	0	482 135	0.0	0.0%
	Sales (units)	3 439	0	4 620	0	11 828	0	17 550	0	3 854	0	329	0	1 316	0	42 936	0.0	0.0%
	Energy (TJ)	1 327.9	0.0	1 343.6	0.0	9 761.8	0.0	14 915.9	0.0	10 191.4	0.0	3 744.0	0.0	73 812.0	0.0	115 096.6	0.0	0.0%
	Expenditure (m€)	21.6	0.0	22.3	0.0	137.1	0.0	214.1	0.0	103.0	0.0	32.1	0.0	568.1	0.0	1 098.4	0.0	0.0%

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA Product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
2013	Stock (units)	25 726	0	34 568	0	155 817	0	203 924	0	47 804	0	3 823	0	15 294	0	486 956	**0.0**	**0.0%**
	Sales (units)	3 473	0	4 667	0	11 946	0	17 726	0	3 893	0	332	0	1 329	0	43 366	**0.0**	**0.0%**
	Energy (TJ)	1 341.2	0.0	1 357.0	0.0	9 859.4	0.0	15 065.1	0.0	10 293.3	0.0	3 781.4	0.0	74 550.1	0.0	116 247.6	**0.0**	**0.0%**
	Expenditure (m€)	21.8	0.0	22.5	0.0	138.5	0.0	216.3	0.0	104.0	0.0	32.5	0.0	573.8	0.0	1 109.3	**0.0**	**0.0%**
2014	Stock (units)	25 983	0	34 914	0	157 375	0	205 963	0	48 282	0	3 861	0	15 447	0	491 825	**0.0**	**0.0%**
	Sales (units)	0	3 508	0	4 713	0	12 065	0	17 903	0	3 932	0	336	0	1 343	43 799	**0.0**	**0.0%**
	Energy (TJ)	1 354.6	0.0	1 370.6	0.0	9 958.0	0.0	15 215.8	0.0	10 396.3	0.0	3 819.2	0.0	75 295.6	0.0	117 410.1	**0.0**	**0.0%**
	Expenditure (m€)	15.1	12.4	14.8	12.7	97.6	84.5	146.8	128.9	77.0	50.4	25.6	13.0	495.6	118.3	1 292.8	**172.4**	**15.4%**
2015	Stock (units)	22 735	3 508	30 549	4 713	146 883	12 065	190 120	17 903	44 834	3 932	3 564	336	14 258	1 343	496 744	**0.0**	**0.0%**
	Sales (units)	0	3 543	0	4 760	0	12 186	0	18 082	0	3 971	0	339	0	1 356	44 237	**0.0**	**0.0%**
	Energy (TJ)	1 185.3	86.7	1 199.3	98.0	9 294.1	325.8	14 045.3	463.3	9 653.7	354.3	3 525.4	135.7	69 503.7	4 913.4	114 784.0	**-3 800.2**	**-3.2%**
	Expenditure (m€)	13.2	13.6	12.9	13.9	91.1	88.6	135.5	134.9	71.5	53.6	23.6	14.1	457.5	152.8	1 276.9	**145.3**	**12.8%**
2016	Stock (units)	19 455	7 051	26 141	9 474	136 287	24 252	174 118	35 985	41 350	7 902	3 264	675	13 058	2 699	501 711	**0.0**	**0.0%**
	Sales (units)	0	3 578	0	4 808	0	12 308	0	18 263	0	4 011	0	342	0	1 370	44 680	**0.0**	**0.0%**
	Energy (TJ)	1 014.3	174.4	1 026.2	197.0	8 623.6	654.8	12 863.2	931.3	8 903.6	712.1	3 228.7	272.8	63 653.8	9 876.0	112 131.7	**-7 638.3**	**-6.4%**
	Expenditure (m€)	11.3	14.7	11.1	15.1	84.6	92.7	124.1	141.0	66.0	56.8	21.6	15.3	419.0	187.6	1 260.9	**117.9**	**10.3%**
2017	Stock (units)	16 142	10 629	21 690	14 282	125 584	36 559	157 956	54 248	37 832	11 913	2 961	1 017	11 846	4 068	506 728	**0.0**	**0.0%**
	Sales (units)	0	3 614	0	4 856	0	12 431	0	18 445	0	4 051	0	346	0	1 383	45 126	**0.0**	**0.0%**
	Energy (TJ)	841.5	262.9	851.5	296.9	7 946.4	987.1	11 669.2	1 403.9	8 146.1	1 073.5	2 929.0	411.3	57 745.4	14 888.2	109 452.8	**-11 514.9**	**-9.5%**
	Expenditure (m€)	9.4	15.8	9.2	16.3	77.9	96.9	112.6	147.1	60.4	60.1	19.6	16.5	380.1	222.8	1 244.7	**90.3**	**7.8%**
2018	Stock (units)	12 795	14 243	17 193	19 138	114 775	48 990	141 633	72 693	34 279	15 964	2 655	1 363	10 622	5 452	511 795	**0.0**	**0.0%**
	Sales (units)	0	3 650	0	4 905	0	12 555	0	18 630	0	4 091	0	349	0	1 397	45 578	**0.0**	**0.0%**
	Energy (TJ)	667.1	352.2	674.9	397.9	7 262.4	1 322.7	10 463.3	1 881.3	7 381.0	1 438.5	2 626.3	551.1	51 777.9	19 950.6	106 747.2	**-15 430.2**	**-12.6%**
	Expenditure (m€)	7.5	17.0	7.3	17.5	71.2	101.2	101.0	153.3	54.7	63.4	17.6	17.7	340.8	258.3	1 228.4	**62.4**	**5.4%**
2019	Stock (units)	9 416	17 893	12 652	24 043	103 857	61 546	125 146	91 323	30 690	20 055	2 346	1 712	9 386	6 849	516 913	**0.0**	**0.0%**
	Sales (units)	0	3 687	0	4 954	0	12 681	0	18 816	0	4 132	0	353	0	1 411	46 034	**0.0**	**0.0%**

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA Product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
	Energy (TJ)	490.9	442.5	496.7	499.9	6 571.6	1 661.7	9 245.3	2 363.4	6 608.3	1 807.1	2 320.6	692.3	45 750.8	25 063.5	104 014.5	**-19 384.6**	**-15.7%**
	Expenditure (m€)	5.5	18.2	5.4	18.8	64.4	105.5	89.2	159.6	49.0	66.7	15.5	18.9	301.2	294.1	1 211.8	**34.2**	**2.9%**
2020	Stock (units)	6 002	21 580	8 065	28 996	92 830	74 227	108 495	110 139	27 066	24 187	2 034	2 065	8 137	8 260	522 083	**0.0**	**0.0%**
	Sales (units)	0	3 724	0	5 003	0	12 808	0	19 004	0	4 173	0	356	0	1 425	46 494	**0.0**	**0.0%**
	Energy (TJ)	312.9	533.7	316.6	602.9	5 873.9	2 004.0	8 015.2	2 850.3	5 827.8	2 179.4	2 011.8	835.0	39 663.3	30 227.6	101 254.5	**-23 378.6**	**-18.8%**
	Expenditure (m€)	3.5	19.3	3.4	20.0	57.6	109.8	77.3	165.9	43.2	70.0	13.5	20.1	261.1	330.4	1 195.1	**5.8**	**0.5%**
2021	Stock (units)	2 554	25 303	3 432	34 000	81 693	87 034	91 677	129 144	23 405	28 360	1 719	2 421	6 876	9 685	527 303	**0.0**	**0.0%**
	Sales (units)	0	3 761	0	5 053	0	12 936	0	19 194	0	4 215	0	360	0	1 440	46 959	**0.0**	**0.0%**
	Energy (TJ)	133.2	625.7	134.7	706.9	5 169.2	2 349.8	6 772.7	3 342.2	5 039.6	2 555.5	1 700.0	979.0	33 515.0	35 443.3	98 466.9	**-27 412.6**	**-21.8%**
	Expenditure (m€)	1.5	20.5	1.5	21.3	50.7	114.2	65.4	172.3	37.3	73.4	11.4	21.3	220.6	367.0	1 178.3	**-23.0**	**-1.9%**
2022	Stock (units)	0	28 136	0	37 806	70 445	99 970	74 691	148 338	19 707	32 576	1 400	2 781	5 602	11 125	532 576	**0.0**	**0.0%**
	Sales (units)	0	3 798	0	5 104	0	13 065	0	19 386	0	4 257	0	363	0	1 454	47 428	**0.0**	**0.0%**
	Energy (TJ)	0.0	695.8	0.0	786.0	4 457.4	2 699.1	5 517.9	3 838.9	4 243.4	2 935.3	1 385.0	1 124.6	27 305.3	40 711.2	95 699.8	**-31 438.4**	**-24.7%**
	Expenditure (m€)	0.0	21.5	0.0	22.3	43.7	118.6	53.2	178.7	31.4	76.8	9.3	22.6	179.7	403.9	1 161.8	**-51.5**	**-4.2%**
2023	Stock (units)	0	28 417	0	38 184	59 084	113 035	57 535	167 724	15 973	36 833	1 079	3 145	4 315	12 579	537 902	**0.0**	**0.0%**
	Sales (units)	0	3 836	0	5 155	0	13 196	0	19 580	0	4 300	0	367	0	1 468	47 903	**0.0**	**0.0%**
	Energy (TJ)	0.0	702.8	0.0	793.9	3 738.6	3 051.8	4 250.4	4 340.6	3 439.3	3 318.9	1 066.9	1 271.5	21 033.4	46 031.8	93 039.8	**-35 369.8**	**-27.5%**
	Expenditure (m€)	0.0	21.7	0.0	22.5	36.7	123.1	41.0	185.2	25.5	80.3	7.1	23.8	138.5	441.2	1 146.6	**-78.8**	**-6.4%**
2024	Stock (units)	0	28 701	0	38 566	47 609	126 231	40 207	187 305	12 201	41 133	754	3 512	3 015	14 047	543 281	**0.0**	**0.0%**
	Sales (units)	0	3 875	0	5 206	0	13 328	0	19 776	0	4 343	0	371	0	1 483	48 382	**0.0**	**0.0%**
	Energy (TJ)	0.0	709.8	0.0	801.8	3 012.5	3 408.1	2 970.3	4 847.3	2 627.1	3 706.4	745.6	1 420.0	14 698.8	51 405.5	90 353.2	**-39 340.5**	**-30.3%**
	Expenditure (m€)	0.0	21.9	0.0	22.7	29.5	127.6	28.7	191.8	19.5	83.8	5.0	25.1	96.8	478.9	1 131.2	**-106.5**	**-8.6%**
2025	Stock (units)	0	28 988	0	38 952	36 020	139 559	22 706	207 081	8 391	45 476	426	3 882	1 703	15 530	548 714	**0.0**	**0.0%**
	Sales (units)	0	3 913	0	5 259	0	13 461	0	19 974	0	4 386	0	374	0	1 498	48 865	**0.0**	**0.0%**
	Energy (TJ)	0.0	716.9	0.0	809.8	2 279.2	3 767.9	1 677.4	5 359.1	1 806.8	4 097.7	421.0	1 569.9	8 300.9	56 833.0	87 639.8	**-43 350.9**	**-33.1%**
	Expenditure (m€)	0.0	22.1	0.0	23.0	22.3	132.1	16.2	198.4	13.4	87.3	2.8	26.4	54.6	517.0	1 115.7	**-134.4**	**-10.7%**

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA Product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
2026	Stock (units)	0	29 278	0	39 341	24 314	153 020	5 030	227 054	4 544	49 862	94	4 257	377	17 028	554 201	0.0	0.0%
	Sales (units)	0	3 953	0	5 311	0	13 596	0	20 174	0	4 430	0	378	0	1 513	49 354	0.0	0.0%
	Energy (TJ)	0.0	724.1	0.0	817.9	1 538.5	4 131.4	371.6	5 876.0	978.4	4 493.0	93.3	1 721.3	1 838.9	62 314.8	84 899.2	-47 401.4	-35.8%
	Expenditure (m€)	0.0	22.3	0.0	23.2	15.1	136.7	3.6	205.1	7.2	90.9	0.6	27.7	12.1	555.5	1 100.0	-162.5	-12.9%
2027	Stock (units)	0	29 571	0	39 735	12 492	166 615	0	234 405	658	54 292	0	4 395	0	17 580	559 743	0.0	0.0%
	Sales (units)	0	3 992	0	5 364	0	13 732	0	20 375	0	4 474	0	382	0	1 528	49 848	0.0	0.0%
	Energy (TJ)	0.0	731.3	0.0	826.1	790.4	4 498.4	0.0	6 066.3	141.6	4 892.1	0.0	1 777.0	0.0	64 332.3	84 055.6	-49 568.0	-37.1%
	Expenditure (m€)	0.0	22.5	0.0	23.4	7.8	141.3	0.0	208.5	1.0	94.5	0.0	28.2	0.0	570.5	1 097.8	-177.4	-13.9%
2028	Stock (units)	0	29 867	0	40 132	552	180 347	0	236 749	0	55 499	0	4 439	0	17 756	565 341	0.0	0.0%
	Sales (units)	0	4 032	0	5 418	0	13 869	0	20 579	0	4 519	0	386	0	1 543	50 346	0.0	0.0%
	Energy (TJ)	0.0	738.6	0.0	834.4	34.9	4 869.2	0.0	6 126.9	0.0	5 000.9	0.0	1 794.8	0.0	64 975.6	84 375.3	-50 584.5	-37.5%
	Expenditure (m€)	0.0	22.8	0.0	23.7	0.3	146.0	0.0	210.6	0.0	95.9	0.0	28.5	0.0	576.2	1 104.0	-184.0	-14.3%
2029	Stock (units)	0	30 166	0	40 533	0	182 708	0	239 117	0	56 054	0	4 483	0	17 933	570 994	0.0	0.0%
	Sales (units)	0	4 072	0	5 472	0	14 008	0	20 785	0	4 564	0	390	0	1 559	50 850	0.0	0.0%
	Energy (TJ)	0.0	746.0	0.0	842.7	0.0	4 932.9	0.0	6 188.2	0.0	5 050.9	0.0	1 812.8	0.0	65 625.4	85 198.9	-51 110.6	-37.5%
	Expenditure (m€)	0.0	23.0	0.0	23.9	0.0	147.6	0.0	212.7	0.0	96.8	0.0	28.8	0.0	581.9	1 114.8	-186.0	-14.3%
2030	Stock (units)	0	30 467	0	40 939	0	184 535	0	241 508	0	56 615	0	4 528	0	18 112	576 704	0.0	0.0%
	Sales (units)	0	4 113	0	5 527	0	14 148	0	20 993	0	4 610	0	394	0	1 574	51 358	0.0	0.0%
	Energy (TJ)	0.0	753.5	0.0	851.1	0.0	4 982.2	0.0	6 250.1	0.0	5 101.4	0.0	1 830.9	0.0	66 281.6	86 050.9	-51 621.7	-37.5%
	Expenditure (m€)	0.0	23.2	0.0	24.1	0.0	149.1	0.0	214.8	0.0	97.8	0.0	29.1	0.0	587.7	1 126.0	-187.9	-14.3%
2010-2020	**Energy (TJ)**	**11 152.1**	**1 852.3**	**11 283.6**	**2 092.5**	**94 386.0**	**6 956.0**	**140 888.6**	**9 893.5**	**97 482.7**	**7 564.8**	**35 363.7**	**2 898.2**	**697 191.5**	**104 919.4**	**1 223 924.9**	**-81 146.8**	**-6.2%**
2010-2020	**Expenditure (m€)**	**151.6**	**111.0**	**152.7**	**114.2**	**1 090.3**	**679.2**	**1 639.0**	**1 030.7**	**831.6**	**421.0**	**264.9**	**115.6**	**4 916.7**	**1 564.3**	**13 082.6**	**628.4**	**5.0%**
2010-2025	**Energy (TJ)**	**11 285.3**	**5 303.4**	**11 418.4**	**5 990.9**	**113 042.8**	**22 232.7**	**162 077.4**	**31 621.5**	**114 638.9**	**24 178.6**	**40 682.2**	**9 263.2**	**802 044.9**	**335 344.3**	**1 689 124.4**	**-258 059.1**	**-13.3%**
2010-2025	**Expenditure (m€)**	**153.1**	**218.6**	**154.1**	**226.1**	**1 273.3**	**1 294.7**	**1 843.4**	**1 957.1**	**958.7**	**822.7**	**300.5**	**234.9**	**5 606.9**	**3 772.3**	**18 816.1**	**234.2**	**1.3%**

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA Product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
2010-2030	Energy (TJ)	11 285.3	8 996.8	11 418.4	10 163.2	115 406.6	45 646.8	162 449.0	62 129.0	115 758.8	48 717.0	40 775.5	18 200.0	803 883.8	658 874.1	2 113 704.3	-508 345.2	-19.4%
2010-2030	Expenditure (m€)	153.1	332.5	154.1	344.4	1 296.5	2 015.5	1 847.0	3 008.9	967.0	1 298.4	301.1	377.2	5 619.0	6 644.0	24 358.7	-663.5	-2.7%

2.4.3 Best Available Technology scenario

The BAT scenario considers that all BAT improvement options are implemented for each base case, as described in Task 7. The market modelling includes that from 2014, all products sold are equivalent to these BAT options and no more base case products are sold (the market shift takes place in one single step). Table 11 reminds the BAT options that were identified for each base case in Task 7.

Table 11 BAT improvement option for each base case

Base case	BAT Improvement option
WM 1 - Semi-professional washer extractor	BA product
WM 2 - Professional washing extractor (<15 kg)	BA product
WM 3 - Professional washing extractor (15–40 kg)	BA product
WM 4 - Professional washing extractor (>40 kg)	M 1.3 Water recovery
WM 5 - Professional washer dryer	M 1.4 Load control
WM 6 - Professional barrier washer	M 1.3 Water recovery
WM 7 - Washing tunnel machine	BA Product
D 1 - Semi-professional dryer, condenser	BA product
D 2 - Semi- professional dryer, air vented	M 2.2 Heat pump
D 3 - Professional cabinet dryer	BA product
D 4 - Professional air tumble dryer (<15 kg)	BA Product
D 5 - Professional air tumble dryer (15–40 kg)	M 2.2 Heat pump
D 6 - Professional air tumble dryer (>40 kg)	M 2.2 Heat pump
D 7 - Industrial pass-through (transfer) tumble dryer	BA product

Table 12 and Table 13 present the outcomes of this scenario modelling. In 2025, the professional washing machine market would require 55.2 PJ of primary energy (-25.2% compared to BAU), and would represent 2.40 b€ (-10.1% compared to BAU). Over the period 2010-2025, the total primary energy consumption would be 983 PJ (-10.2% compared to BAU) and the total expenditure 39.2 b€ (-0.8% compared to BAU).

In 2025, the professional dryer market would require 86.8 PJ of primary energy (-33.8% compared to BAU), and would represent 1.14 b€ (-9.0% compared to BAU). Over the period 2010-2025, the total primary energy consumption would be 1 684 PJ (-13.5% compared to BAU) and the total expenditure 19.1 b€ (+2.8% compared to BAU).

Table 12 BAT scenario outcomes and comparison with BAU scenario for washing machines: market data, energy consumption and expenditure

Year	Units	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
	Product price (€/unit)	2 670	5 340	5 000	6 250	15 250	19 825	58 750	76 375	8 000	8 160	38 250	49 725	390 000	507 000			
2009	Stock (units)	193 139	0	557 280	0	81 379	0	2 799	0	2 093	0	10 471	0	3 063	0	850 224	0.0	0.0%
	Sales (units)	26 074	0	48 440	0	6 627	0	215	0	211	0	957	0	266	0	82 790	0.0	0.0%
	Energy (TJ)	3 280.8	0.0	19 276.4	0.0	8 801.3	0.0	1 902.1	0.0	178.3	0.0	2 243.0	0.0	26 882.5	0.0	62 564.5	0.0	0.0%
	Expenditure (m€)	185.6	0.0	897.9	0.0	372.7	0.0	59.7	0.0	4.0	0.0	98.0	0.0	638.5	0.0	2 256.3	0.0	0.0%
2010	Stock (units)	195 070	0	562 853	0	82 193	0	2 827	0	2 114	0	10 680	0	3 094	0	858 831	0.0	0.0%
	Sales (units)	26 335	0	48 925	0	6 693	0	217	0	213	0	976	0	269	0	83 628	0.0	0.0%
	Energy (TJ)	3 313.7	0.0	19 469.2	0.0	8 889.3	0.0	1 921.1	0.0	180.1	0.0	2 287.8	0.0	27 151.4	0.0	63 212.6	0.0	0.0%
	Expenditure (m€)	187.4	0.0	906.8	0.0	376.4	0.0	60.3	0.0	4.0	0.0	99.9	0.0	644.9	0.0	2 279.8	0.0	0.0%
2011	Stock (units)	197 021	0	568 481	0	83 015	0	2 855	0	2 135	0	10 894	0	3 125	0	867 526	0.0	0.0%
	Sales (units)	26 598	0	49 414	0	6 760	0	219	0	215	0	996	0	272	0	84 474	0.0	0.0%
	Energy (TJ)	3 346.8	0.0	19 663.9	0.0	8 978.2	0.0	1 940.3	0.0	181.9	0.0	2 333.6	0.0	27 422.9	0.0	63 867.6	0.0	0.0%
	Expenditure (m€)	189.3	0.0	915.9	0.0	380.2	0.0	60.9	0.0	4.1	0.0	101.9	0.0	651.3	0.0	2 303.6	0.0	0.0%
2012	Stock (units)	198 991	0	574 166	0	83 845	0	2 884	0	2 156	0	11 112	0	3 156	0	876 310	0.0	0.0%
	Sales (units)	26 864	0	49 908	0	6 827	0	221	0	218	0	1 016	0	274	0	85 328	0.0	0.0%
	Energy (TJ)	3 380.3	0.0	19 860.5	0.0	9 068.0	0.0	1 959.7	0.0	183.7	0.0	2 380.3	0.0	27 697.1	0.0	64 529.6	0.0	0.0%
	Expenditure (m€)	191.2	0.0	925.1	0.0	384.0	0.0	61.5	0.0	4.1	0.0	104.0	0.0	657.8	0.0	2 327.7	0.0	0.0%
2013	Stock (units)	200 981	0	579 908	0	84 683	0	2 913	0	2 178	0	11 334	0	3 187	0	885 184	0.0	0.0%
	Sales (units)	27 132	0	50 407	0	6 896	0	223	0	220	0	1 036	0	277	0	86 192	0.0	0.0%
	Energy (TJ)	3 414.1	0.0	20 059.2	0.0	9 158.6	0.0	1 979.3	0.0	185.6	0.0	2 427.9	0.0	27 974.1	0.0	65 198.7	0.0	0.0%
	Expenditure (m€)	193.1	0.0	934.3	0.0	387.8	0.0	62.1	0.0	4.2	0.0	106.0	0.0	664.4	0.0	2 352.0	0.0	0.0%

Year	Units	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2014	Stock (units)	202 991	0	585 707	0	85 530	0	2 942	0	2 200	0	11 561	0	3 219	0	894 150	0.0	0.0%
	Sales (units)	0	27 404	0	50 911	0	6 965	0	226	0	222	0	1 057	0	280	87 064	0.0	0.0%
	Energy (TJ)	3 448.2	0.0	20 259.7	0.0	9 250.2	0.0	1 999.1	0.0	187.4	0.0	2 476.4	0.0	28 253.8	0.0	65 875.0	0.0	0.0%
	Expenditure (m€)	121.9	146.3	689.1	318.2	285.5	138.1	49.5	17.2	2.4	1.8	67.7	52.6	561.9	141.9	2 594.1	217.5	9.2%
2015	Stock (units)	177 617	27 404	540 653	50 911	79 421	6 965	2 746	226	2 000	222	10 735	1 057	2 972	280	903 207	0.0	0.0%
	Sales (units)	0	27 678	0	51 421	0	7 034	0	228	0	224	0	1 078	0	283	87 945	0.0	0.0%
	Energy (TJ)	3 017.2	335.4	18 701.3	1 415.6	8 589.5	612.7	1 865.8	106.0	170.4	15.2	2 299.6	157.4	26 080.4	1 548.6	64 915.1	-1 643.4	-2.5%
	Expenditure (m€)	106.6	159.3	636.1	368.8	265.1	158.1	46.2	20.0	2.2	2.0	62.9	58.0	518.7	171.6	2 575.6	174.2	7.3%
2016	Stock (units)	151 990	55 082	495 148	102 332	73 250	13 999	2 548	453	1 798	446	9 893	2 135	2 721	562	912 357	0.0	0.0%
	Sales (units)	0	27 955	0	51 935	0	7 105	0	230	0	226	0	1 100	0	285	88 836	0.0	0.0%
	Energy (TJ)	2 581.8	674.2	17 127.3	2 845.3	7 922.2	1 231.6	1 731.2	213.0	153.2	30.5	2 119.1	318.0	23 885.3	3 112.6	63 945.5	-3 303.9	-4.9%
	Expenditure (m€)	91.2	172.3	582.6	419.9	244.5	178.4	42.9	22.8	2.0	2.2	58.0	63.6	475.0	201.6	2 557.0	130.5	5.4%
2017	Stock (units)	126 106	83 036	449 188	154 267	67 018	21 103	2 348	683	1 594	673	9 034	3 235	2 469	848	921 601	0.0	0.0%
	Sales (units)	0	28 234	0	52 454	0	7 176	0	232	0	229	0	1 122	0	288	89 735	0.0	0.0%
	Energy (TJ)	2 142.2	1 016.4	15 537.5	4 289.3	7 248.2	1 856.7	1 595.3	321.1	135.8	46.0	1 935.1	481.8	21 668.3	4 692.3	62 965.9	-4 981.7	-7.3%
	Expenditure (m€)	75.7	185.5	528.5	471.6	223.7	198.8	39.5	25.6	1.8	2.4	52.9	69.3	431.0	231.9	2 538.2	86.3	3.5%
2018	Stock (units)	99 963	111 270	402 768	206 721	60 724	28 279	2 145	916	1 388	901	8 157	4 356	2 214	1 136	930 939	0.0	0.0%
	Sales (units)	0	28 516	0	52 979	0	7 247	0	235	0	231	0	1 144	0	291	90 644	0.0	0.0%
	Energy (TJ)	1 698.1	1 362.0	13 931.8	5 747.8	6 567.4	2 488.0	1 458.0	430.3	118.2	61.6	1 747.4	648.9	19 429.1	6 287.8	61 976.4	-6 677.0	-9.7%
	Expenditure (m€)	60.0	198.9	473.9	523.7	202.7	219.5	36.1	28.4	1.5	2.6	47.8	75.2	386.4	262.5	2 519.2	41.6	1.7%
2019	Stock (units)	73 559	139 787	355 884	259 700	54 367	35 526	1 941	1 150	1 180	1 132	7 263	5 501	1 956	1 427	940 374	0.0	0.0%
	Sales (units)	0	28 802	0	53 508	0	7 320	0	237	0	233	0	1 167	0	294	91 561	0.0	0.0%
	Energy (TJ)	1 249.5	1 711.1	12 310.1	7 220.9	5 879.8	3 125.6	1 319.3	540.5	100.5	77.4	1 555.9	819.3	17 167.4	7 899.3	60 976.7	-8 390.0	-12.1%
	Expenditure (m€)	44.2	212.3	418.7	576.4	181.5	240.4	32.7	31.3	1.3	2.9	42.5	81.1	341.4	293.4	2 500.0	-3.5	-0.1%

Year	Units	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2020	Stock (units)	46 891	168 589	308 532	313 208	47 946	42 846	1 735	1 388	969	1 366	6 352	6 668	1 696	1 721	949 905	**0.0**	**0.0%**
	Sales (units)	0	29 090	0	54 044	0	7 393	0	239	0	236	0	1 190	0	297	92 489	**0.0**	**0.0%**
	Energy (TJ)	796.5	2 063.6	10 672.2	8 708.7	5 185.4	3 769.6	1 179.2	651.9	82.6	93.3	1 360.6	993.1	14 883.2	9 526.8	59 966.9	**-10 120.8**	**-14.4%**
	Expenditure (m€)	28.1	225.9	363.0	629.6	160.0	261.4	29.2	34.1	1.1	3.1	37.2	87.2	296.0	324.6	2 480.6	**-49.1**	**-1.9%**
2021	Stock (units)	19 956	197 678	260 706	367 251	41 461	50 239	1 527	1 627	757	1 601	5 422	7 858	1 433	2 019	959 534	**0.0**	**0.0%**
	Sales (units)	0	29 381	0	54 584	0	7 467	0	242	0	238	0	1 214	0	300	93 425	**0.0**	**0.0%**
	Energy (TJ)	339.0	2 419.7	9 017.9	10 211.3	4 484.0	4 420.1	1 037.7	764.4	64.5	109.4	1 161.4	1 170.4	12 576.1	11 170.7	58 946.7	**-11 869.8**	**-16.8%**
	Expenditure (m€)	12.0	239.7	306.7	683.4	138.4	282.7	25.7	37.1	0.8	3.3	31.8	93.3	250.1	356.1	2 461.0	**-95.2**	**-3.7%**
2022	Stock (units)	0	219 810	212 401	421 835	34 911	57 706	1 317	1 869	543	1 839	4 473	9 072	1 167	2 319	969 263	**0.0**	**0.0%**
	Sales (units)	0	29 674	0	55 130	0	7 542	0	244	0	240	0	1 238	0	303	94 372	**0.0**	**0.0%**
	Energy (TJ)	0.0	2 690.6	7 347.0	11 729.0	3 775.6	5 077.0	894.9	878.0	46.2	125.7	958.2	1 351.3	10 246.0	12 831.0	57 950.5	**-13 602.6**	**-19.0%**
	Expenditure (m€)	0.0	250.5	249.9	737.6	116.5	304.2	22.2	40.0	0.6	3.5	26.2	99.6	203.8	387.9	2 442.6	**-140.5**	**-5.4%**
2023	Stock (units)	0	222 008	163 614	476 965	28 295	65 248	1 104	2 113	326	2 080	3 506	10 311	899	2 622	979 091	**0.0**	**0.0%**
	Sales (units)	0	29 971	0	55 681	0	7 617	0	247	0	243	0	1 263	0	306	95 328	**0.0**	**0.0%**
	Energy (TJ)	0.0	2 717.5	5 659.4	13 261.9	3 060.2	5 740.5	750.5	992.8	27.8	142.1	751.0	1 535.8	7 892.5	14 507.9	57 039.8	**-15 257.8**	**-21.1%**
	Expenditure (m€)	0.0	253.0	192.5	792.4	94.4	325.9	18.6	43.0	0.4	3.7	20.5	106.1	157.0	420.1	2 427.7	**-182.5**	**-7.0%**
2024	Stock (units)	0	224 228	114 338	532 646	21 613	72 865	890	2 360	108	2 322	2 519	11 574	628	2 928	989 020	**0.0**	**0.0%**
	Sales (units)	0	30 271	0	56 238	0	7 693	0	249	0	245	0	1 288	0	309	96 294	**0.0**	**0.0%**
	Energy (TJ)	0.0	2 744.7	3 955.0	14 810.1	2 337.5	6 410.7	604.8	1 108.7	9.2	158.7	539.6	1 723.9	5 515.6	16 201.5	56 119.7	**-16 930.4**	**-23.2%**
	Expenditure (m€)	0.0	255.5	134.5	847.8	72.1	347.9	15.0	46.0	0.1	4.0	14.8	112.6	109.7	452.6	2 412.6	**-225.0**	**-8.5%**
2025	Stock (units)	0	226 471	64 570	588 884	14 865	80 558	673	2 609	0	2 454	1 512	12 862	355	3 237	999 051	**0.0**	**0.0%**
	Sales (units)	0	30 574	0	56 800	0	7 770	0	252	0	248	0	1 314	0	312	97 270	**0.0**	**0.0%**
	Energy (TJ)	0.0	2 772.1	2 233.5	16 373.7	1 607.7	7 087.5	457.6	1 225.7	0.0	167.7	323.9	1 915.8	3 114.8	17 912.1	55 192.2	**-18 618.7**	**-25.2%**
	Expenditure (m€)	0.0	258.1	76.0	903.7	49.6	370.0	11.3	49.0	0.0	4.1	8.9	119.3	61.9	485.4	2 397.4	**-267.9**	**-10.1%**

Year	Units	WM1		WM2		WM3		WM4		WM5		WM6		WM7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 M 1.4 Load control	2010 Base case	2014 M 1.3 Water recov.	2010 Base case	2014 BA product		absolute	relative
2026	Stock (units)	0	228 735	14 305	645 685	8 049	88 329	455	2 860	0	2 479	485	14 176	79	3 549	1 009 185	0.0	0.0%
	Sales (units)	0	30 879	0	57 368	0	7 848	0	254	0	250	0	1 341	0	315	98 256	0.0	0.0%
	Energy (TJ)	0.0	2 799.9	494.8	17 953.1	870.5	7 771.1	308.9	1 343.9	0.0	169.4	104.0	2 111.6	690.0	19 639.8	54 256.9	-20 322.8	-27.2%
	Expenditure (m€)	0.0	260.7	16.8	960.2	26.9	392.4	7.6	52.1	0.0	4.1	2.8	126.1	13.7	518.5	2 382.1	-311.2	-11.6%
2027	Stock (units)	0	231 023	0	666 589	1 165	96 176	234	3 115	0	2 504	0	14 955	0	3 664	1 019 424	0.0	0.0%
	Sales (units)	0	31 188	0	57 942	0	7 926	0	257	0	253	0	1 367	0	318	99 252	0.0	0.0%
	Energy (TJ)	0.0	2 827.9	0.0	18 534.3	126.0	8 461.6	158.7	1 463.4	0.0	171.1	0.0	2 227.6	0.0	20 275.6	54 246.0	-21 110.9	-28.0%
	Expenditure (m€)	0.0	263.3	0.0	983.3	3.9	415.0	3.9	55.2	0.0	4.2	0.0	130.7	0.0	531.7	2 391.2	-330.4	-12.1%
2028	Stock (units)	0	233 333	0	673 255	0	98 315	10	3 371	0	2 529	0	15 254	0	3 700	1 029 767	0.0	0.0%
	Sales (units)	0	31 500	0	58 521	0	8 006	0	259	0	255	0	1 395	0	322	100 258	0.0	0.0%
	Energy (TJ)	0.0	2 856.1	0.0	18 719.6	0.0	8 649.7	7.0	1 584.0	0.0	172.8	0.0	2 272.1	0.0	20 478.4	54 739.8	-21 402.8	-28.1%
	Expenditure (m€)	0.0	265.9	0.0	993.1	0.0	422.3	0.2	58.3	0.0	4.2	0.0	133.4	0.0	537.1	2 414.4	-335.8	-12.2%
2029	Stock (units)	0	235 666	0	679 988	0	99 298	0	3 415	0	2 554	0	15 559	0	3 737	1 040 218	0.0	0.0%
	Sales (units)	0	31 815	0	59 107	0	8 086	0	262	0	258	0	1 423	0	325	101 274	0.0	0.0%
	Energy (TJ)	0.0	2 884.7	0.0	18 906.8	0.0	8 736.2	0.0	1 604.7	0.0	174.5	0.0	2 317.6	0.0	20 683.2	55 307.7	-21 629.0	-28.1%
	Expenditure (m€)	0.0	268.6	0.0	1 003.0	0.0	426.5	0.0	59.0	0.0	4.3	0.0	136.0	0.0	542.4	2 439.8	-339.3	-12.2%
2030	Stock (units)	0	238 023	0	686 787	0	100 291	0	3 449	0	2 579	0	15 871	0	3 775	1 050 775	0.0	0.0%
	Sales (units)	0	32 133	0	59 698	0	8 167	0	264	0	260	0	1 451	0	328	102 301	0.0	0.0%
	Energy (TJ)	0.0	2 913.5	0.0	19 095.9	0.0	8 823.6	0.0	1 620.7	0.0	176.2	0.0	2 363.9	0.0	20 890.0	55 883.9	-21 855.4	-28.1%
	Expenditure (m€)	0.0	271.2	0.0	1 013.1	0.0	430.8	0.0	59.6	0.0	4.3	0.0	138.7	0.0	547.8	2 465.6	-342.8	-12.2%
2010-2020	**Energy (TJ)**	**28 388**	**7 163**	**187 593**	**30 228**	**86 737**	**13 084**	**18 948**	**2 263**	**1 679**	**324**	**22 924**	**3 419**	**261 613**	**33 067**	**697 430**	**-35 117**	**-4.8%**
2010-2020	**Expenditure (m€)**	**1 289**	**1 301**	**7 374**	**3 308**	**3 091**	**1 395**	**521**	**179**	**29**	**17**	**781**	**487**	**5 629**	**1 627**	**27 028**	**597**	**2.3%**
2010-2025	**Energy (TJ)**	**28 727**	**20 507**	**215 806**	**96 614**	**102 002**	**41 820**	**22 694**	**7 232**	**1 827**	**1 027**	**26 658**	**11 116**	**300 958**	**105 691**	**982 679**	**-111 396**	**-10.2%**
2010-2025	**Expenditure (m€)**	**1 301**	**2 557**	**8 334**	**7 273**	**3 562**	**3 025**	**614**	**394**	**30**	**36**	**883**	**1 018**	**6 411**	**3 729**	**39 169**	**-314**	**-0.8%**
2010-2030	**Energy (TJ)**	**28 727**	**34 790**	**216 300**	**189 823**	**102 998**	**84 262**	**23 168**	**14 849**	**1 827**	**1 891**	**26 762**	**22 409**	**301 648**	**207 658**	**1 257 113**	**-217 717**	**-14.8%**
2010-2030	**Expenditure (m€)**	**1 301**	**3 887**	**8 350**	**12 226**	**3 593**	**5 112**	**625**	**679**	**30**	**57**	**886**	**1 683**	**6 425**	**6 407**	**51 262**	**-1 973**	**-3.7%**

Table 13 BAT scenario outcomes and comparison with BAU scenario for dryers: market data, energy consumption and expenditure

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
	Product price (€/unit)	1 970	4 925	1 680	2 688	3 500	8 750	4 000	7 200	7 125	12 825	21 500	38 700	62 500	88 125			
2009	Stock (units)	24 722	0	33 219	0	149 737	0	195 967	0	45 939	0	3 674	0	14 697	0	467 955	0.0	0.0%
	Sales (units)	3 337	0	4 485	0	11 480	0	17 034	0	3 741	0	319	0	1 278	0	41 674	0.0	0.0%
	Energy (TJ)	1 288.9	0.0	1 304.1	0.0	9 474.7	0.0	14 477.3	0.0	9 891.7	0.0	3 633.9	0.0	71 641.2	0.0	111 711.6	0.0	0.0%
	Expenditure (m€)	21.0	0.0	21.6	0.0	133.1	0.0	207.8	0.0	99.9	0.0	31.2	0.0	551.4	0.0	1 066.1	0.0	0.0%
2010	Stock (units)	24 969	0	33 551	0	151 234	0	197 927	0	46 398	0	3 711	0	14 844	0	472 635	0.0	0.0%
	Sales (units)	3 371	0	4 529	0	11 595	0	17 204	0	3 778	0	323	0	1 290	0	42 090	0.0	0.0%
	Energy (TJ)	1 301.7	0.0	1 317.1	0.0	9 569.5	0.0	14 622.0	0.0	9 990.6	0.0	3 670.2	0.0	72 357.6	0.0	112 828.8	0.0	0.0%
	Expenditure (m€)	21.2	0.0	21.8	0.0	134.4	0.0	209.9	0.0	100.9	0.0	31.5	0.0	556.9	0.0	1 076.7	0.0	0.0%
2011	Stock (units)	25 219	0	33 887	0	152 747	0	199 906	0	46 862	0	3 748	0	14 992	0	477 361	0.0	0.0%
	Sales (units)	3 405	0	4 575	0	11 711	0	17 376	0	3 816	0	326	0	1 303	0	42 511	0.0	0.0%
	Energy (TJ)	1 314.8	0.0	1 330.3	0.0	9 665.1	0.0	14 768.3	0.0	10 090.5	0.0	3 706.9	0.0	73 081.2	0.0	113 957.1	0.0	0.0%
	Expenditure (m€)	21.4	0.0	22.0	0.0	135.8	0.0	212.0	0.0	101.9	0.0	31.8	0.0	562.5	0.0	1 087.5	0.0	0.0%
2012	Stock (units)	25 471	0	34 226	0	154 274	0	201 905	0	47 331	0	3 785	0	15 142	0	482 135	0.0	0.0%
	Sales (units)	3 439	0	4 620	0	11 828	0	17 550	0	3 854	0	329	0	1 316	0	42 936	0.0	0.0%
	Energy (TJ)	1 327.9	0.0	1 343.6	0.0	9 761.8	0.0	14 915.9	0.0	10 191.4	0.0	3 744.0	0.0	73 812.0	0.0	115 096.6	0.0	0.0%
	Expenditure (m€)	21.6	0.0	22.3	0.0	137.1	0.0	214.1	0.0	103.0	0.0	32.1	0.0	568.1	0.0	1 098.4	0.0	0.0%
2013	Stock (units)	25 726	0	34 568	0	155 817	0	203 924	0	47 804	0	3 823	0	15 294	0	486 956	0.0	0.0%
	Sales (units)	3 473	0	4 667	0	11 946	0	17 726	0	3 893	0	332	0	1 329	0	43 366	0.0	0.0%
	Energy (TJ)	1 341.2	0.0	1 357.0	0.0	9 859.4	0.0	15 065.1	0.0	10 293.3	0.0	3 781.4	0.0	74 550.1	0.0	116 247.6	0.0	0.0%
	Expenditure (m€)	21.8	0.0	22.5	0.0	138.5	0.0	216.3	0.0	104.0	0.0	32.5	0.0	573.8	0.0	1 109.3	0.0	0.0%

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
2014	Stock (units)	25 983	0	34 914	0	157 375	0	205 963	0	48 282	0	3 861	0	15 447	0	491 825	**0.0**	**0.0%**
	Sales (units)	0	3 508	0	4 713	0	12 065	0	17 903	0	3 932	0	336	0	1 343	43 799	**0.0**	**0.0%**
	Energy (TJ)	1 354.6	0.0	1 370.6	0.0	9 958.0	0.0	15 215.8	0.0	10 396.3	0.0	3 819.2	0.0	75 295.6	0.0	117 410.1	**0.0**	**0.0%**
	Expenditure (m€)	15.1	17.3	14.8	12.7	97.6	105.6	146.8	128.9	77.0	50.4	25.6	13.0	495.6	118.3	1 318.8	**198.3**	**17.7%**
2015	Stock (units)	22 735	3 508	30 549	4 713	146 883	12 065	190 120	17 903	44 834	3 932	3 564	336	14 258	1 343	496 744	**0.0**	**0.0%**
	Sales (units)	0	3 543	0	4 760	0	12 186	0	18 082	0	3 971	0	339	0	1 356	44 237	**0.0**	**0.0%**
	Energy (TJ)	1 185.3	65.5	1 199.3	98.0	9 294.1	266.1	14 045.3	463.3	9 653.7	354.3	3 525.4	135.7	69 503.7	4 913.4	114 703.1	**-3 881.1**	**-3.3%**
	Expenditure (m€)	13.2	18.2	12.9	13.9	91.1	109.4	135.5	134.9	71.5	53.6	23.6	14.1	457.5	152.8	1 302.5	**170.8**	**15.1%**
2016	Stock (units)	19 455	7 051	26 141	9 474	136 287	24 252	174 118	35 985	41 350	7 902	3 264	675	13 058	2 699	501 711	**0.0**	**0.0%**
	Sales (units)	0	3 578	0	4 808	0	12 308	0	18 263	0	4 011	0	342	0	1 370	44 680	**0.0**	**0.0%**
	Energy (TJ)	1 014.3	131.7	1 026.2	197.0	8 623.6	534.8	12 863.2	931.3	8 903.6	712.1	3 228.7	272.8	63 653.8	9 876.0	111 969.1	**-7 800.9**	**-6.5%**
	Expenditure (m€)	11.3	19.2	11.1	15.1	84.6	113.3	124.1	141.0	66.0	56.8	21.6	15.3	419.0	187.6	1 286.0	**143.0**	**12.5%**
2017	Stock (units)	16 142	10 629	21 690	14 282	125 584	36 559	157 956	54 248	37 832	11 913	2 961	1 017	11 846	4 068	506 728	**0.0**	**0.0%**
	Sales (units)	0	3 614	0	4 856	0	12 431	0	18 445	0	4 051	0	346	0	1 383	45 126	**0.0**	**0.0%**
	Energy (TJ)	841.5	198.5	851.5	296.9	7 946.4	806.2	11 669.2	1 403.9	8 146.1	1 073.5	2 929.0	411.3	57 745.4	14 888.2	109 207.7	**-11 760.0**	**-9.7%**
	Expenditure (m€)	9.4	20.2	9.2	16.3	77.9	117.2	112.6	147.1	60.4	60.1	19.6	16.5	380.1	222.8	1 269.3	**114.9**	**10.0%**
2018	Stock (units)	12 795	14 243	17 193	19 138	114 775	48 990	141 633	72 693	34 279	15 964	2 655	1 363	10 622	5 452	511 795	**0.0**	**0.0%**
	Sales (units)	0	3 650	0	4 905	0	12 555	0	18 630	0	4 091	0	349	0	1 397	45 578	**0.0**	**0.0%**
	Energy (TJ)	667.1	266.0	674.9	397.9	7 262.4	1 080.4	10 463.3	1 881.3	7 381.0	1 438.5	2 626.3	551.1	51 777.9	19 950.6	106 418.7	**-15 758.7**	**-12.9%**
	Expenditure (m€)	7.5	21.2	7.3	17.5	71.2	121.1	101.0	153.3	54.7	63.4	17.6	17.7	340.8	258.3	1 252.5	**86.6**	**7.4%**
2019	Stock (units)	9 416	17 893	12 652	24 043	103 857	61 546	125 146	91 323	30 690	20 055	2 346	1 712	9 386	6 849	516 913	**0.0**	**0.0%**
	Sales (units)	0	3 687	0	4 954	0	12 681	0	18 816	0	4 132	0	353	0	1 411	46 034	**0.0**	**0.0%**
	Energy (TJ)	490.9	334.2	496.7	499.9	6 571.6	1 357.3	9 245.3	2 363.4	6 608.3	1 807.1	2 320.6	692.3	45 750.8	25 063.5	103 601.8	**-19 797.3**	**-16.0%**
	Expenditure (m€)	5.5	22.2	5.4	18.8	64.4	125.1	89.2	159.6	49.0	66.7	15.5	18.9	301.2	294.1	1 235.6	**58.0**	**4.9%**

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
2020	Stock (units)	6 002	21 580	8 065	28 996	92 830	74 227	108 495	110 139	27 066	24 187	2 034	2 065	8 137	8 260	522 083	**0.0**	**0.0%**
	Sales (units)	0	3 724	0	5 003	0	12 808	0	19 004	0	4 173	0	356	0	1 425	46 494	**0.0**	**0.0%**
	Energy (TJ)	312.9	403.1	316.6	602.9	5 873.9	1 636.9	8 015.2	2 850.3	5 827.8	2 179.4	2 011.8	835.0	39 663.3	30 227.6	100 756.8	**-23 876.4**	**-19.2%**
	Expenditure (m€)	3.5	23.2	3.4	20.0	57.6	129.2	77.3	165.9	43.2	70.0	13.5	20.1	261.1	330.4	1 218.4	**29.0**	**2.4%**
2021	Stock (units)	2 554	25 303	3 432	34 000	81 693	87 034	91 677	129 144	23 405	28 360	1 719	2 421	6 876	9 685	527 303	**0.0**	**0.0%**
	Sales (units)	0	3 761	0	5 053	0	12 936	0	19 194	0	4 215	0	360	0	1 440	46 959	**0.0**	**0.0%**
	Energy (TJ)	133.2	472.6	134.7	706.9	5 169.2	1 919.4	6 772.7	3 342.2	5 039.6	2 555.5	1 700.0	979.0	33 515.0	35 443.3	97 883.3	**-27 996.2**	**-22.2%**
	Expenditure (m€)	1.5	24.3	1.5	21.3	50.7	133.2	65.4	172.3	37.3	73.4	11.4	21.3	220.6	367.0	1 201.1	**-0.2**	**0.0%**
2022	Stock (units)	0	28 136	0	37 806	70 445	99 970	74 691	148 338	19 707	32 576	1 400	2 781	5 602	11 125	532 576	**0.0**	**0.0%**
	Sales (units)	0	3 798	0	5 104	0	13 065	0	19 386	0	4 257	0	363	0	1 454	47 428	**0.0**	**0.0%**
	Energy (TJ)	0.0	525.5	0.0	786.0	4 457.4	2 204.6	5 517.9	3 838.9	4 243.4	2 935.3	1 385.0	1 124.6	27 305.3	40 711.2	95 035.1	**-32 103.2**	**-25.3%**
	Expenditure (m€)	0.0	25.1	0.0	22.3	43.7	137.3	53.2	178.7	31.4	76.8	9.3	22.6	179.7	403.9	1 184.2	**-29.1**	**-2.4%**
2023	Stock (units)	0	28 417	0	38 184	59 084	113 035	57 535	167 724	15 973	36 833	1 079	3 145	4 315	12 579	537 902	**0.0**	**0.0%**
	Sales (units)	0	3 836	0	5 155	0	13 196	0	19 580	0	4 300	0	367	0	1 468	47 903	**0.0**	**0.0%**
	Energy (TJ)	0.0	530.8	0.0	793.9	3 738.6	2 492.8	4 250.4	4 340.6	3 439.3	3 318.9	1 066.9	1 271.5	21 033.4	46 031.8	92 308.8	**-36 100.9**	**-28.1%**
	Expenditure (m€)	0.0	25.3	0.0	22.5	36.7	141.5	41.0	185.2	25.5	80.3	7.1	23.8	138.5	441.2	1 168.7	**-56.7**	**-4.6%**
2024	Stock (units)	0	28 701	0	38 566	47 609	126 231	40 207	187 305	12 201	41 133	754	3 512	3 015	14 047	543 281	**0.0**	**0.0%**
	Sales (units)	0	3 875	0	5 206	0	13 328	0	19 776	0	4 343	0	371	0	1 483	48 382	**0.0**	**0.0%**
	Energy (TJ)	0.0	536.1	0.0	801.8	3 012.5	2 783.8	2 970.3	4 847.3	2 627.1	3 706.4	745.6	1 420.0	14 698.8	51 405.5	89 555.2	**-40 138.5**	**-30.9%**
	Expenditure (m€)	0.0	25.6	0.0	22.7	29.5	145.7	28.7	191.8	19.5	83.8	5.0	25.1	96.8	478.9	1 153.0	**-84.6**	**-6.8%**
2025	Stock (units)	0	28 988	0	38 952	36 020	139 559	22 706	207 081	8 391	45 476	426	3 882	1 703	15 530	548 714	**0.0**	**0.0%**
	Sales (units)	0	3 913	0	5 259	0	13 461	0	19 974	0	4 386	0	374	0	1 498	48 865	**0.0**	**0.0%**
	Energy (TJ)	0.0	541.5	0.0	809.8	2 279.2	3 077.7	1 677.4	5 359.1	1 806.8	4 097.7	421.0	1 569.9	8 300.9	56 833.0	86 774.1	**-44 216.6**	**-33.8%**
	Expenditure (m€)	0.0	25.9	0.0	23.0	22.3	149.9	16.2	198.4	13.4	87.3	2.8	26.4	54.6	517.0	1 137.2	**-112.8**	**-9.0%**

Year	Unit	D1		D2		D3		D4		D5		D6		D7		Total	Difference with BAU	
		2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product	2010 Base case	2014 BA product	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 M 2.2 Heat pump	2010 Base case	2014 BA product		absolute	relative
2026	Stock (units)	0	29 278	0	39 341	24 314	153 020	5 030	227 054	4 544	49 862	94	4 257	377	17 028	554 201	**0.0**	**0.0%**
	Sales (units)	0	3 953	0	5 311	0	13 596	0	20 174	0	4 430	0	378	0	1 513	49 354	**0.0**	**0.0%**
	Energy (TJ)	0.0	546.9	0.0	817.9	1 538.5	3 374.5	371.6	5 876.0	978.4	4 493.0	93.3	1 721.3	1 838.9	62 314.8	83 965.1	**-48 335.5**	**-36.5%**
	Expenditure (m€)	0.0	26.1	0.0	23.2	15.1	154.2	3.6	205.1	7.2	90.9	0.6	27.7	12.1	555.5	1 121.3	**-141.3**	**-11.2%**
2027	Stock (units)	0	29 571	0	39 735	12 492	166 615	0	234 405	658	54 292	0	4 395	0	17 580	559 743	**0.0**	**0.0%**
	Sales (units)	0	3 992	0	5 364	0	13 732	0	20 375	0	4 474	0	382	0	1 528	49 848	**0.0**	**0.0%**
	Energy (TJ)	0.0	552.3	0.0	826.1	790.4	3 674.4	0.0	6 066.3	141.6	4 892.1	0.0	1 777.0	0.0	64 332.3	83 052.6	**-50 571.0**	**-37.8%**
	Expenditure (m€)	0.0	26.4	0.0	23.4	7.8	158.5	0.0	208.5	1.0	94.5	0.0	28.2	0.0	570.5	1 118.8	**-156.4**	**-12.3%**
2028	Stock (units)	0	29 867	0	40 132	552	180 347	0	236 749	0	55 499	0	4 439	0	17 756	565 341	**0.0**	**0.0%**
	Sales (units)	0	4 032	0	5 418	0	13 869	0	20 579	0	4 519	0	386	0	1 543	50 346	**0.0**	**0.0%**
	Energy (TJ)	0.0	557.9	0.0	834.4	34.9	3 977.2	0.0	6 126.9	0.0	5 000.9	0.0	1 794.8	0.0	64 975.6	83 302.6	**-51 657.2**	**-38.3%**
	Expenditure (m€)	0.0	26.6	0.0	23.7	0.3	162.9	0.0	210.6	0.0	95.9	0.0	28.5	0.0	576.2	1 124.7	**-163.3**	**-12.7%**
2029	Stock (units)	0	30 166	0	40 533	0	182 708	0	239 117	0	56 054	0	4 483	0	17 933	570 994	**0.0**	**0.0%**
	Sales (units)	0	4 072	0	5 472	0	14 008	0	20 785	0	4 564	0	390	0	1 559	50 850	**0.0**	**0.0%**
	Energy (TJ)	0.0	563.4	0.0	842.7	0.0	4 029.2	0.0	6 188.2	0.0	5 050.9	0.0	1 812.8	0.0	65 625.4	84 112.7	**-52 196.8**	**-38.3%**
	Expenditure (m€)	0.0	26.9	0.0	23.9	0.0	164.6	0.0	212.7	0.0	96.8	0.0	28.8	0.0	581.9	1 135.7	**-165.1**	**-12.7%**
2030	Stock (units)	0	30 467	0	40 939	0	184 535	0	241 508	0	56 615	0	4 528	0	18 112	576 704	**0.0**	**0.0%**
	Sales (units)	0	4 113	0	5 527	0	14 148	0	20 993	0	4 610	0	394	0	1 574	51 358	**0.0**	**0.0%**
	Energy (TJ)	0.0	569.1	0.0	851.1	0.0	4 069.5	0.0	6 250.1	0.0	5 101.4	0.0	1 830.9	0.0	66 281.6	84 953.8	**-52 718.7**	**-38.3%**
	Expenditure (m€)	0.0	27.2	0.0	24.1	0.0	166.3	0.0	214.8	0.0	97.8	0.0	29.1	0.0	587.7	1 147.1	**-166.8**	**-12.7%**
2010-2020	**Energy (TJ)**	**11 152**	**1 399**	**11 284**	**2 092**	**94 386**	**5 682**	**140 889**	**9 893**	**97 483**	**7 565**	**35 364**	**2 898**	**697 192**	**104 919**	**1 222 197**	**-82 874**	**-6.4%**
	Expenditure (m€)	**152**	**142**	**153**	**114**	**1 090**	**821**	**1 639**	**1 031**	**832**	**421**	**265**	**116**	**4 917**	**1 564**	**13 255**	**801**	**6.4%**
2010-2025	**Energy (TJ)**	**11 285**	**4 005**	**11 418**	**5 991**	**113 043**	**18 160**	**162 077**	**31 622**	**114 639**	**24 179**	**40 682**	**9 263**	**802 045**	**335 344**	**1 683 754**	**-263 430**	**-13.5%**
	Expenditure (m€)	**153**	**268**	**154**	**226**	**1 273**	**1 528**	**1 843**	**1 957**	**959**	**823**	**300**	**235**	**5 607**	**3 772**	**19 099**	**517**	**2.8%**
2010-2030	**Energy (TJ)**	**11 285**	**6 795**	**11 418**	**10 163**	**115 407**	**37 285**	**162 449**	**62 129**	**115 759**	**48 717**	**40 775**	**18 200**	**803 884**	**658 874**	**2 103 141**	**-518 909**	**-19.8%**
	Expenditure (m€)	**153**	**401**	**154**	**344**	**1 296**	**2 335**	**1 847**	**3 009**	**967**	**1 298**	**301**	**377**	**5 619**	**6 644**	**24 747**	**-276**	**-1.1%**

2.4.4 Comparison of BAT and LLCC scenarios with BAU

Figure 9 to Figure 26 show the evolution of total primary energy consumption and expenditure in time (between 2010 and 2030), by base case and according to the BAT and LLCC scenarios previously described.

The figures show that in the LLCC scenarios the initial larger investment due to higher product prices can be counterbalanced by the lower operating costs: for example this is the case for base case WM 2 in both LLCC and BAT scenarios. But, depending on the specific case, the investment will be either never paid back or will be paid back in a much longer period under the BAT scenarios.

As planned, the BAT scenario is therefore the scenario that enables the largest primary energy savings (both annually and over the period 2010-2025) while the LLCC scenario results in the smallest annual expenditure.

For base cases where the same improvement option corresponds to both the LLCC and the BAT option, the figures obviously show no differences between the LLCC and the BAT scenarios: this is the case for WM 4-5-6-7 and D 2-4-5-6-7. For WM 2-3, the difference between the two scenarios is relatively low. The payback period for BAT scenario of WM 3 is around 5 years longer than for LLCC scenario and the primary energy consumptions are almost similar. Base case WM 1 shows some more important differences: the reduction of energy consumption in 2030 is about twice more important for the BAT than for the LLCC; the BAT scenario never becomes economically interesting in comparison with the BAU scenario while the payback period with the LLCC scenario is approximately five years. D 1 and D 3 result in similar situations: the energy savings enabled by the BAT scenario are a bit larger than with the LLCC scenario, but it is not economically beneficial on the period considered (till 2030).

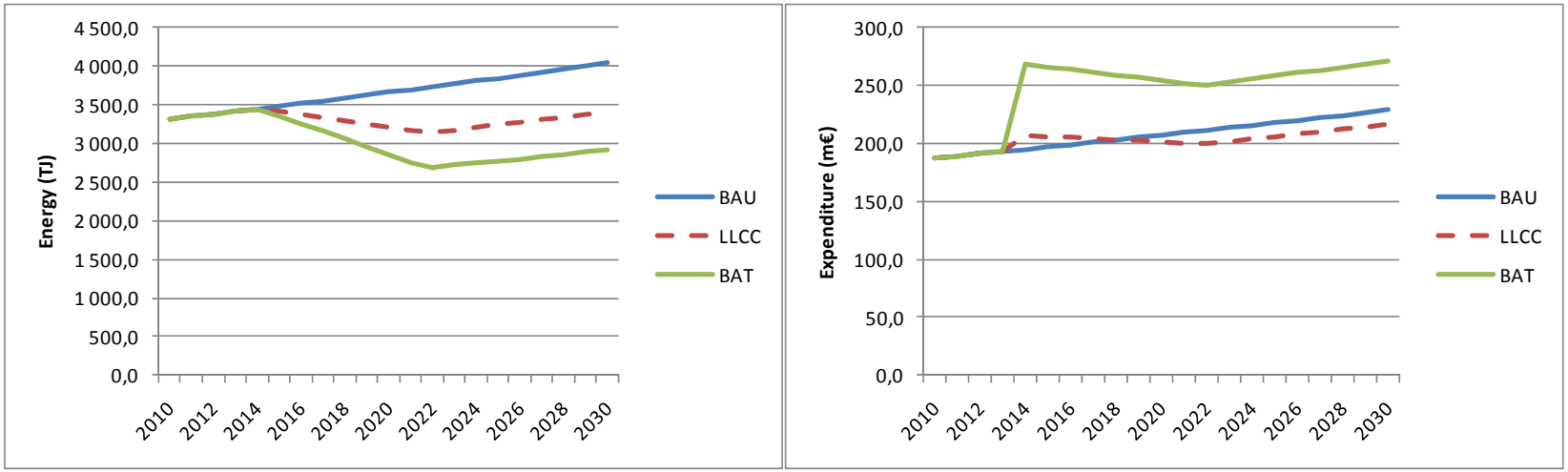


Figure 9 Primary energy consumption and expenditure by scenario, base case WM 1

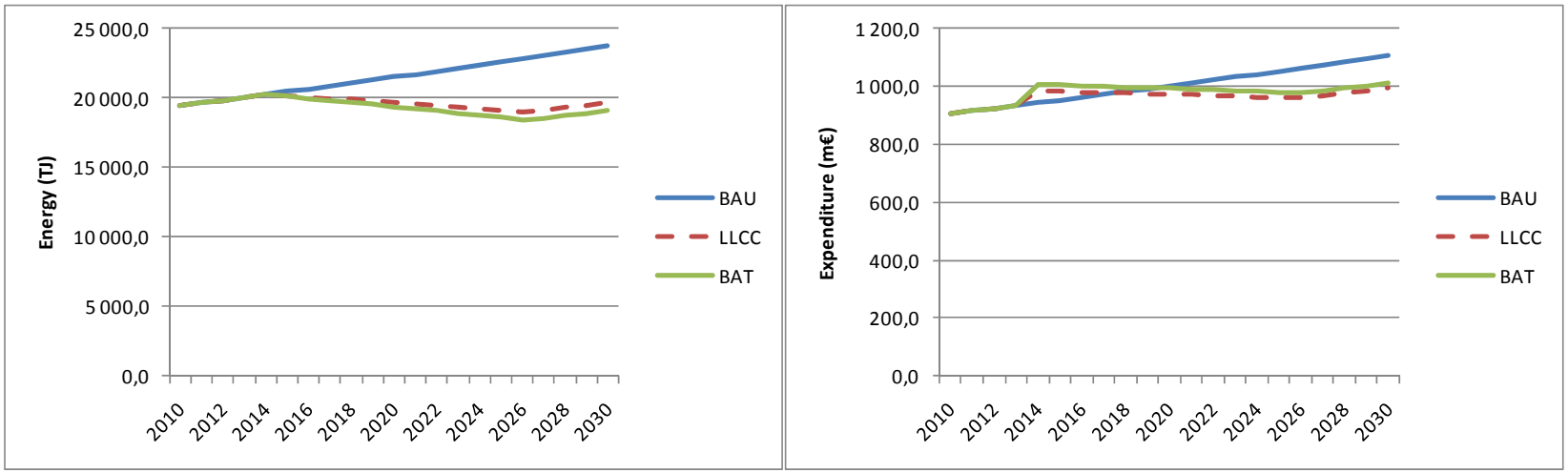


Figure 10 Primary energy consumption and expenditure by scenario, base case WM 2

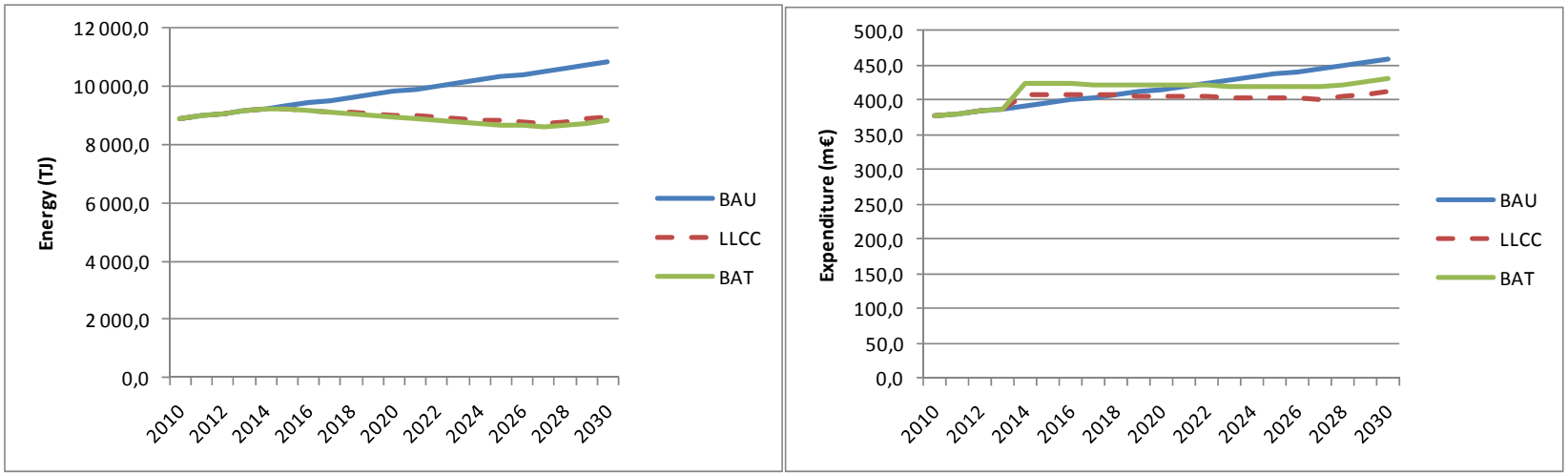


Figure 11 Primary energy consumption and expenditure by scenario, base case WM 3

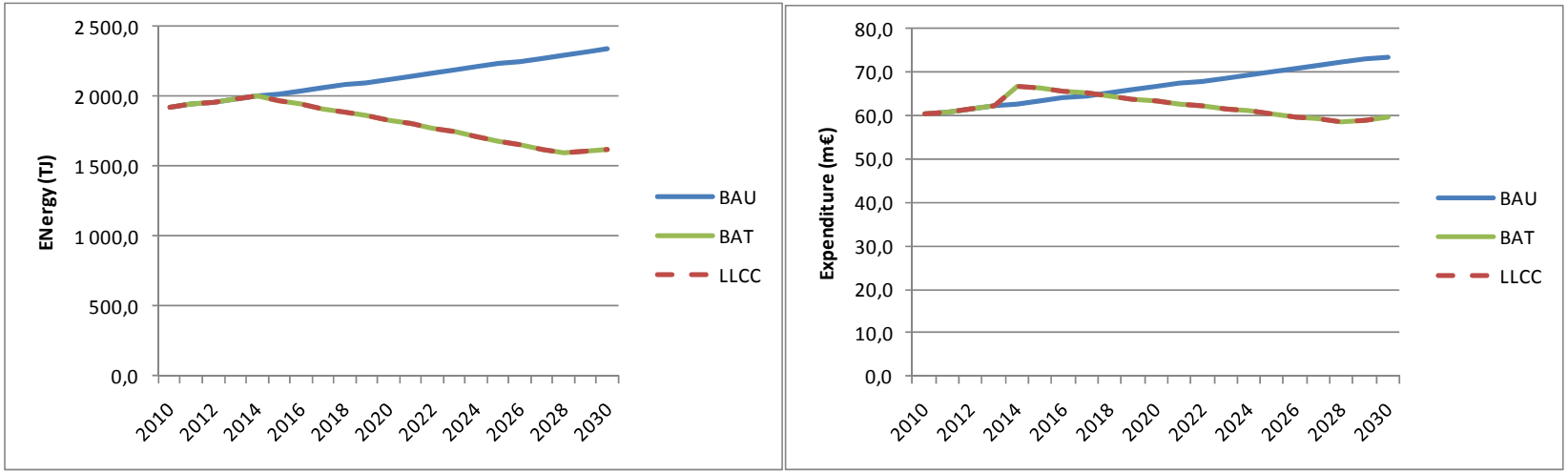


Figure 12 Primary energy consumption and expenditure by scenario, base case WM 4

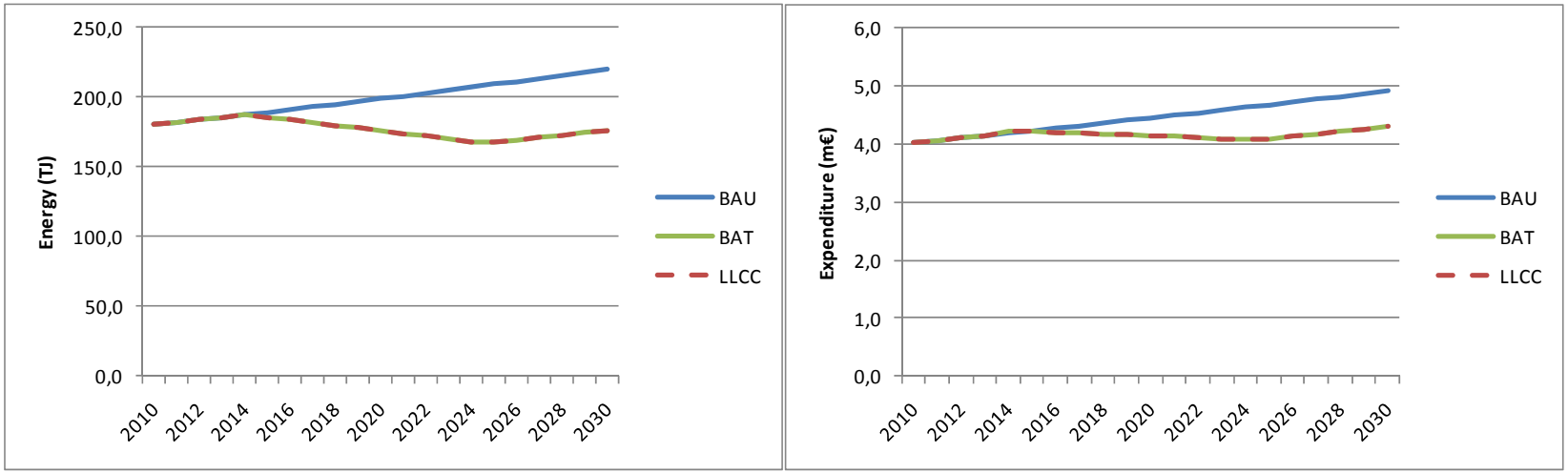


Figure 13 Primary energy consumption and expenditure by scenario, base case WM 5

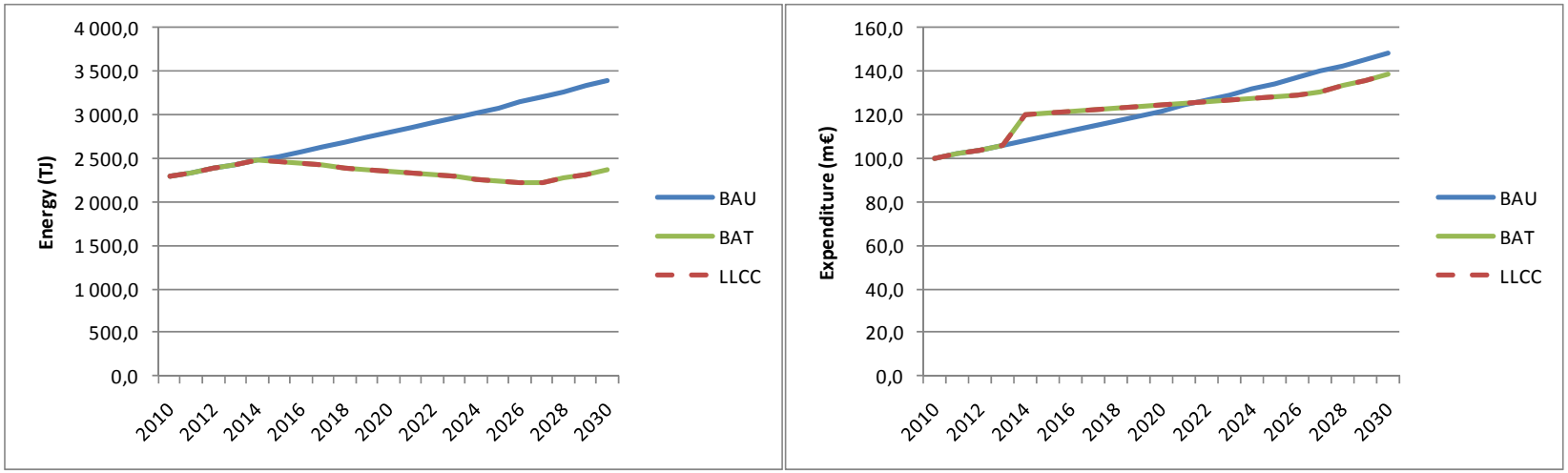


Figure 14 Primary energy consumption and expenditure by scenario, base case WM 6

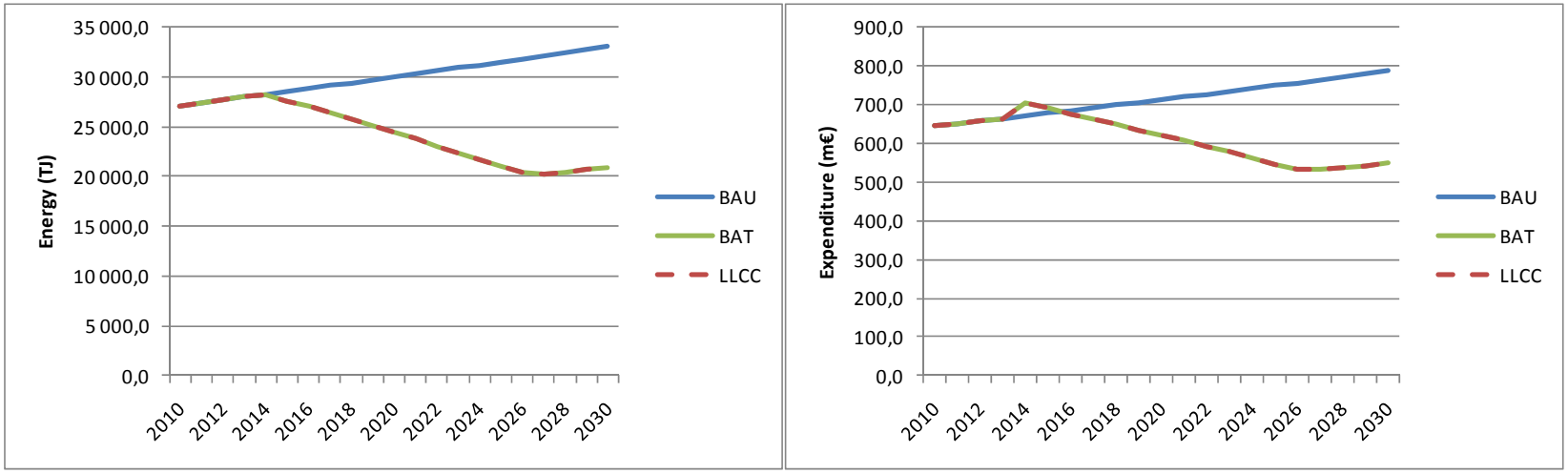


Figure 15 Primary energy consumption and expenditure by scenario, base case WM 7

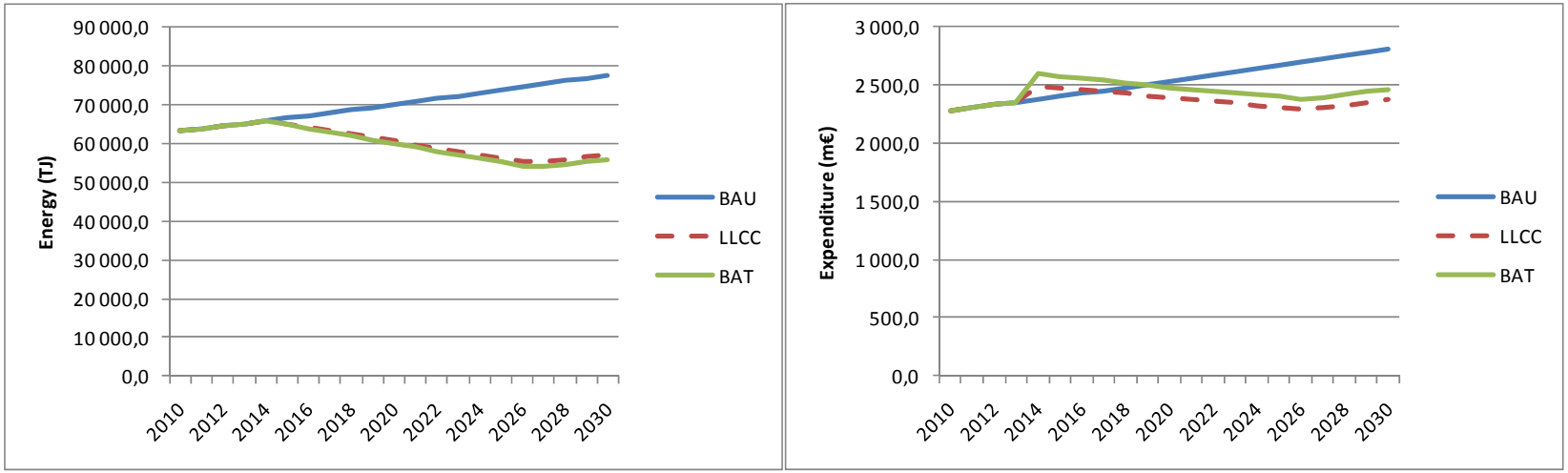


Figure 16 Primary energy consumption and expenditure by scenario, total for all professional washing machines base cases

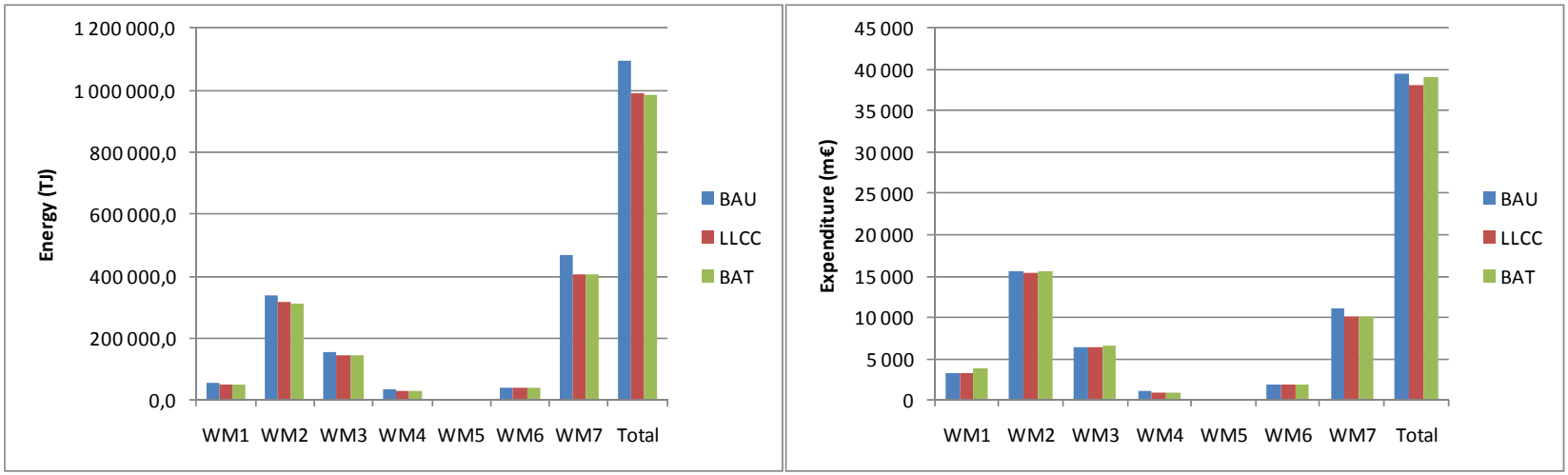


Figure 17 Primary energy consumption and expenditure by scenario, for professional washing machines over the period 2010-2025

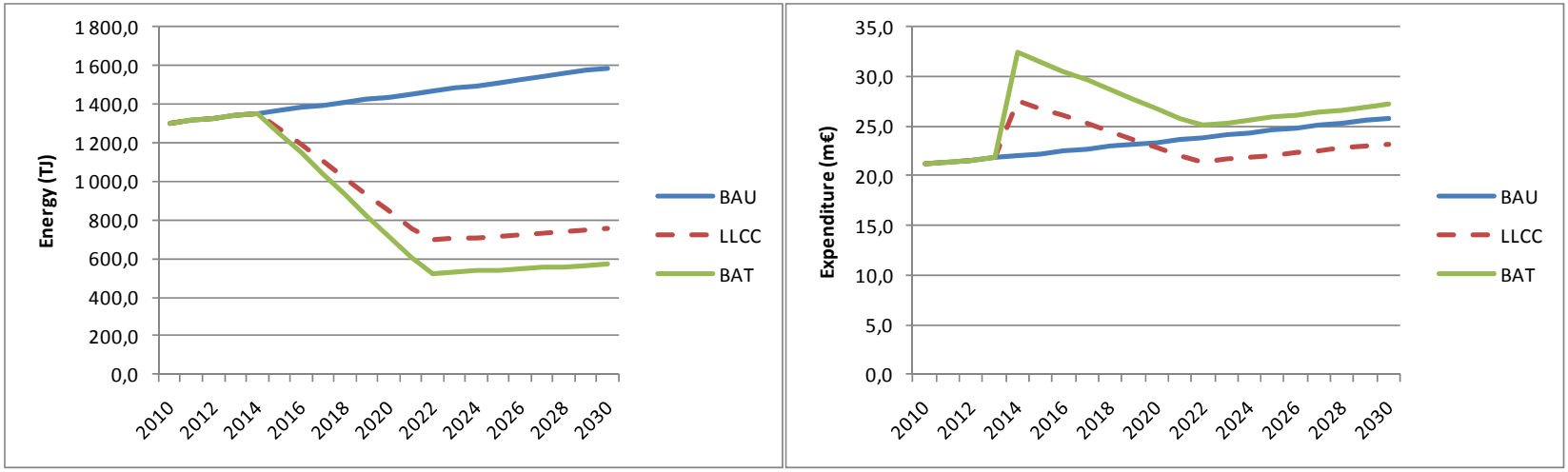


Figure 18 Primary energy consumption and expenditure by scenario, base case D 1

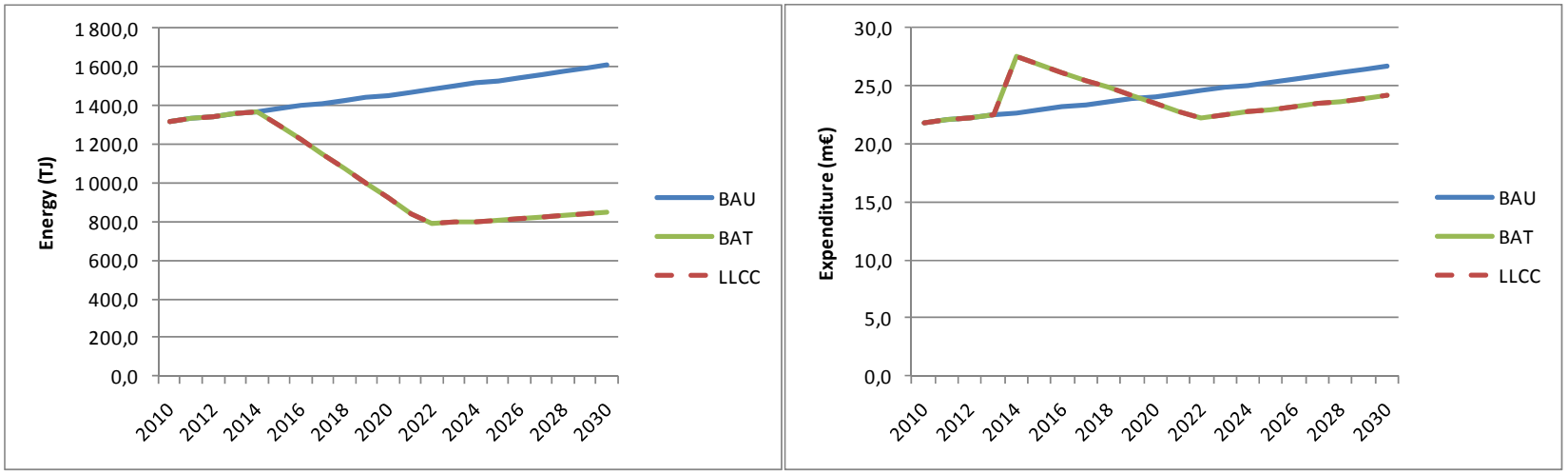


Figure 19 Primary energy consumption and expenditure by scenario, base case D 2

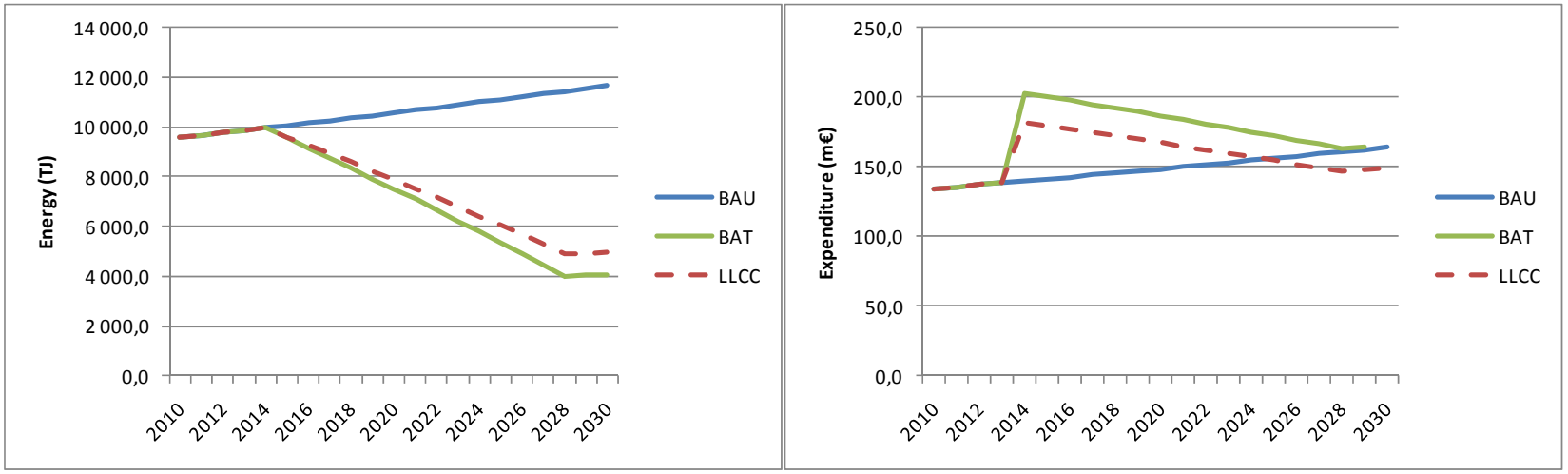


Figure 20 Primary energy consumption and expenditure by scenario, base case D 3

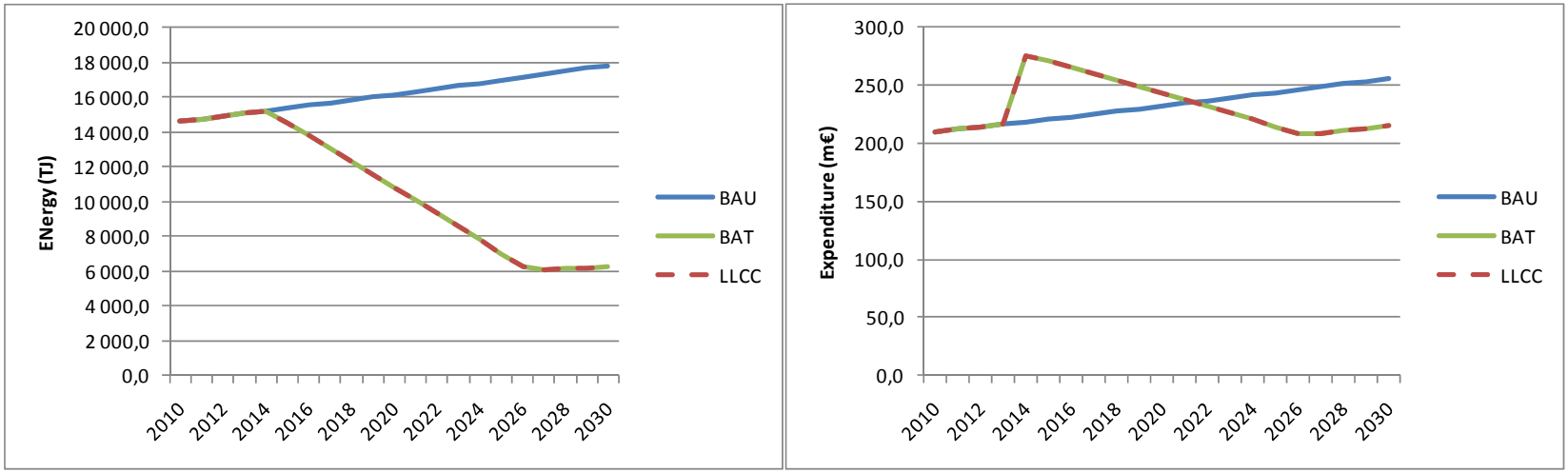


Figure 21 Primary energy consumption and expenditure by scenario, base case D 4

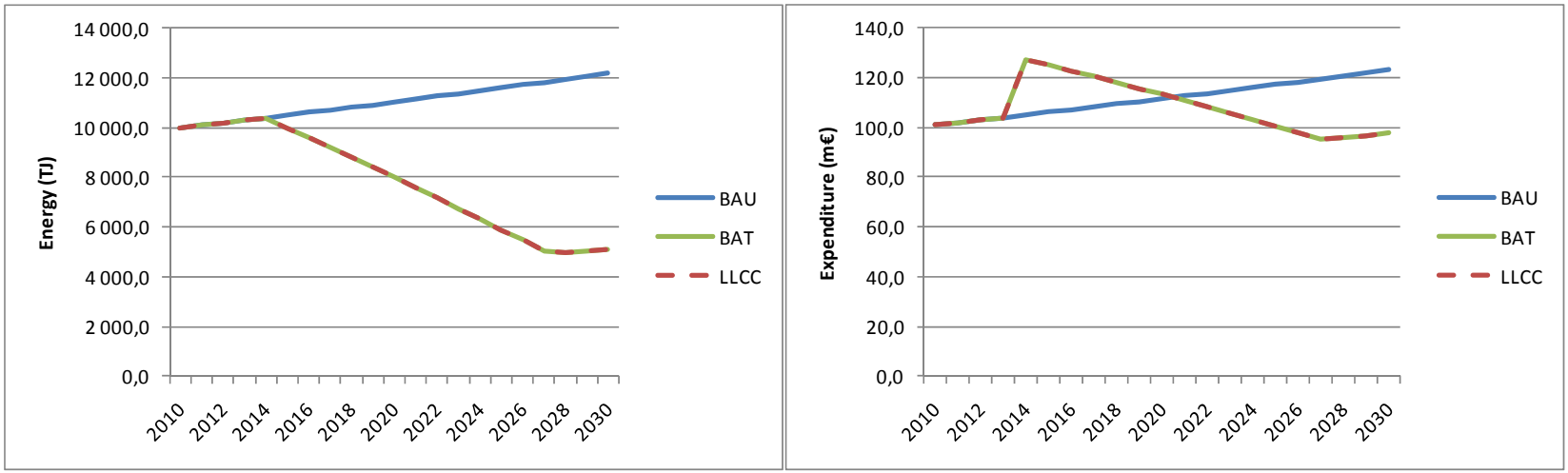


Figure 22 Primary energy consumption and expenditure by scenario, base case D 5

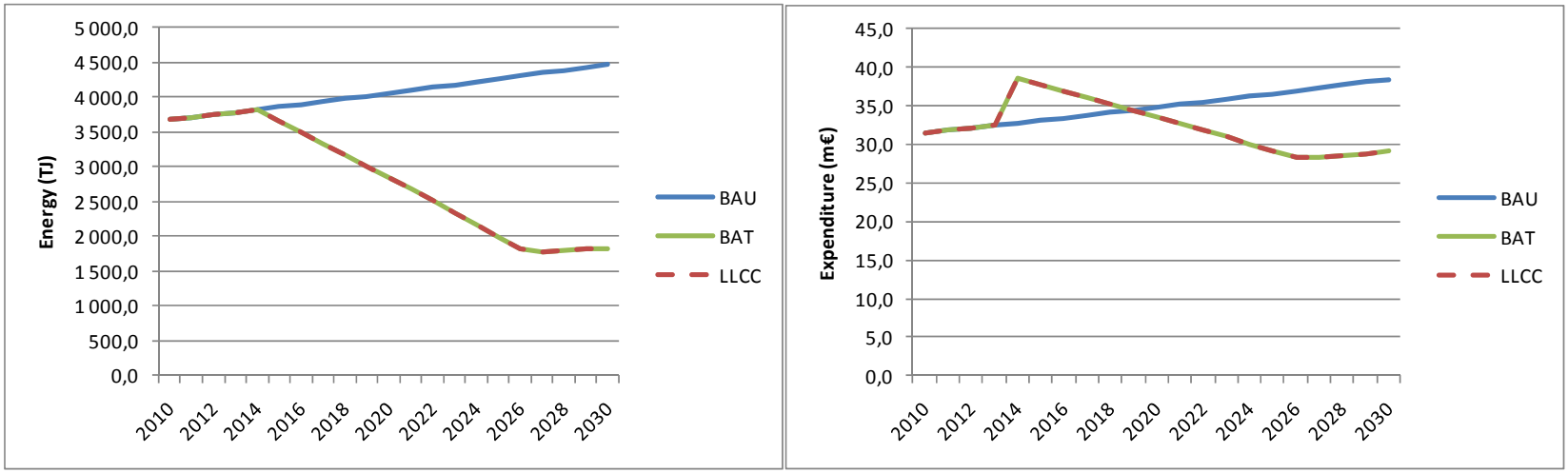


Figure 23 Primary energy consumption and expenditure by scenario, base case D 6

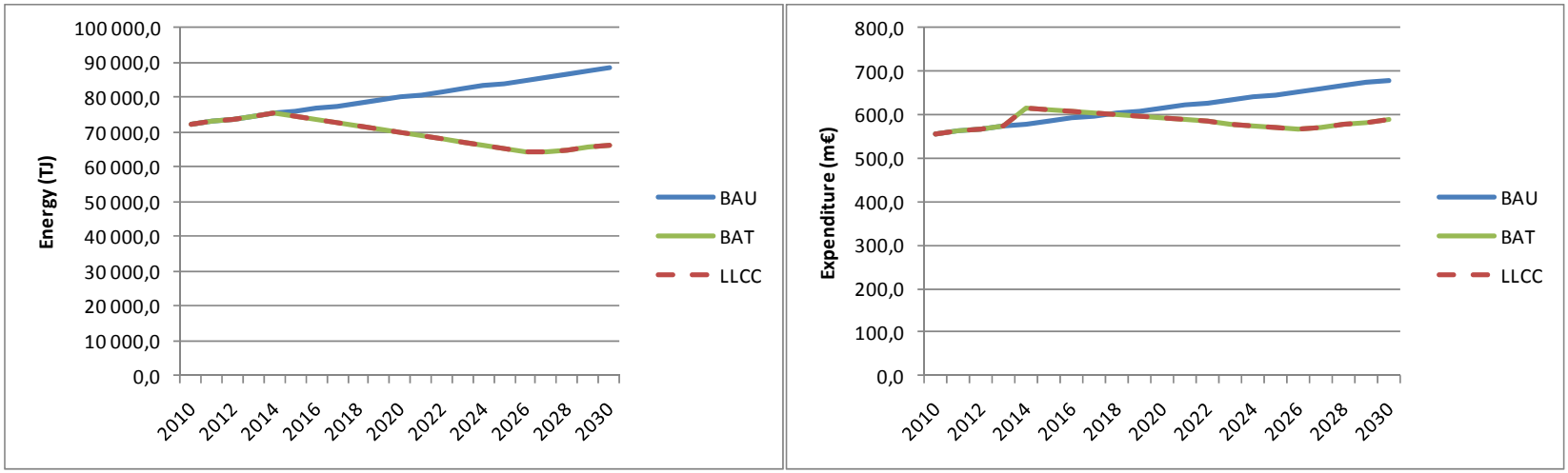


Figure 24 Primary energy consumption and expenditure by scenario, base case D 7

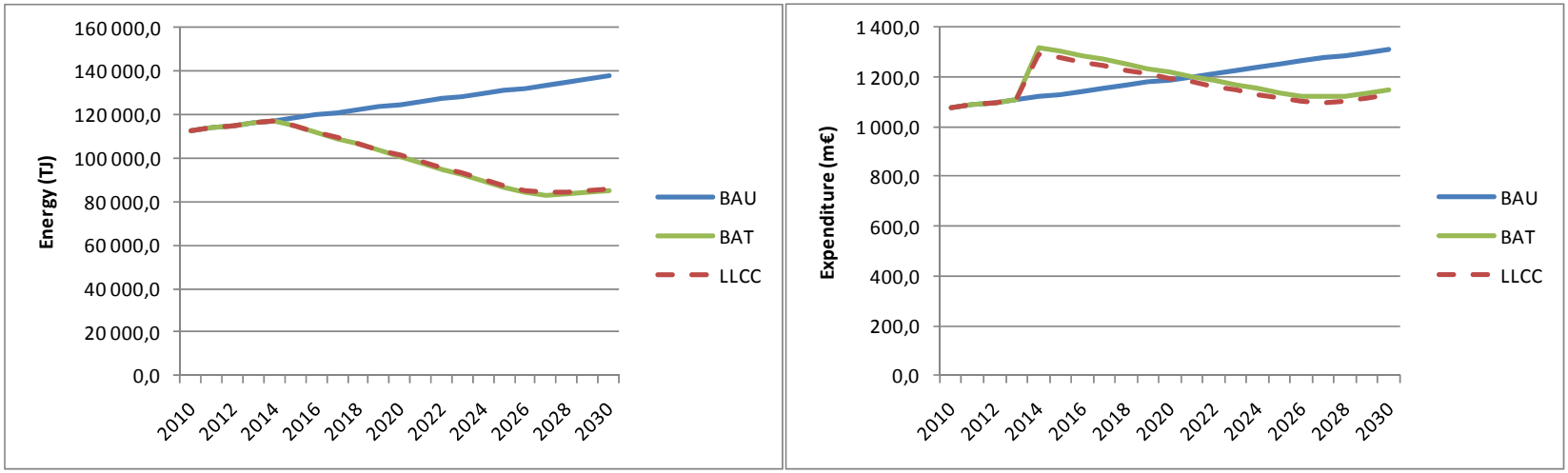


Figure 25 Primary energy consumption and expenditure by scenario, total for all dryers base cases

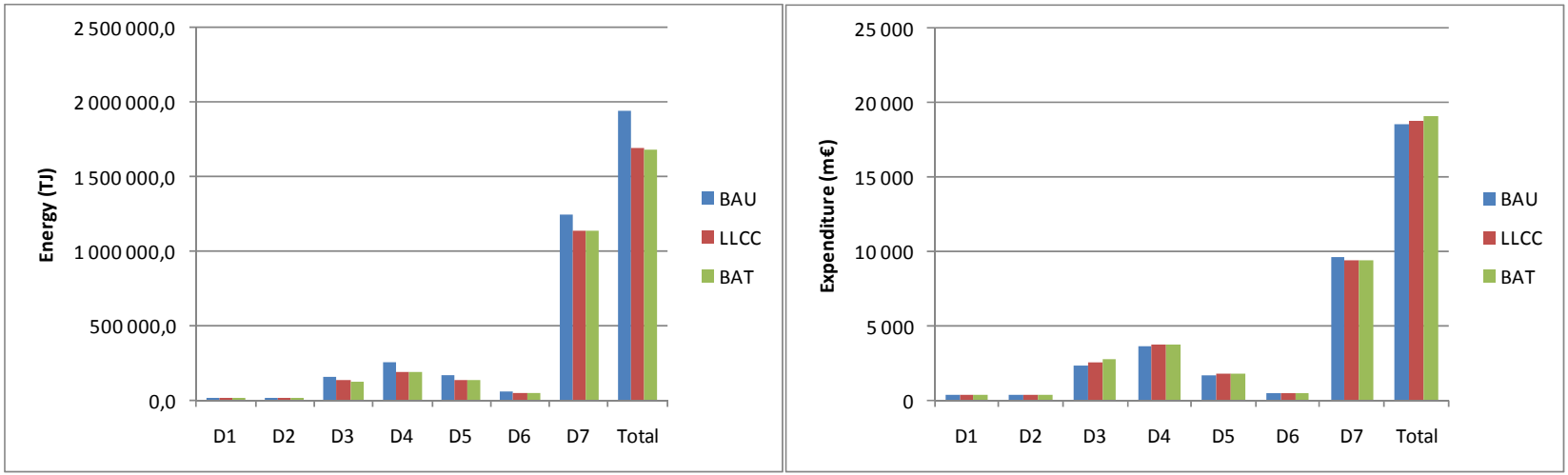


Figure 26 Primary energy consumption and expenditure by scenario, for dryers, over the period 2010-2025

3 Impact analysis

This section presents the impact analysis. It consists of an estimate of the impact on consumers (purchasing power, societal costs) and industry (employment, profitability, competitiveness, investment level, etc.), explicitly describing and taking into account the typical design cycle (platform change) in this product sector.

3.1 Impacts on manufacturers and competition

All the technologies described in this study and considered as improvement options in the scenarios are already available on the market today. As a result, the possible implementation of eco-design requirements dealing with relevant targets should not have a major negative impact on manufacturers, especially because the professional laundry sector is very competitive and has been continuously improving product performance (See Task 2).

Regarding the definition of a timeline to implement the requirements, it should take into account the time necessary to adapt production lines. This redesign time is very variable depending on the type of change to be achieved: it has been estimated that between 6 and 36 months are needed for a change of a single part of the appliance (see Task 2). The full redesign cycle may take even longer. Assuming the development of the required standards (see Section 2.2.1) is finished by 2012/2013, Tier 1 has thus been set at 2014 for the eco-design requirements.

Manufacturers of professional laundry appliances are mostly large international companies. If eco-design requirements were set, all manufacturers should be able to keep up with the market requirements, using common technology or their own technological developments. Appropriate and progressive targets should be set, both in terms of performance and timeline.

EU manufacturers claim to produce amongst the most efficient professional laundry appliances manufactured worldwide. Therefore, the implementation of eco-design requirements is not expected to hamper the economic development of large EU manufacturers, to the benefit of extra-EU competitors.

3.2 Monetary impacts

The scenario analysis partly addresses monetary impacts. The LLCC and BAT scenarios reduce the monetary expenditure for many base cases (see Section 2.4). Table 14 and Table 15 show the payback periods of the improvement options by base case, as presented in Task 7.

Table 14 Payback periods (in years) of the improvement options for professional washing machines

Base case	Life time considered in previous analysis	M 1.1 Increased motor efficiency	M 1.2 Heat ex-changer	M 1.3 Water recovery	M 1.4 Load control	M 1.5 Further control systems	M 1.7 Drum construc-tion	BA product
WM 1	8	>20	14	15	4	4	17	17
WM 2	12	>20	11	11	3	1	4	5
WM 3	14	>20	14	12	4	1	5	7
WM 4	15	>20	>20	4	3	4	-	6
WM 5	11	>20	-	-	1	1	-	-
WM 6	14	>20	>20	7	5	9	-	15
WM 7	13	>20	1	-	-	-	-	1

Table 15 Payback periods (in years) of the improvement options for professional dryers

Base case	Life time considered In previous analysis	M 2.1 Increased motor effi-ciency	M 2.2 Heat pump	M 2.3 Heat recovery from exhaust air	M 2.4 Im-proved air flow system	M 2.5 Load control	M 2.6 Residual Moisture Control	M 2.7 Im-proved insu-lation	BA product
D 1	8	6	6	-	3	4	4	4	9
D 2	8	7	5	15	4	4	4	4	9
D 3	15	-	10	>20	3	-	-	5	14
D 4	13	4	8	15	4	7	3	4	7
D 5	14	4	6	13	3	6	4	4	6
D 6	13	7	5	>20	6	8	12	20	5
D 7	13	15	-	3	-	-	-	7	4

The possible implementation of eco-design requirements may require additional capital investment from manufacturers to adapt manufacturing techniques to efficiently produce the more efficient products (e.g. changing production lines before their “end-of-life”). It is, however, not estimated that these investments would represent a significant burden for manufacturers as they are used to continuously improving the efficiency of their appliances. Investment costs may also be partly counterbalanced by slightly higher selling prices of more efficient machines. On the other hand, economies of scale may enable manufacturers to have a larger margin and/or drop prices when selling efficient appliances.

On the consumers’ side, purchasing more efficient professional washing machines and dryers may represent a larger initial investment but if eco-design requirements are set based on LCC calculations, the investment becomes beneficial in the long term. Owners of smaller appliances (e.g. used in AHL or Laundromats) are usually more reluctant to long payback times, compared to owners of large capacity appliances.

3.3 Impacts on consumer use

For the improvement options presented, the functional unit and the service given by the improved product remains the same as the base case (this is a necessary condition to make a relevant comparative life cycle assessment) (see Task 6): this is a crucial condition to assess their implementation in professional laundry appliances. Thus, there should be no trade-off in terms of functionality (e.g. increase of noise), for the increase of energy, water or detergent efficiency. In particular, the measure of the cleaning and drying performance should appear in the measurement standards to be developed (see Section 2.2.1).

3.4 Impacts on innovation and development

The Best Not yet Available Technology and current research priorities in the sector were not very thoroughly described throughout this study, because of a major lack of data. Such information is very sensitive and manufacturers were obviously not willing to share. In addition, little or no independent research has been carried out. The possible implementation of minimum eco-design requirements can be seen as an opportunity for manufacturers to look for innovative and efficient technological solutions in order to decrease costs. Again, given the competitiveness of the sector, it seems that following the current trend regarding research and development is feasible for the manufacturers and should enable them to meet proposed requirements.

3.5 Social impacts

Most of the EU manufacturers have their production plants within the EU. If eco-design requirements were set, they should not have a detrimental impact on the number of jobs or the well-being of the EU manufacturers' employees. Companies have experience in carrying out continuous production transitions. Regarding the security of supply, the improvement options presented do not require any specific material that might be difficult to obtain in the EU so that the supply chain could be kept unchanged, without damaging EU industries.

4 Sensitivity analysis of the main parameters

The sensitivity analysis checks the robustness of the overall outcomes. It should cover the main parameters as described in Annex II of the EuP directive (such as the price of energy, the cost of raw materials or production costs, discount rates, including, where appropriate, external environmental costs, such as avoided greenhouse gas emissions), to check if there are significant changes and if the overall conclusions are reliable and robust.

The parameters that were considered the most relevant for this sensitivity analysis (because of their importance and/or uncertainty) in the case of professional laundry appliances are listed below:

- Energy, water and detergent consumption;
- Intensity of use of the machines (kg of laundry per year);
- Life time;
- Energy (electricity and gas), water and detergent prices;
- Product price;
- Discount rate.

Parameters such as resource and consumables prices, product purchase prices and discount rate have a direct influence on the LCC calculations of the base cases and their improvement options (but not on the environmental impacts of the products) while others (resource and consumables consumption, life time) will influence both the environmental impacts of the products and the LCC through operating costs.

The influence of the single parameters on the results will be first studied separately and the analysis of combined changes in several parameters at the same time will be made in Section 4.7.

4.1 Resource and consumables consumption

4.1.1 Assumptions

In Task 4, average energy, water and detergent consumption data were determined for the base cases. Given the uncertainty that remains regarding the definition of “average market” products, the sensitivity analysis will consider an error margin of 20% on the given values, both for minimum and maximum values. The tested values are therefore presented in Table 16, Table 17 and Table 18.

Table 16 Energy consumption range for the sensitivity analysis

Base Case	Base total energy consumption (kWh per year)	Min	Max
WM 1 - Semi-professional washer extractor	1 332	1 066	1 598
WM 2 - Professional washing extractor (<15 kg)	3 026	2 421	3 631
WM 3 - Professional washing extractor (15-40 kg)	10 973	8 778	13 168
WM 4 - Professional washing extractor (>40 kg)	81 648	65 318	97 978
WM 5 - Professional washer dryer	7 400	5 920	8 880
WM 6 - Professional barrier washer	26 461	21 169	31 753
WM 7 - Washing tunnel machine	1 606 500	1 285 200	1 927 800
D 1 - Semi-professional dryer, condenser	4 877	3 902	5 852
D 2 - Semi-professional dryer, air vented	4 552	3 642	5 462
D 3 - Professional cabinet dryer	5 924	4 739	7 109
D 4 - Professional air tumble dryer (<15 kg)	9 936	7 949	11 923
D 5 - Professional air tumble dryer (15–40 kg)	32 805	26 244	39 366
D 6 - Professional air tumble dryer (>40 kg)	171 360	137 088	205 632
D 7 - Industrial pass-through (transfer) tumble dryer	979 200	783 360	1 175 040

Table 17 Water consumption range for the sensitivity analysis

Base case	Base water consumption (m^3 per year)	Min	Max
WM 1 - Semi-professional washer extractor	85	68	102
WM 2 - Professional washing extractor (<15 kg)	233	186	280
WM 3 - Professional washing extractor (15-40 kg)	741	593	889
WM 4 - Professional washing extractor (>40 kg)	3 266	2 613	3 919
WM 5 - Professional washer dryer	100	80	120
WM 6 - Professional barrier washer	1 081	865	1 297
WM 7 - Washing tunnel machine	27 540	22 032	33 048

Table 18 Detergent consumption range for the sensitivity analysis

Base case	Base detergent consumption (kg per year)	Min	Max
WM 1 - Semi-professional washer extractor	161	129	193
WM 2 - Professional washing extractor (<15 kg)	330	264	396
WM 3 - Professional washing extractor (15-40 kg)	798	638	958
WM 4 - Professional washing extractor (>40 kg)	4 199	3 359	5 039
WM 5 - Professional washer dryer	140	112	168
WM 6 - Professional barrier washer	1 216	973	1 459
WM 7 - Washing tunnel machine	41 310	33 048	49 572

4.1.2 Results

Figure 27 to Figure 82 show the influence of the variation of the energy consumption per cycle on the total energy consumption over the life cycle and the life cycle costs of the different base cases and associated improvement options. For washing machines, the influence of the water consumption on total energy consumption and life cycle costs, and the influence of the detergent consumption on eutrophisation and life cycle costs are also presented.

The option leading to the lowest energy consumption, eutrophication or life cycle costs always remain the same for a given base case, whatever the consumption values considered (base, min or max). However, a few relative changes in the rankings of options happen, for instance:

- For base case D 1, the LCC of the BA product becomes lower than the LCC of the base case with the upper values;
- For base case D 3, the LCC of the BA product becomes higher than the LCC of the base case with the lower values;
- For base case D 4, the LCC of the M 2.3 option becomes lower than the LCC of the base case with the upper values.

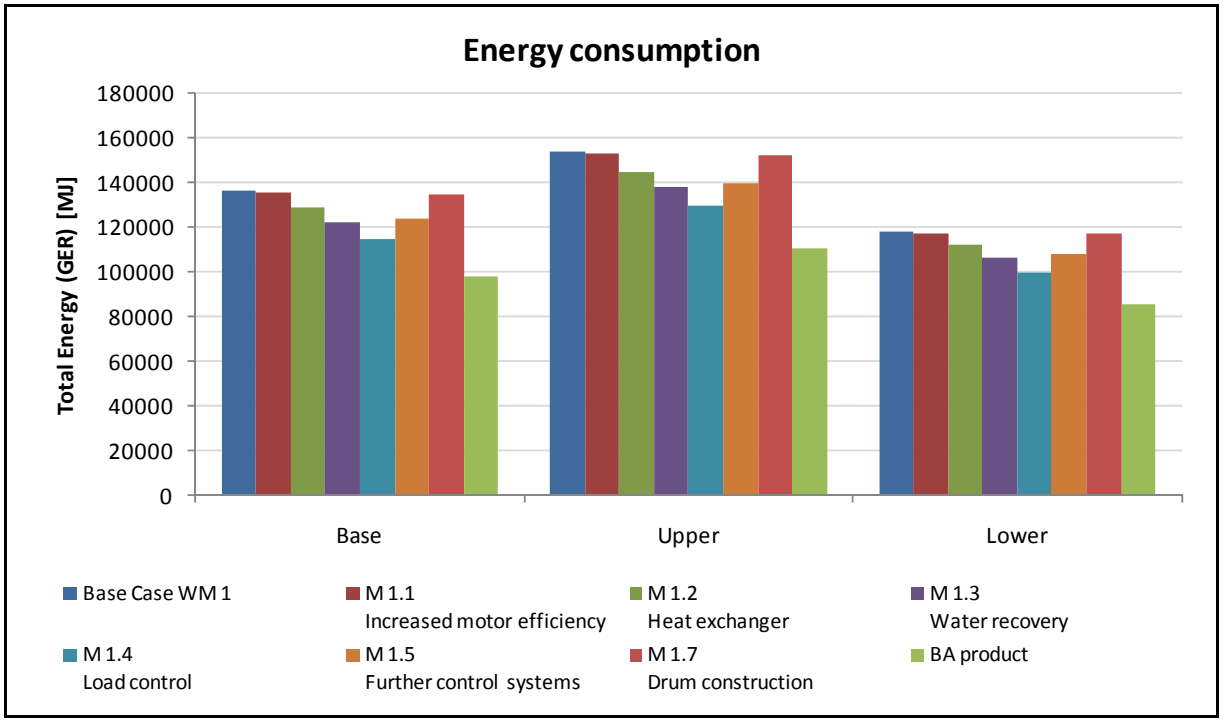


Figure 27 Base case WM 1 and improvement options – impact of energy consumption on total energy over life time by product.

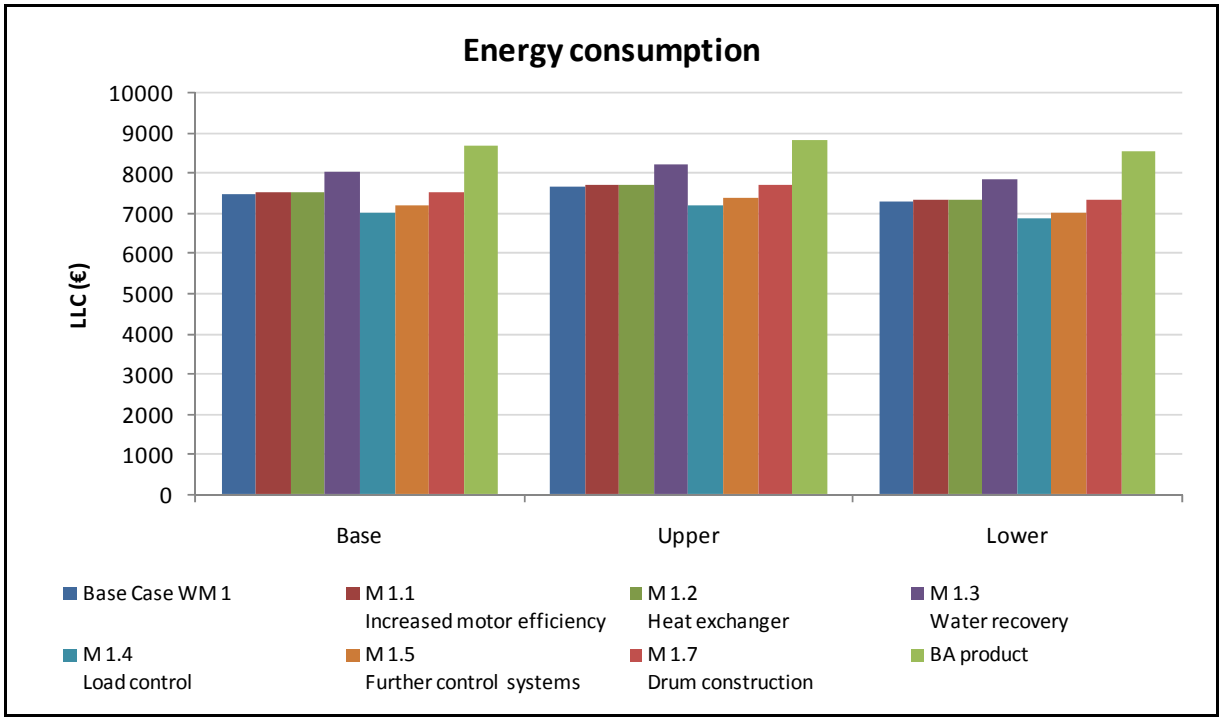


Figure 28 Base case WM 1 and improvement options – impact of energy consumption on LCC by product

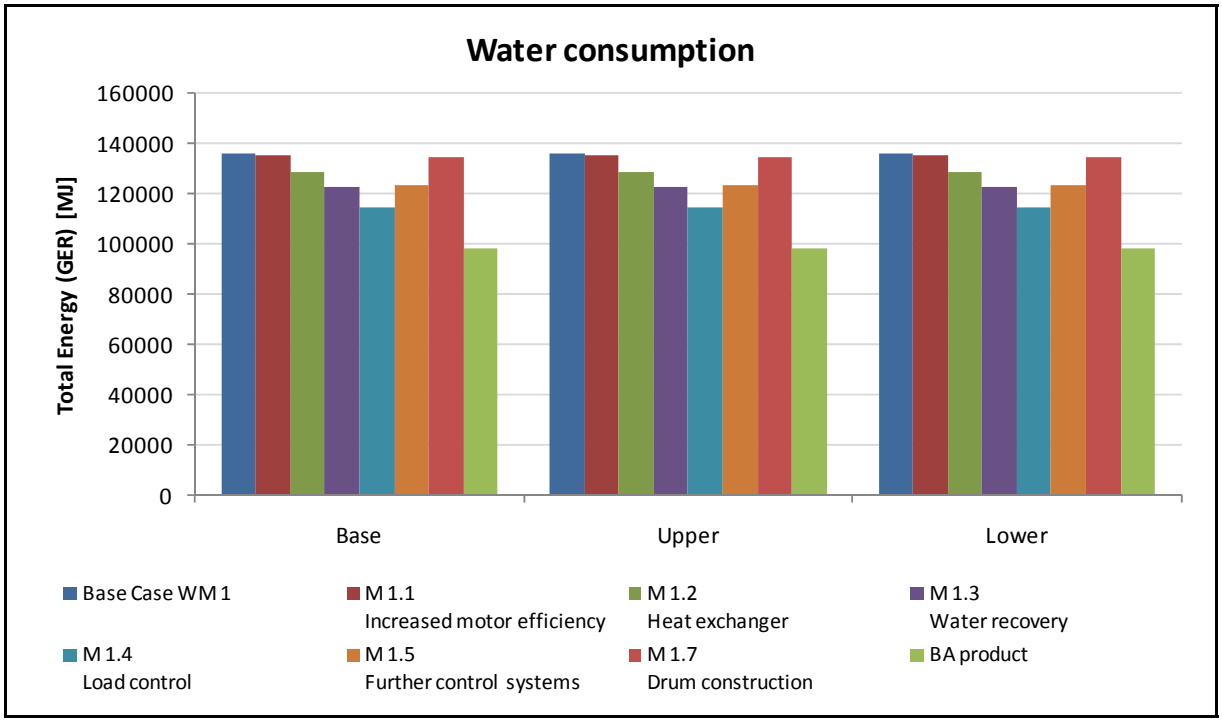


Figure 29 Base case WM 1 and improvement options – impact of water consumption on total energy over life time by product.

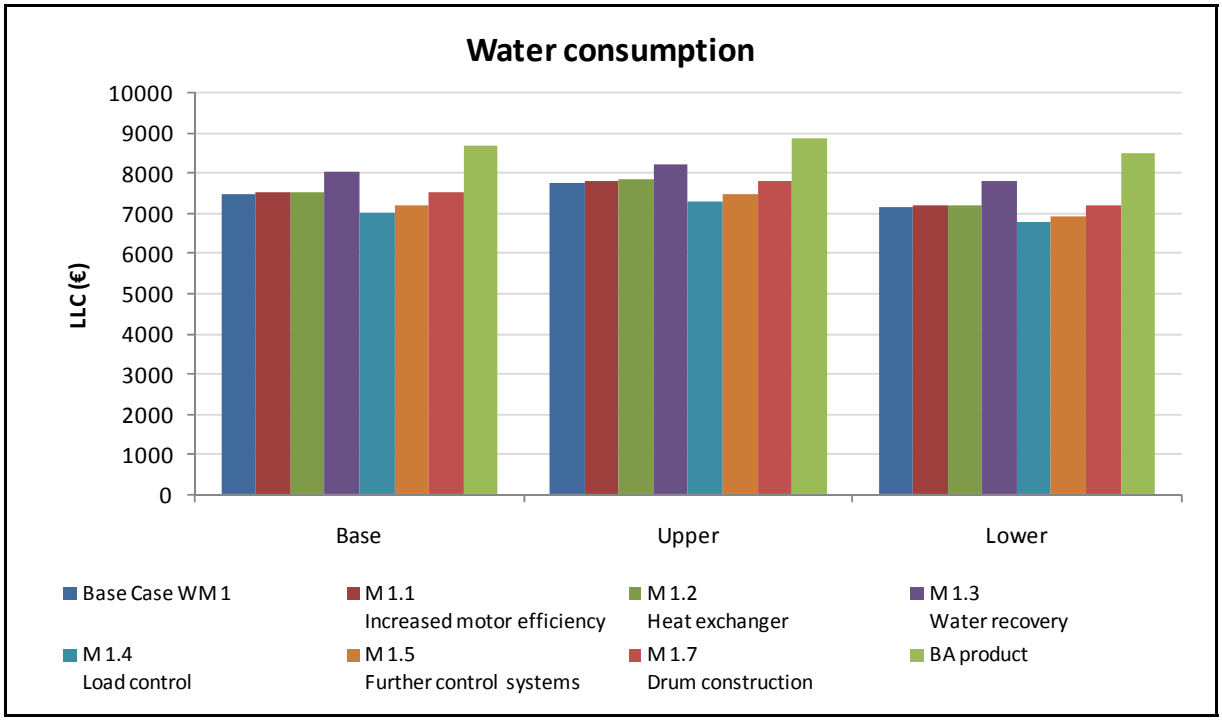


Figure 30 Base case WM 1 and improvement options – impact of water consumption on LCC by product

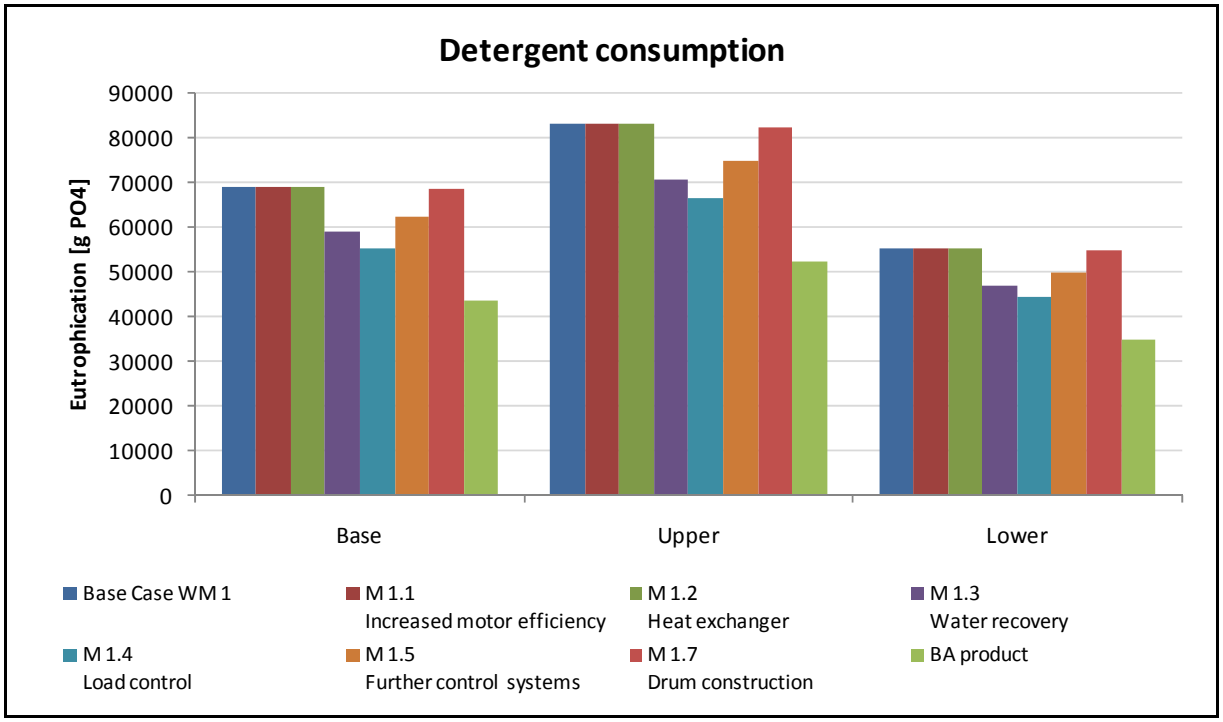


Figure 31 Base case WM 1 and improvement options – impact of detergent consumption on eutrophication over life time by product

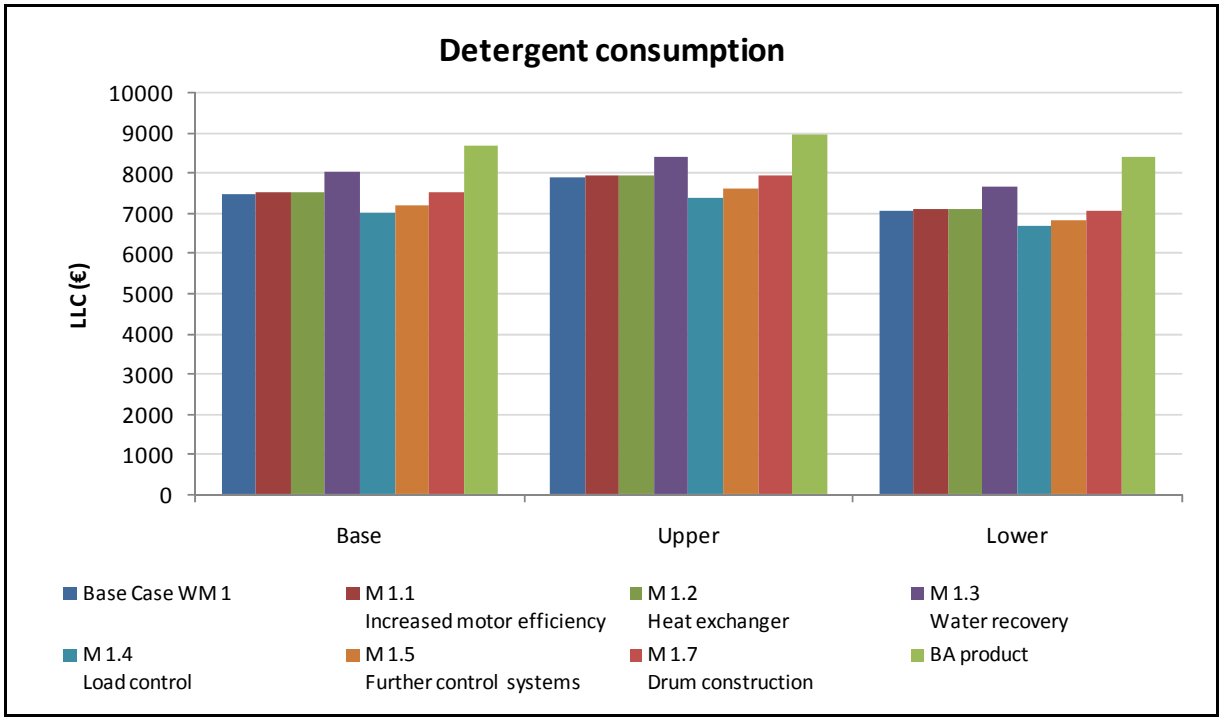


Figure 32 Base case WM 1 and improvement options – impact of detergent consumption on LCC by product

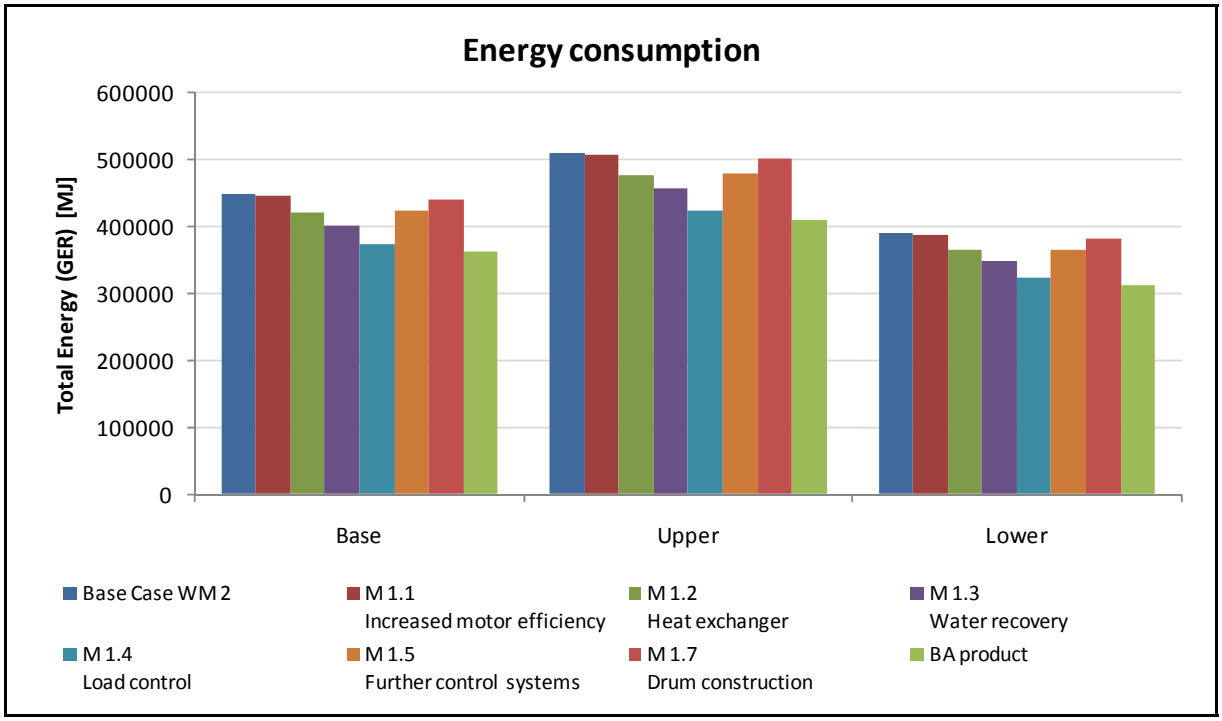


Figure 33 Base case WM 2 and improvement options – impact of energy consumption on total energy over life time by product.

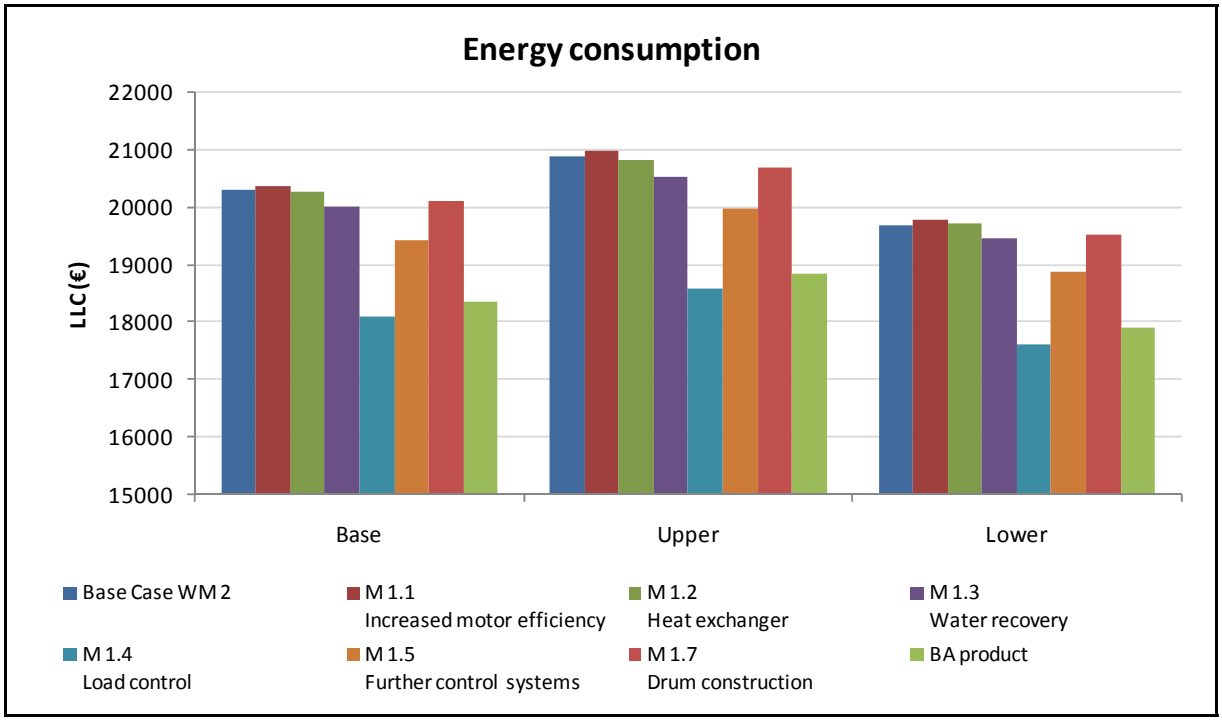


Figure 34 Base case WM 2 and improvement options – impact of energy consumption on LCC by product

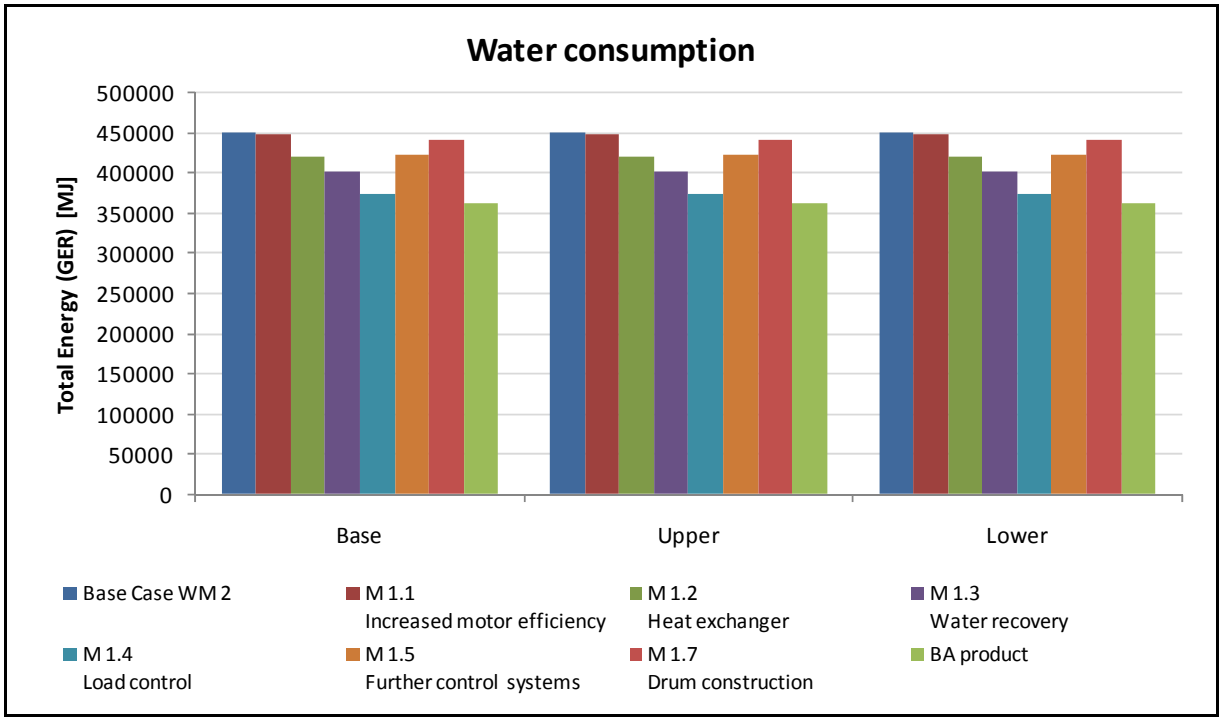


Figure 35 Base case WM 2 and improvement options – impact of water consumption on total energy over life time by product

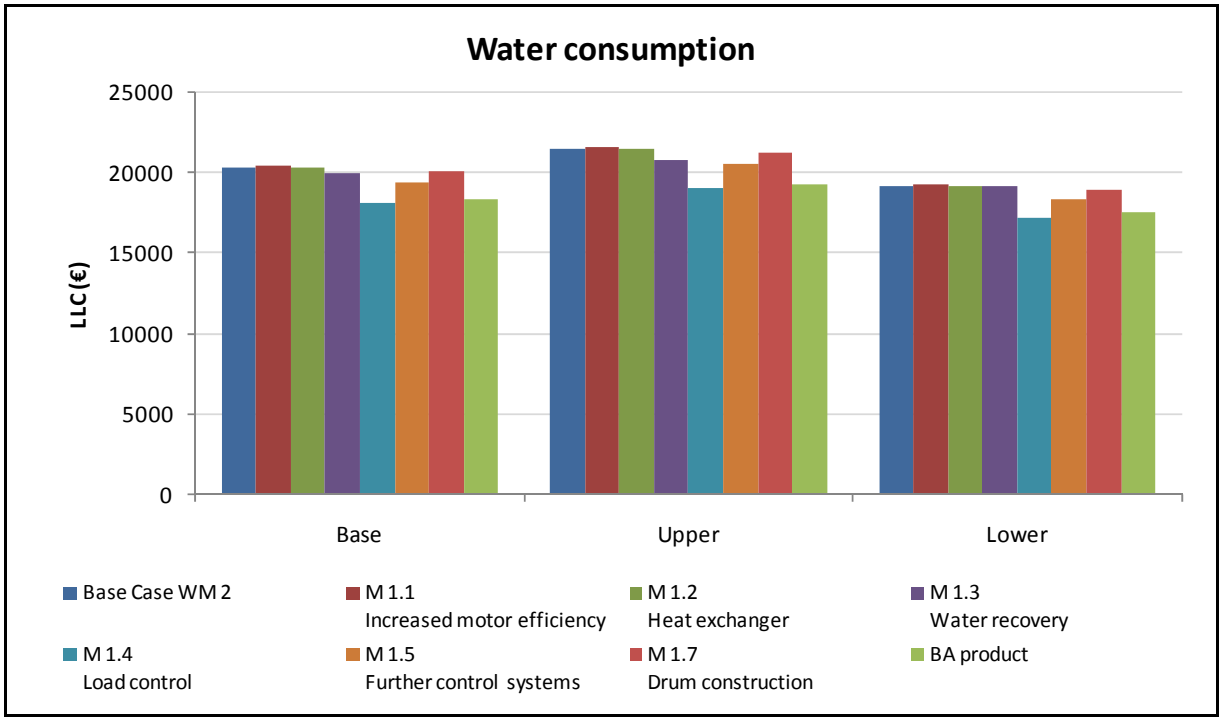


Figure 36 Base case WM 2 and improvement options – impact of water consumption on LCC by product

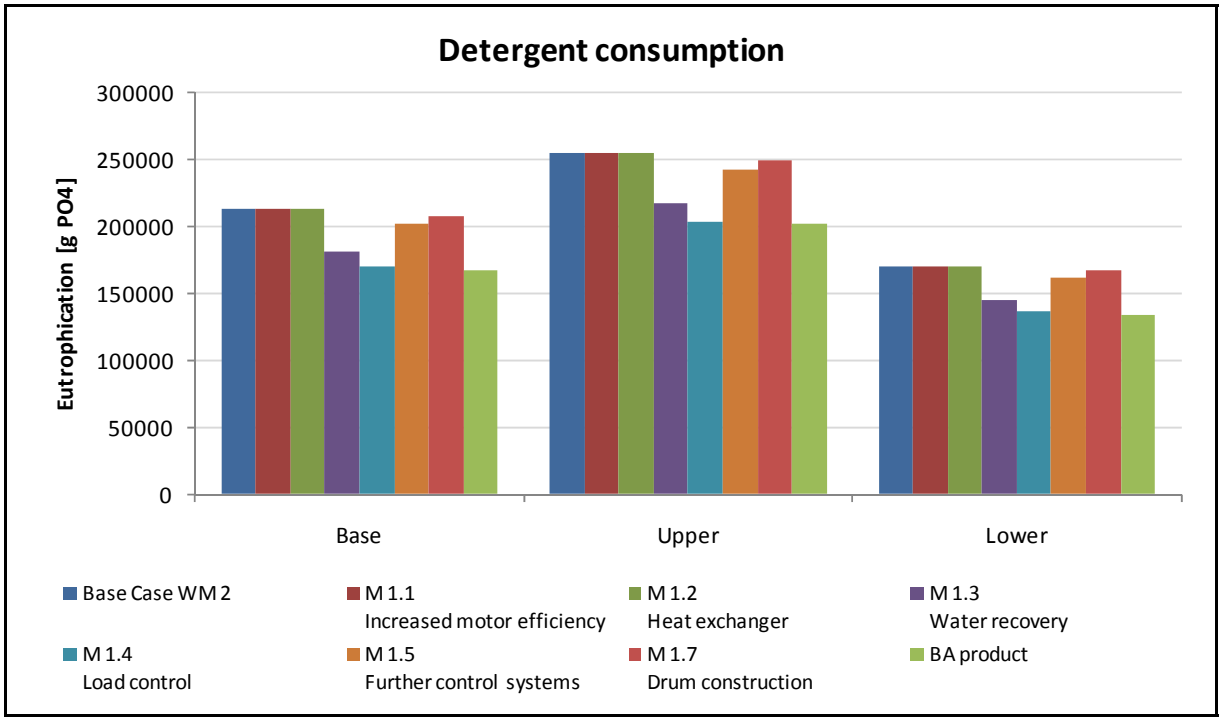


Figure 37 Base case WM 2 and improvement options – impact of detergent consumption on eutrophication over life time by product

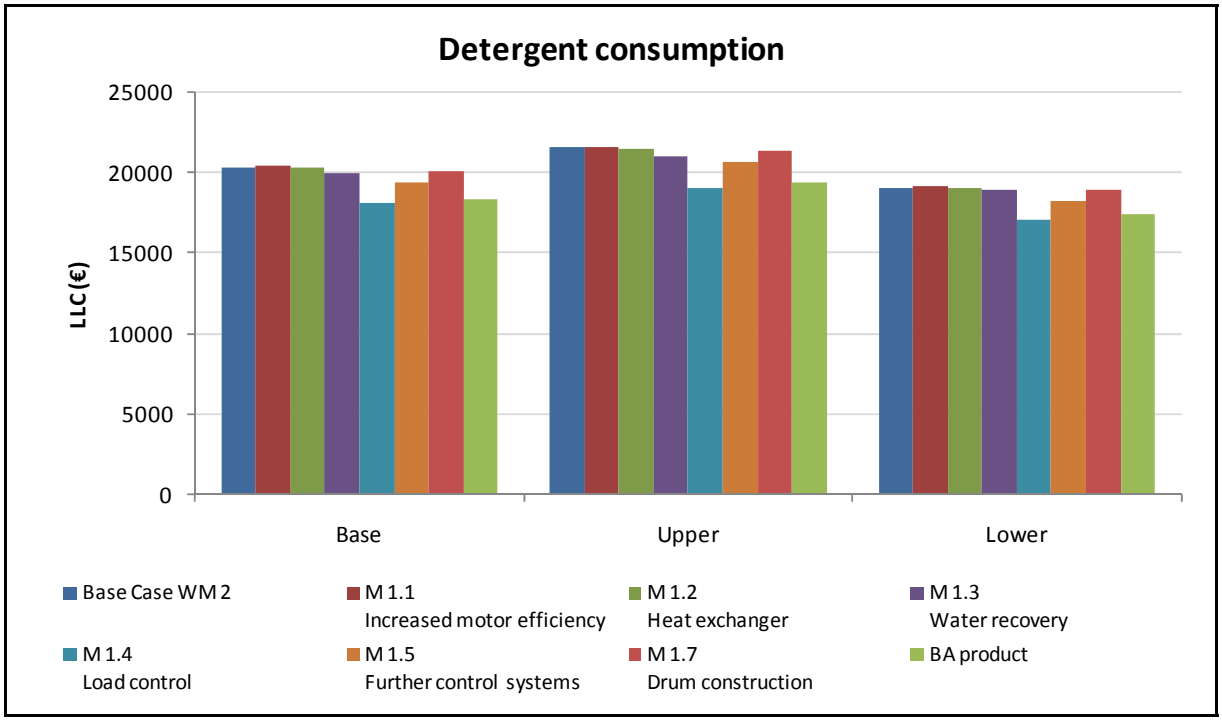


Figure 38 Base case WM 2 and improvement options – impact of detergent consumption on LCC by product

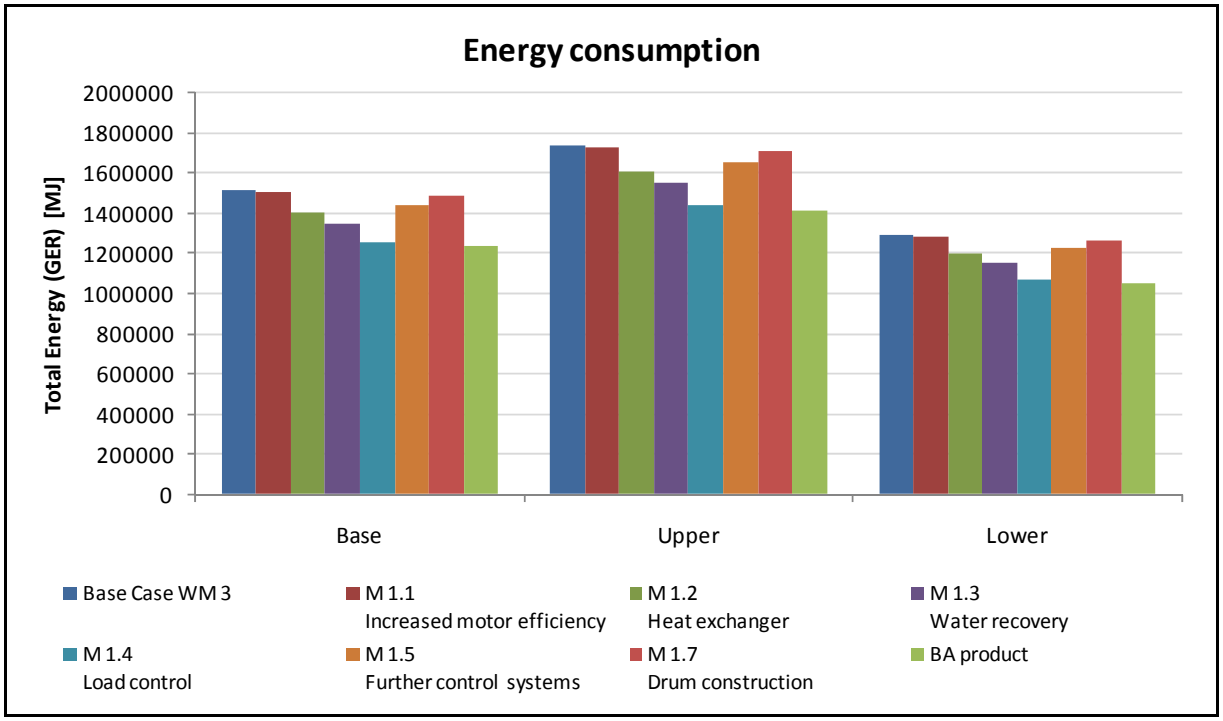


Figure 39 Base case WM 3 and improvement options – impact of energy consumption on total energy over life time by product

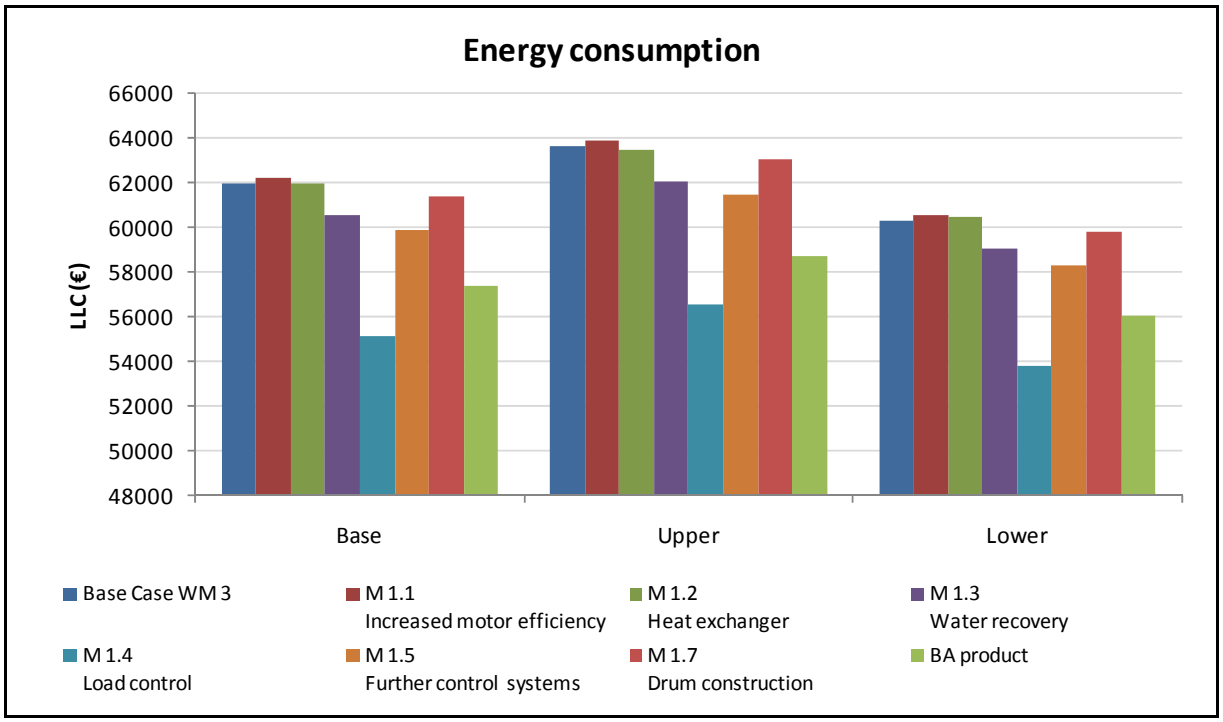


Figure 40 Base case WM 3 and improvement options – impact of energy consumption on LCC by product

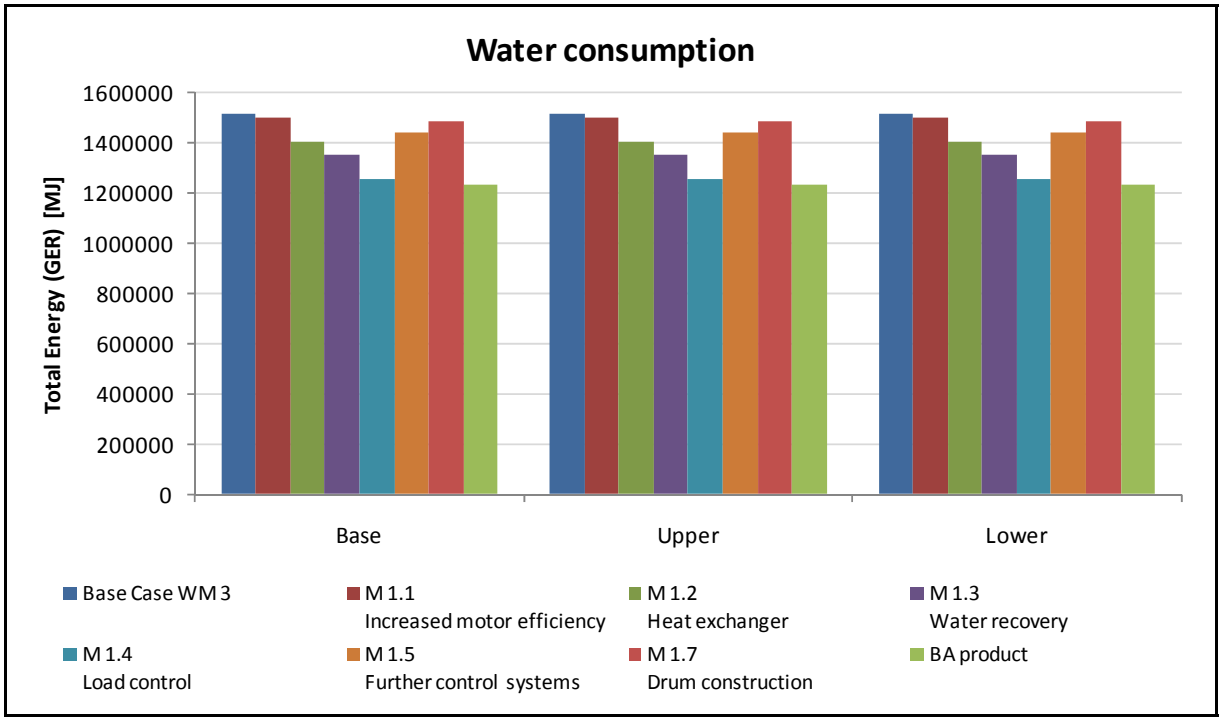


Figure 41 Base case WM 3 and improvement options – impact of water consumption on total energy over life time by product

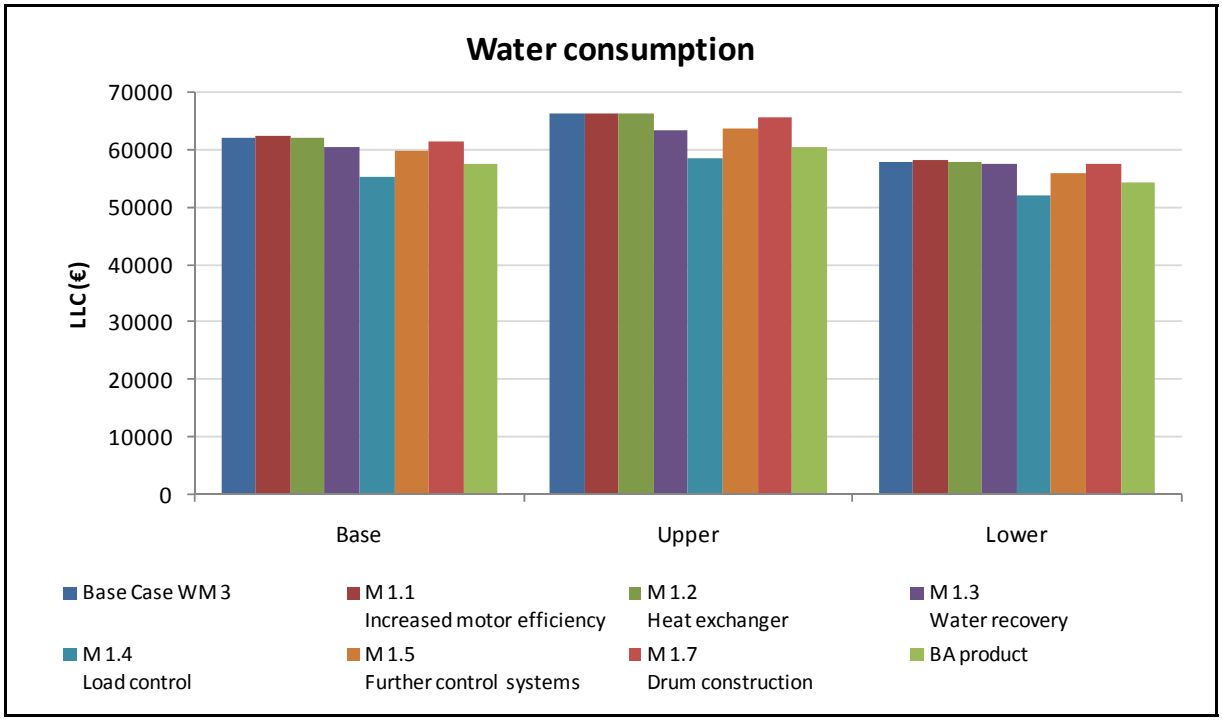


Figure 42 Base case WM 3 and improvement options – impact of water consumption on LCC by product

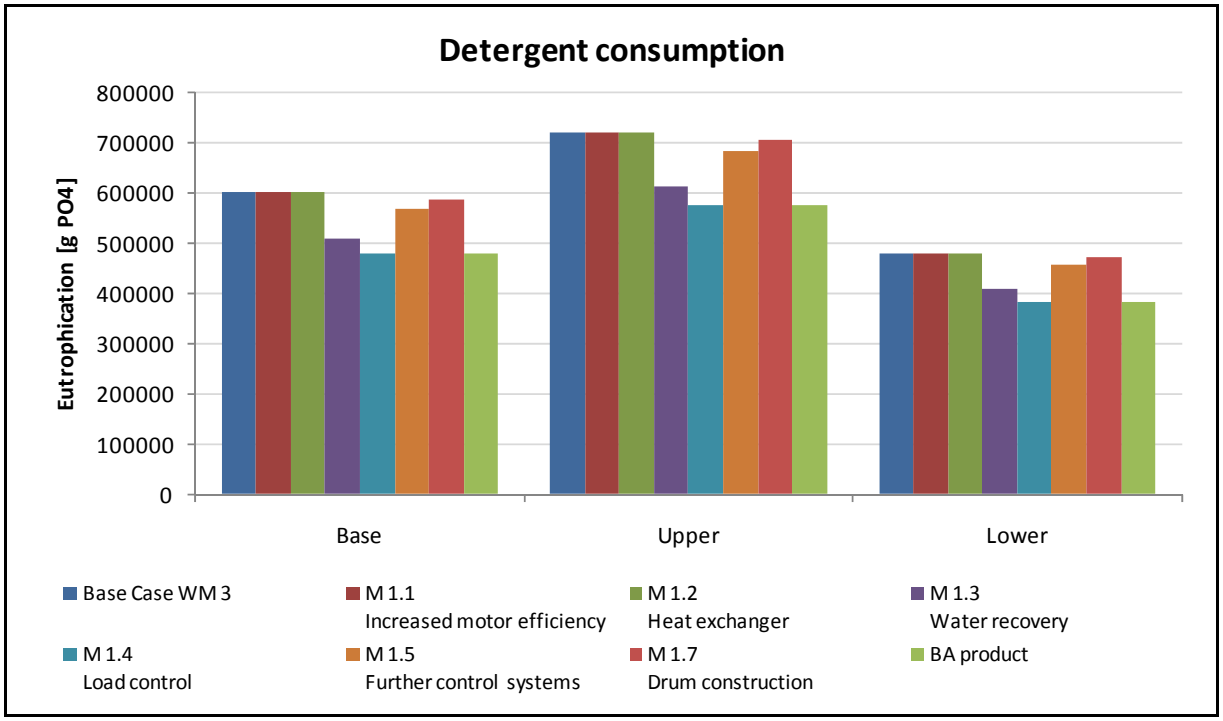


Figure 43 Base case WM 3 and improvement options – impact of detergent consumption on eutrophication over life time by product

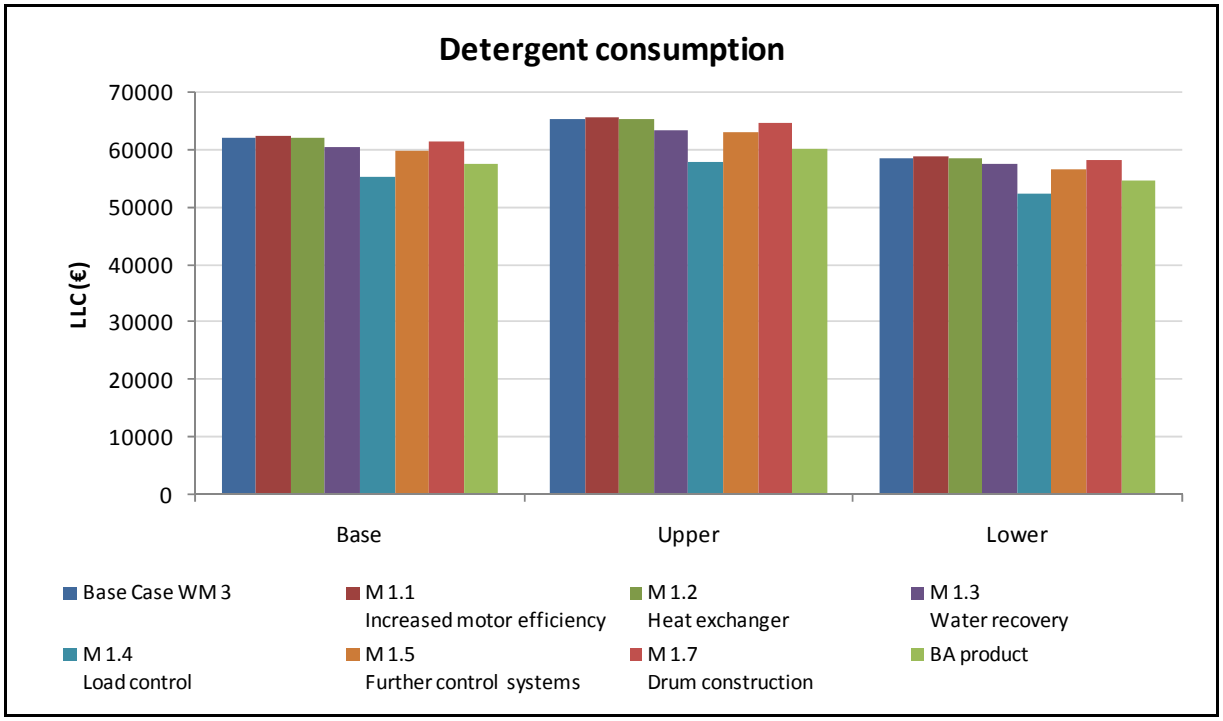


Figure 44 Base case WM 3 and improvement options – impact of detergent consumption on LCC by product

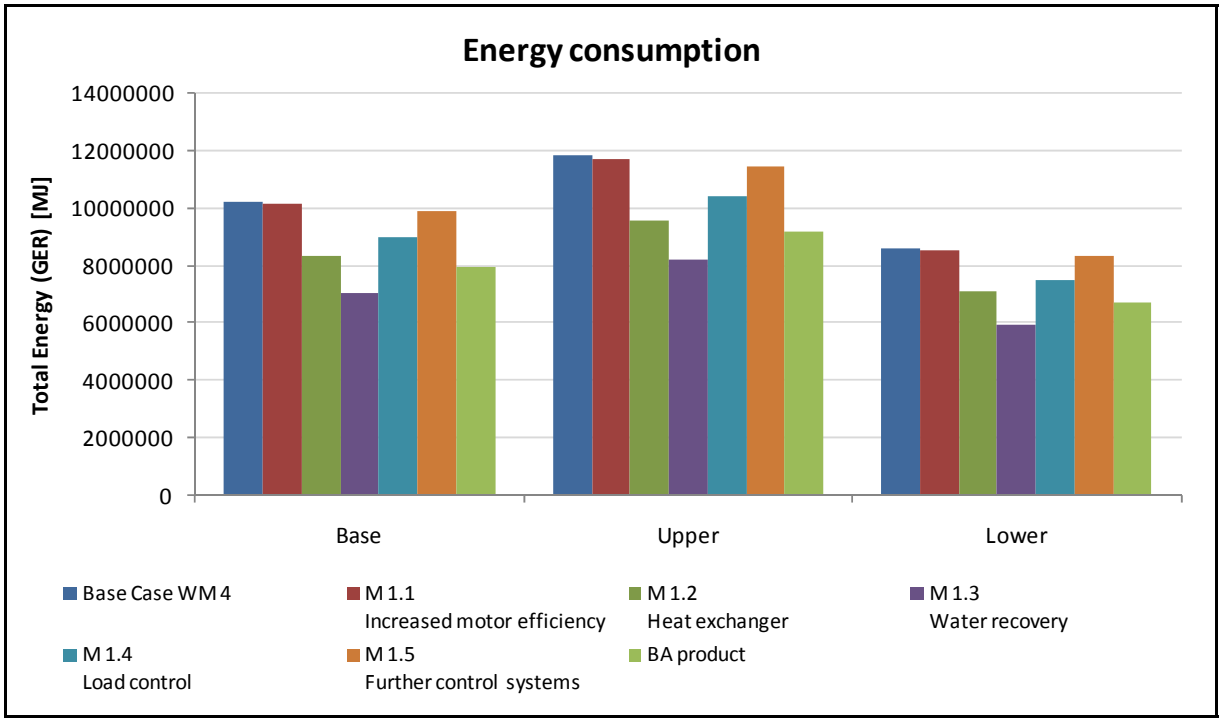


Figure 45 Base case WM 4 and improvement options – impact of energy consumption on total energy over life time by product

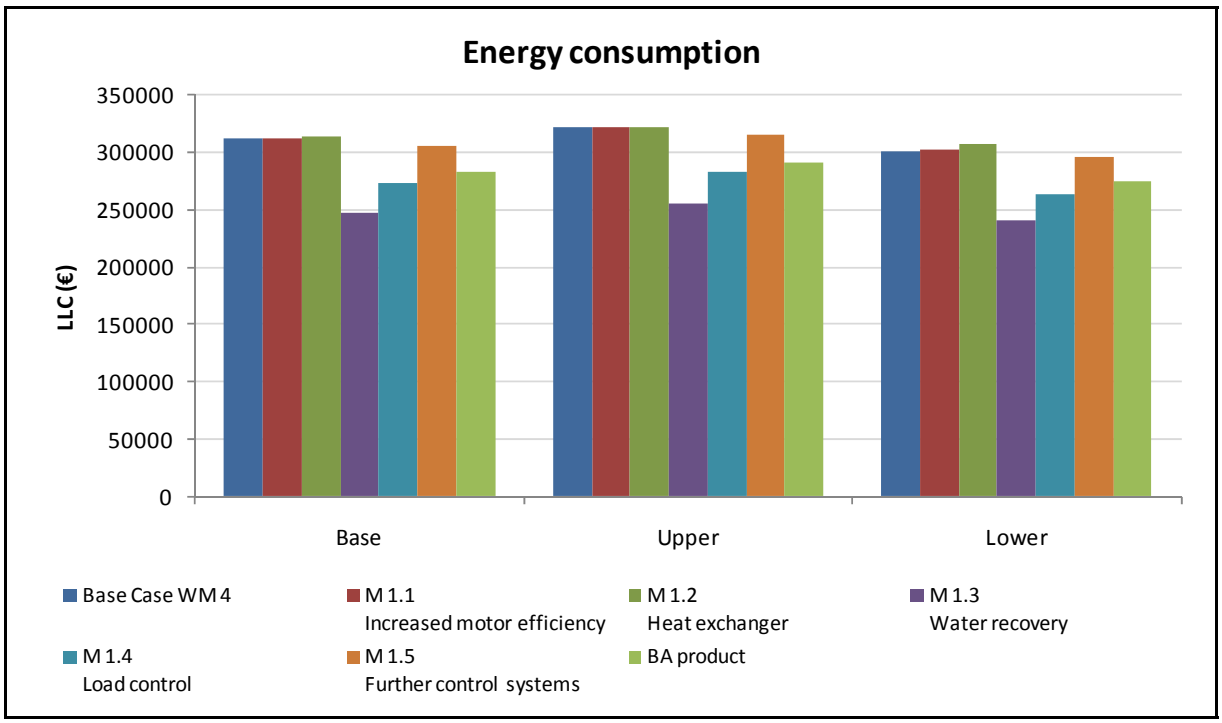


Figure 46 Base case WM 4 and improvement options – impact of energy consumption on LCC by product

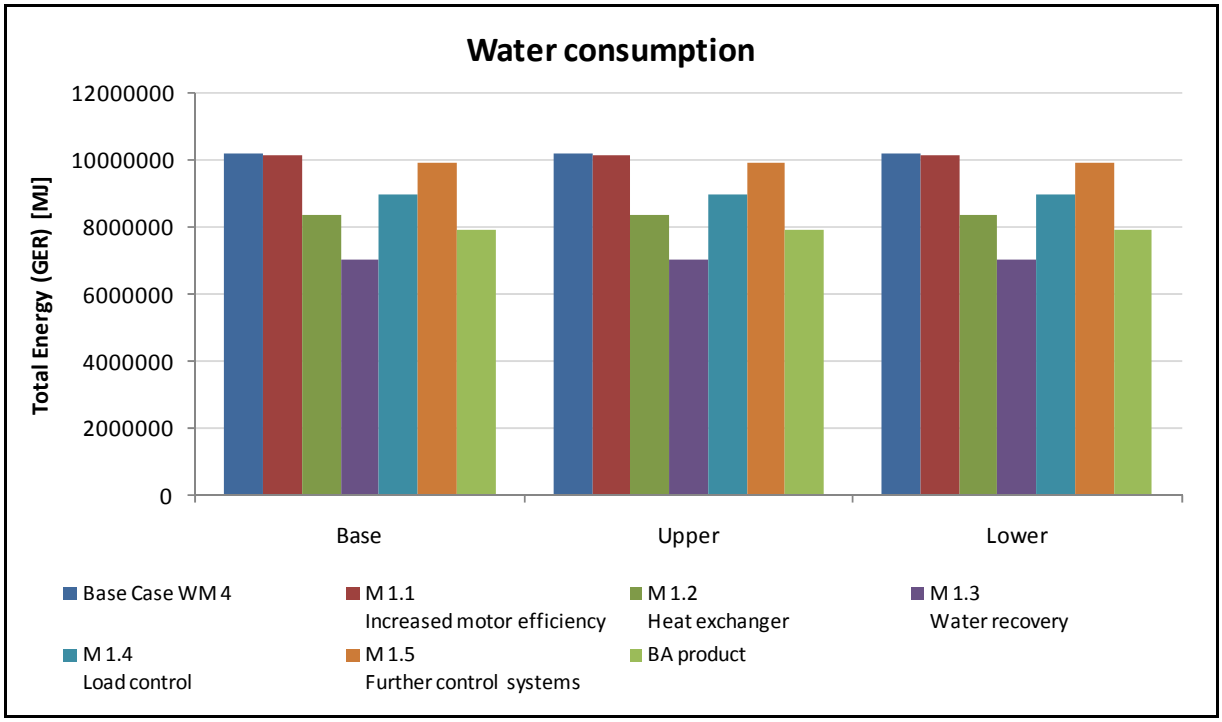


Figure 47 Base case WM 4 and improvement options – impact of water consumption on total energy over life time by product

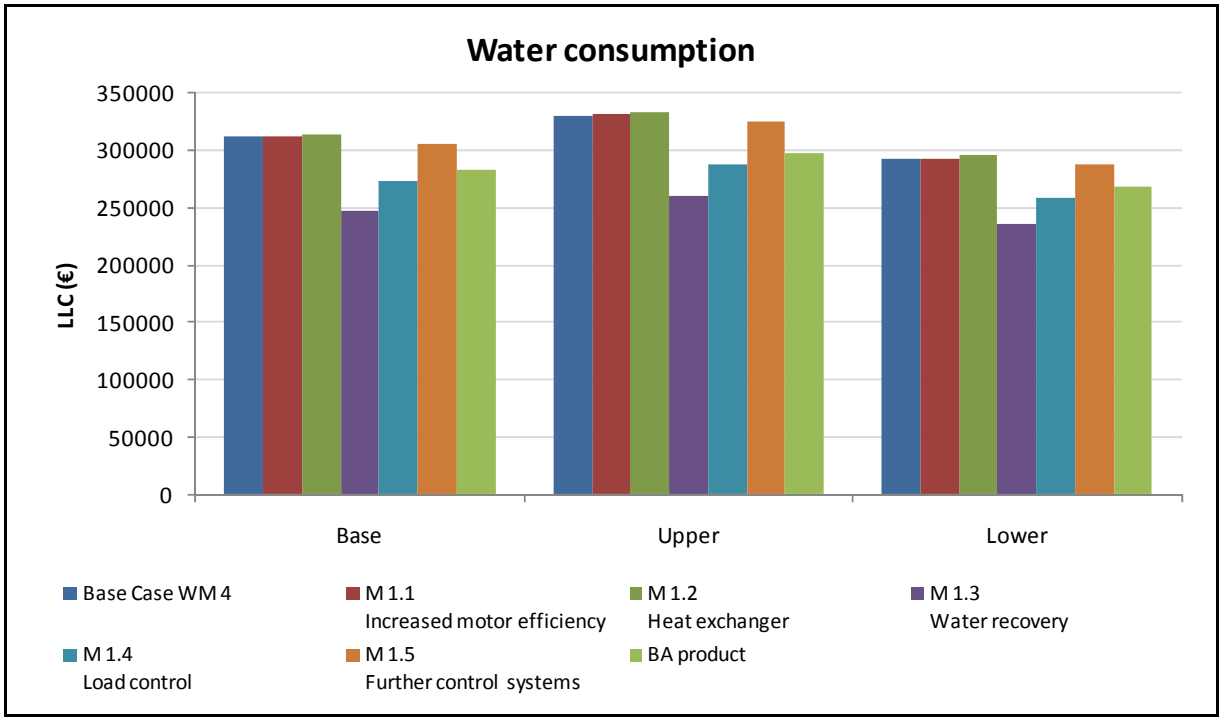


Figure 48 Base case WM 4 and improvement options – impact of water consumption on LCC by product

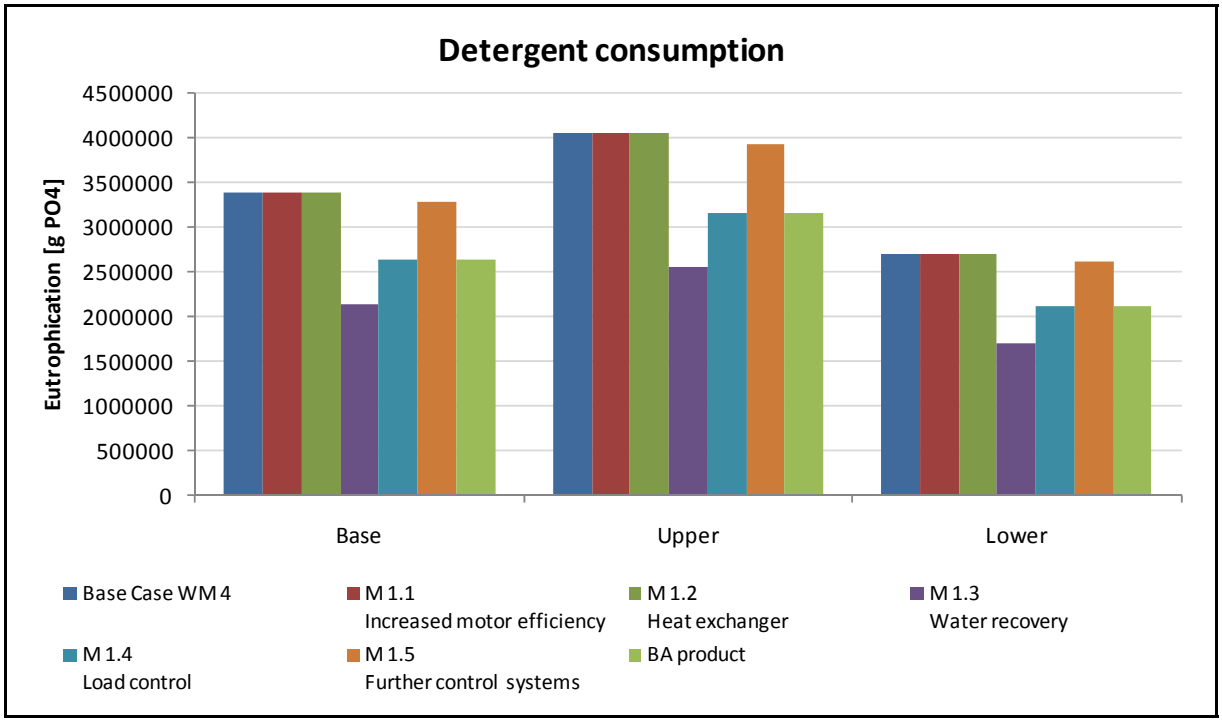


Figure 49 Base case WM 4 and improvement options – impact of detergent consumption on eutrophication over life time by product

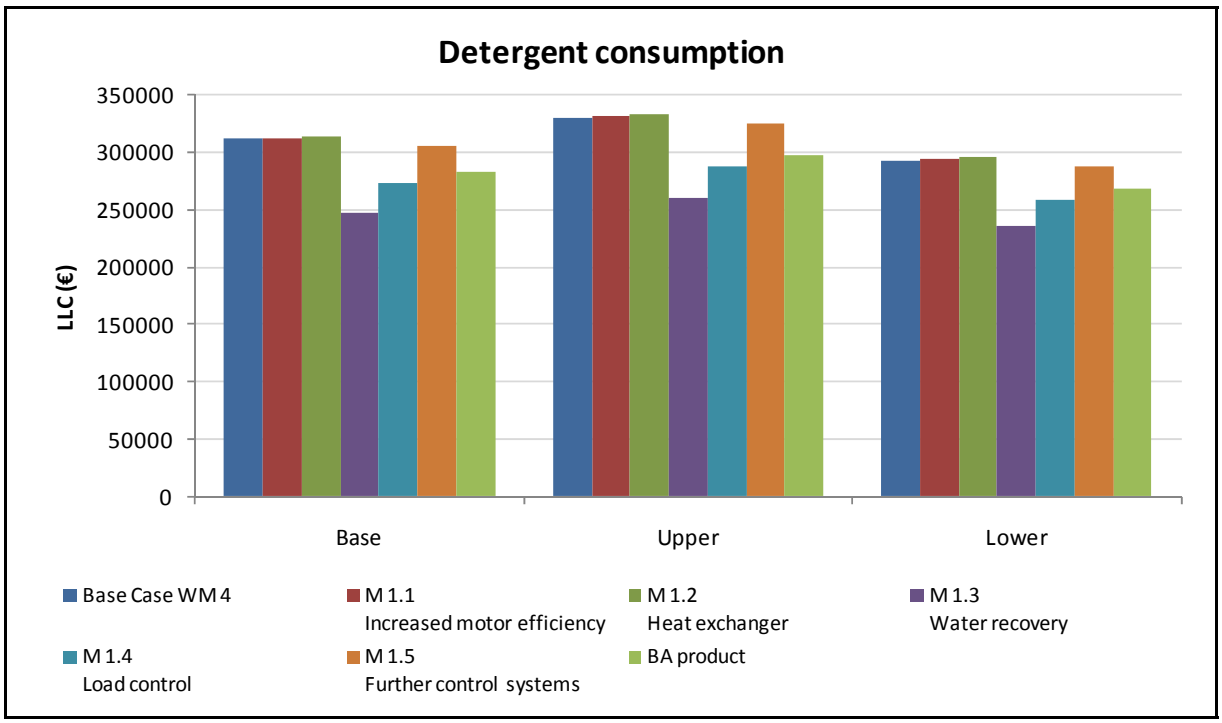


Figure 50 Base case WM 4 and improvement options – impact of detergent consumption on LCC by product

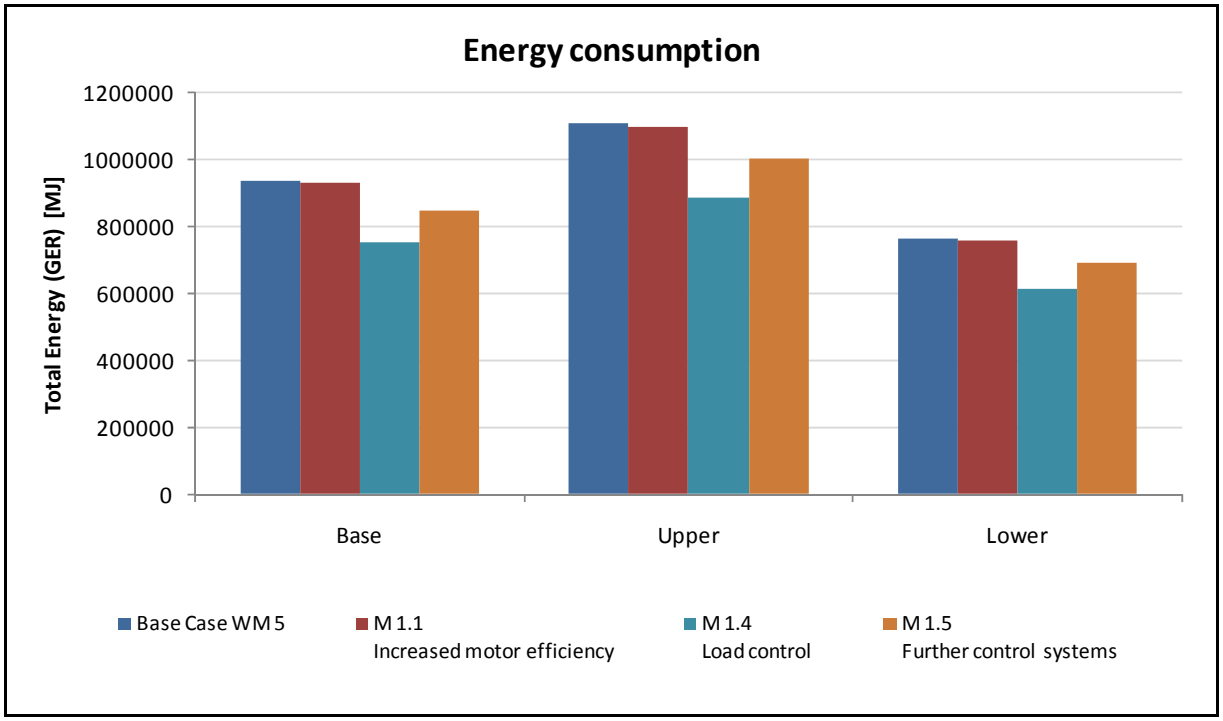


Figure 51 Base case WM 5 and improvement options – impact of energy consumption on total energy over life time by product

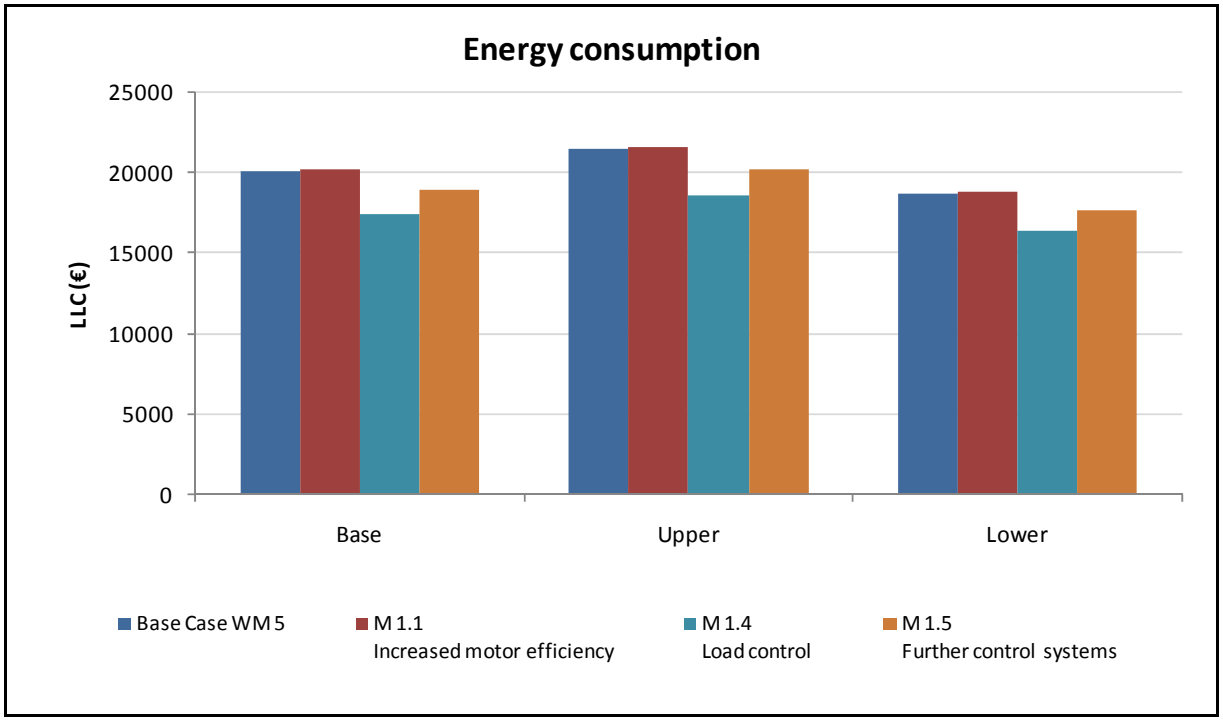


Figure 52 Base case WM 5 and improvement options – impact of energy consumption on LCC by product

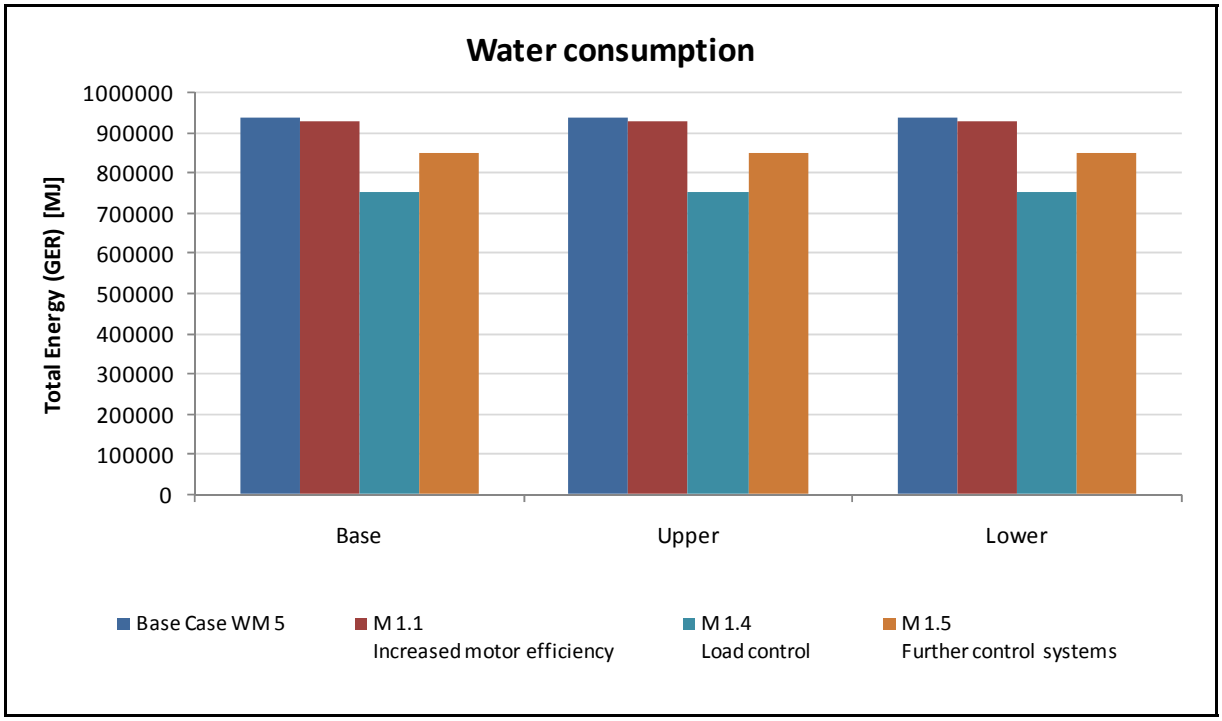


Figure 53 Base case WM 5 and improvement options – impact of water consumption on total energy over life time by product

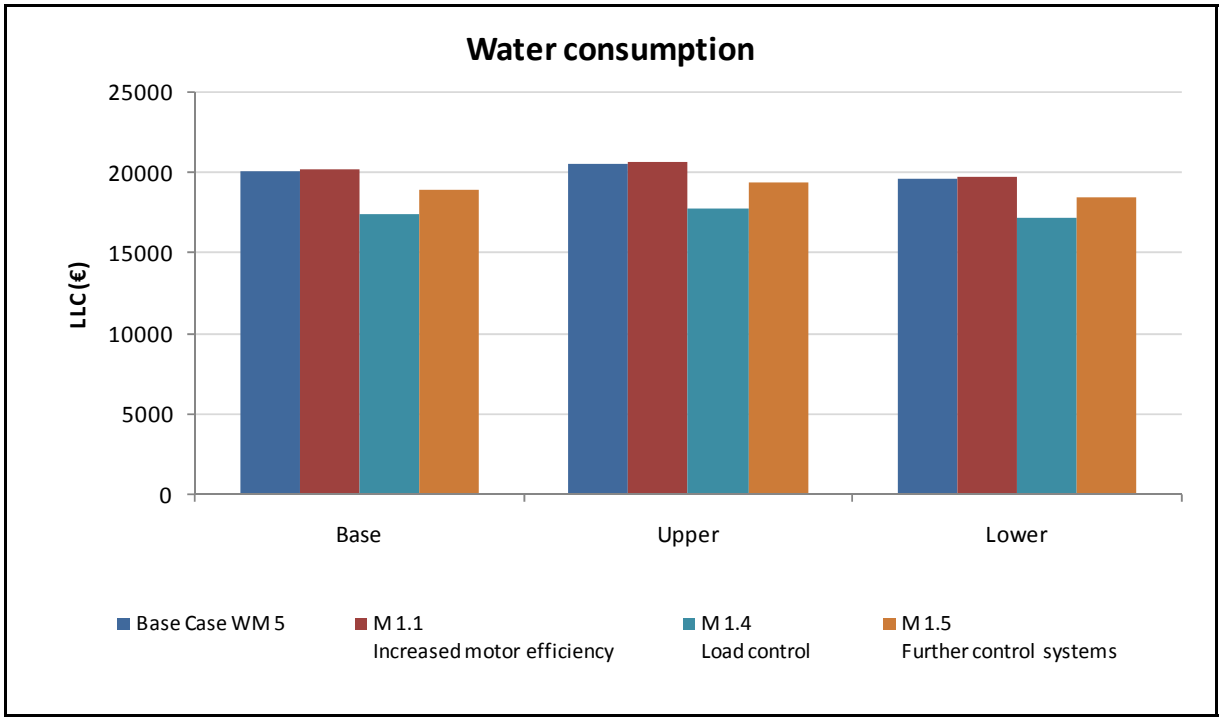


Figure 54 Base case WM 5 and improvement options – impact of water consumption on LCC by product

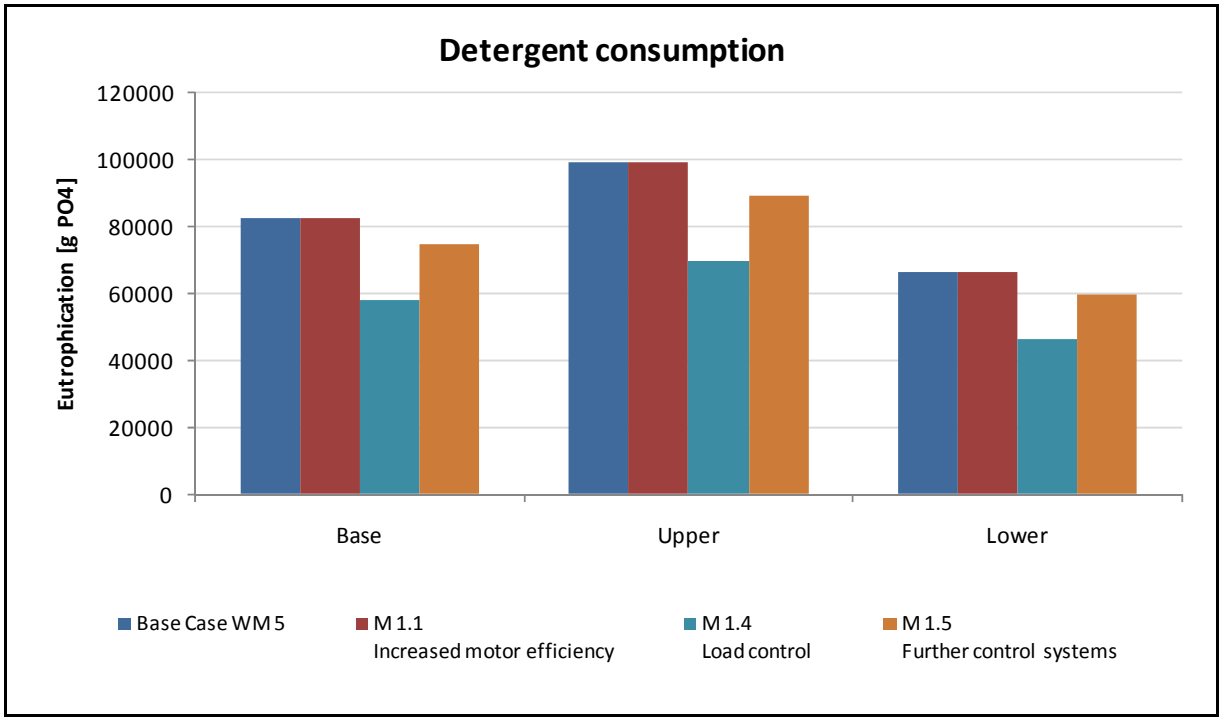


Figure 55 Base case WM 5 and improvement options – impact of detergent consumption on eutrophication over life time by product

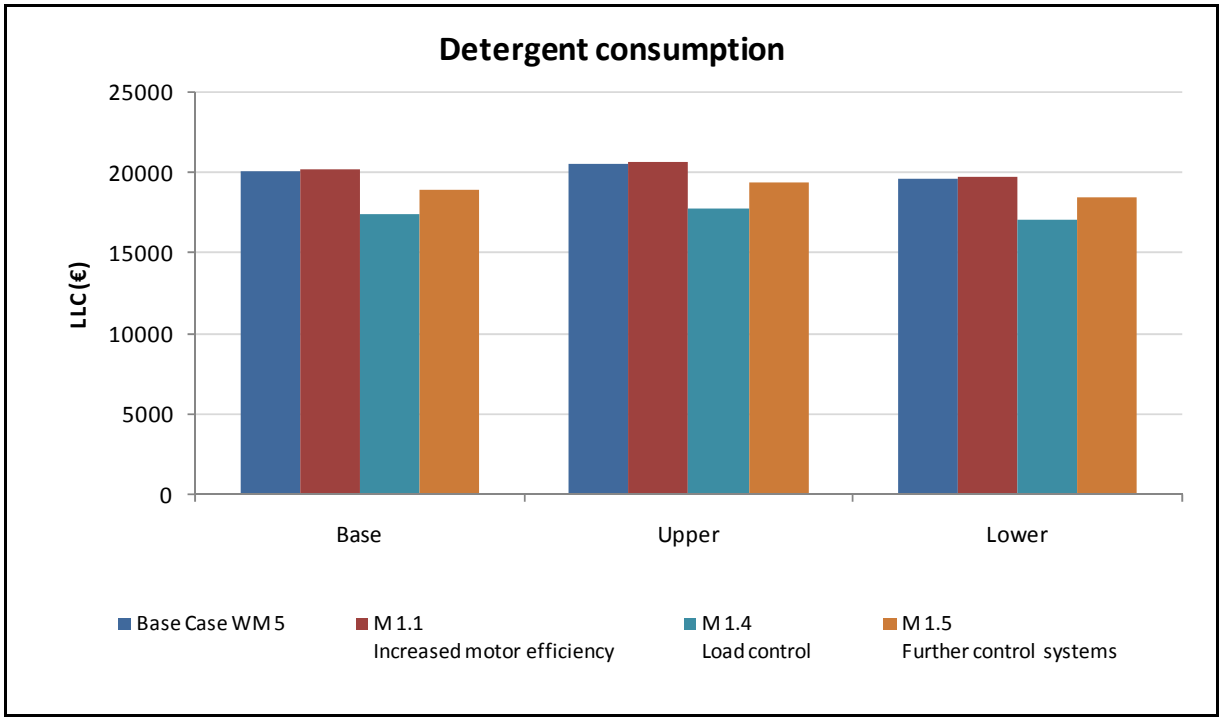


Figure 56 Base case WM 5 and improvement options – impact of detergent consumption on LCC by product

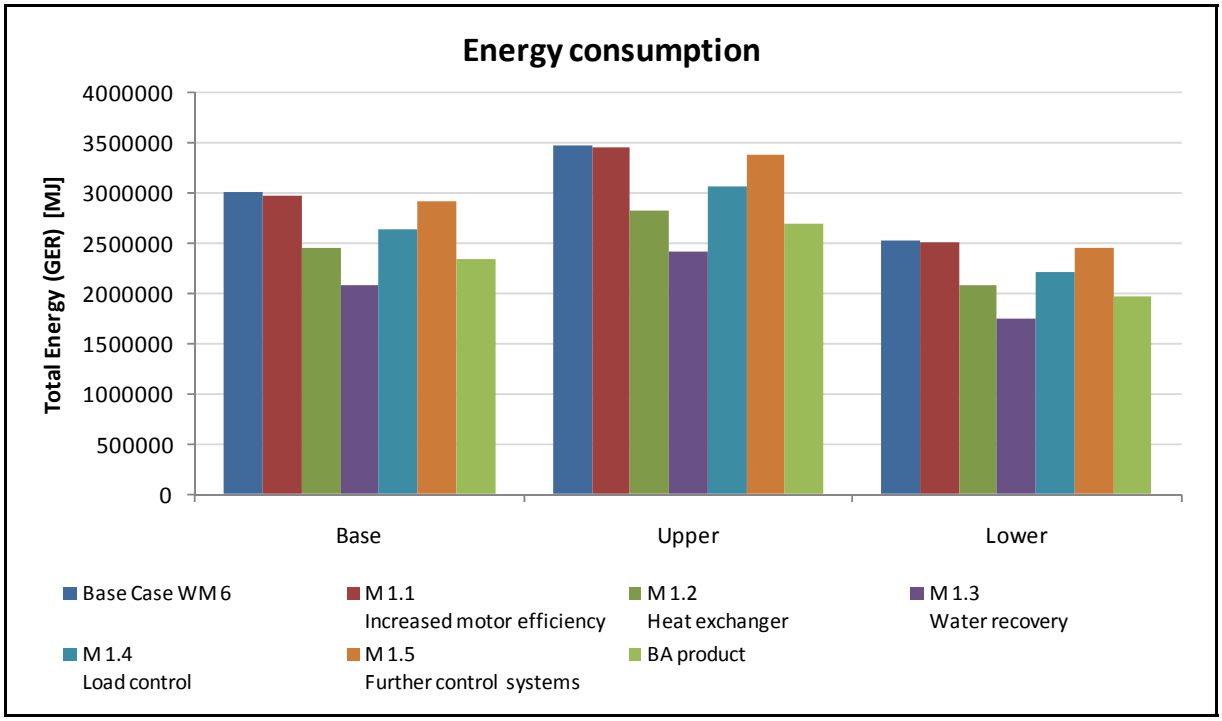


Figure 57 Base case WM 6 and improvement options – impact of energy consumption on total energy over life time by product

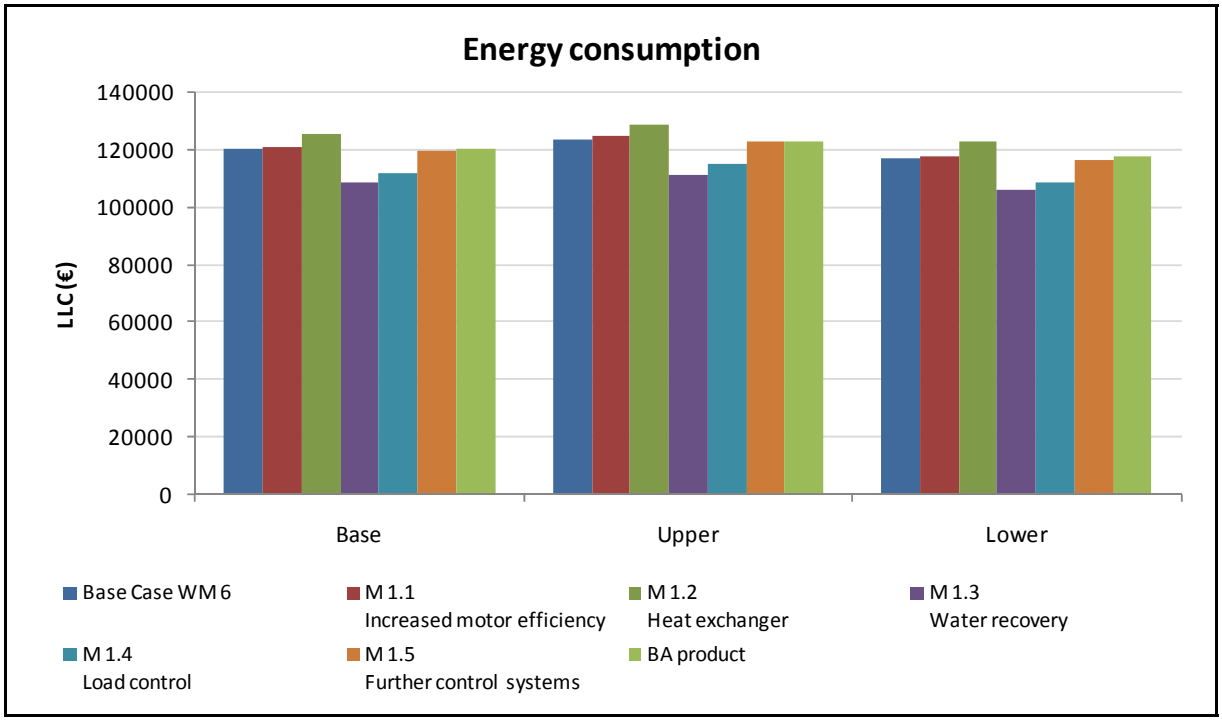


Figure 58 Base case WM 6 and improvement options – impact of energy consumption on LCC by product

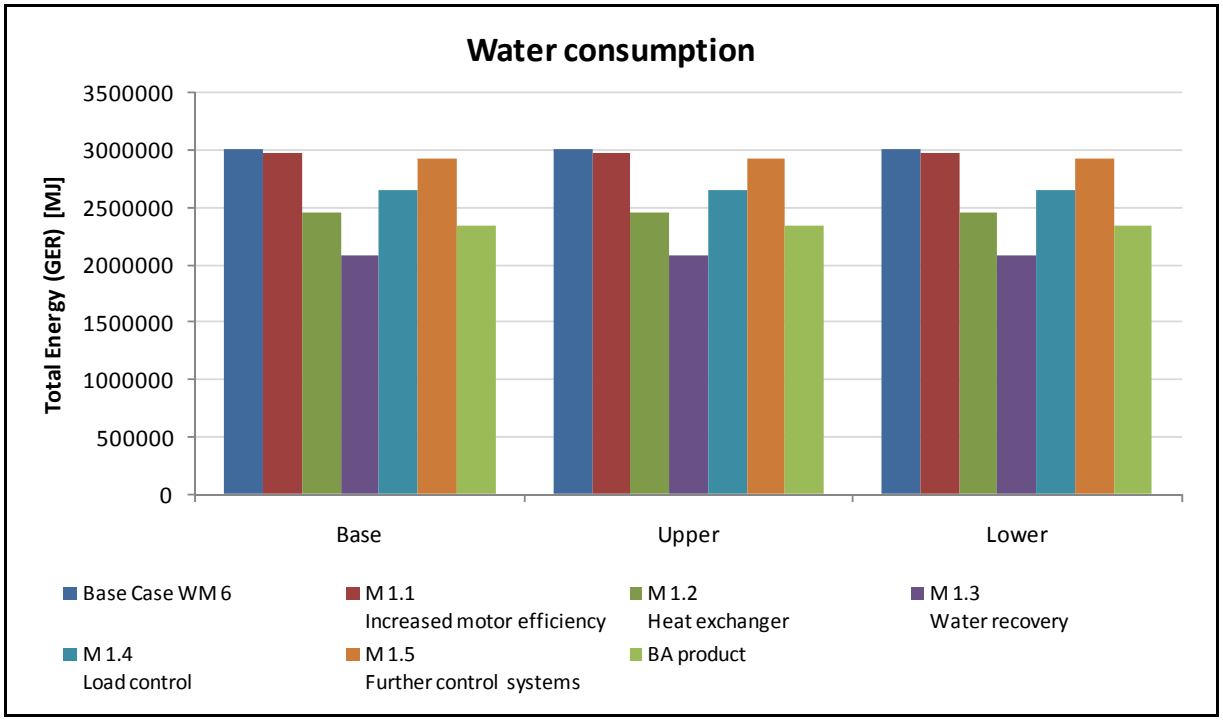


Figure 59 Base case WM 6 and improvement options – impact of water consumption on total energy over life time by product

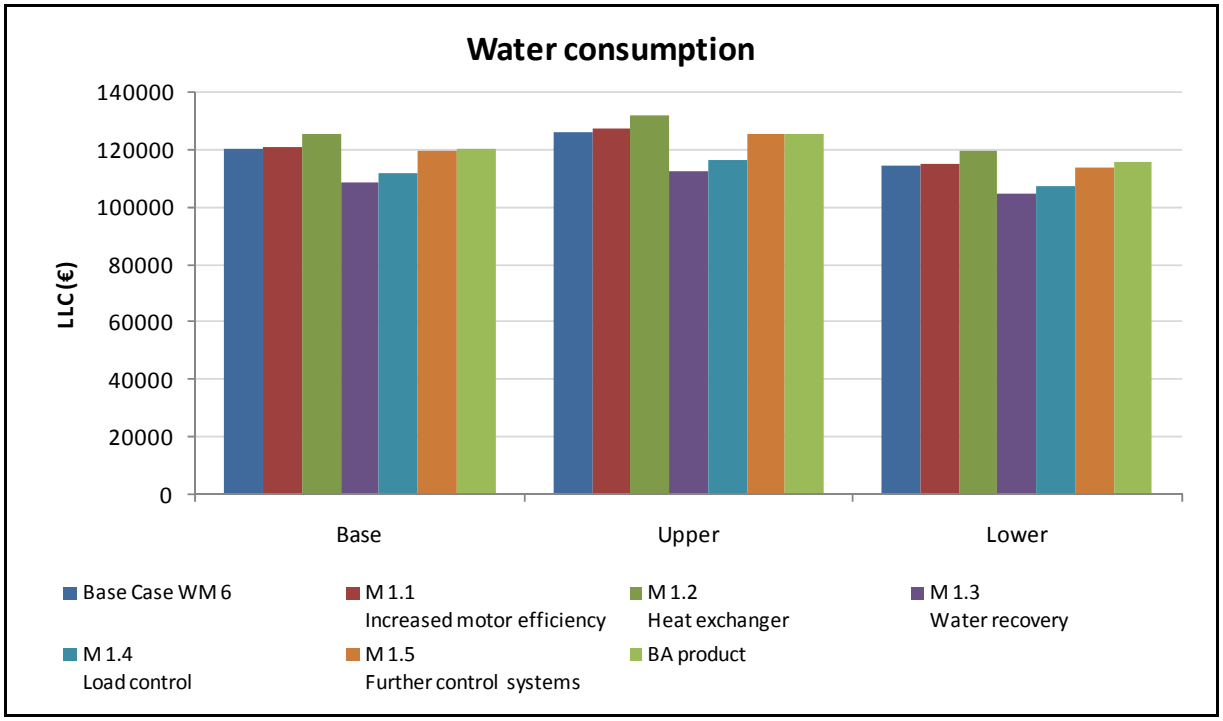


Figure 60 Base case WM 6 and improvement options – impact of water consumption on LCC by product

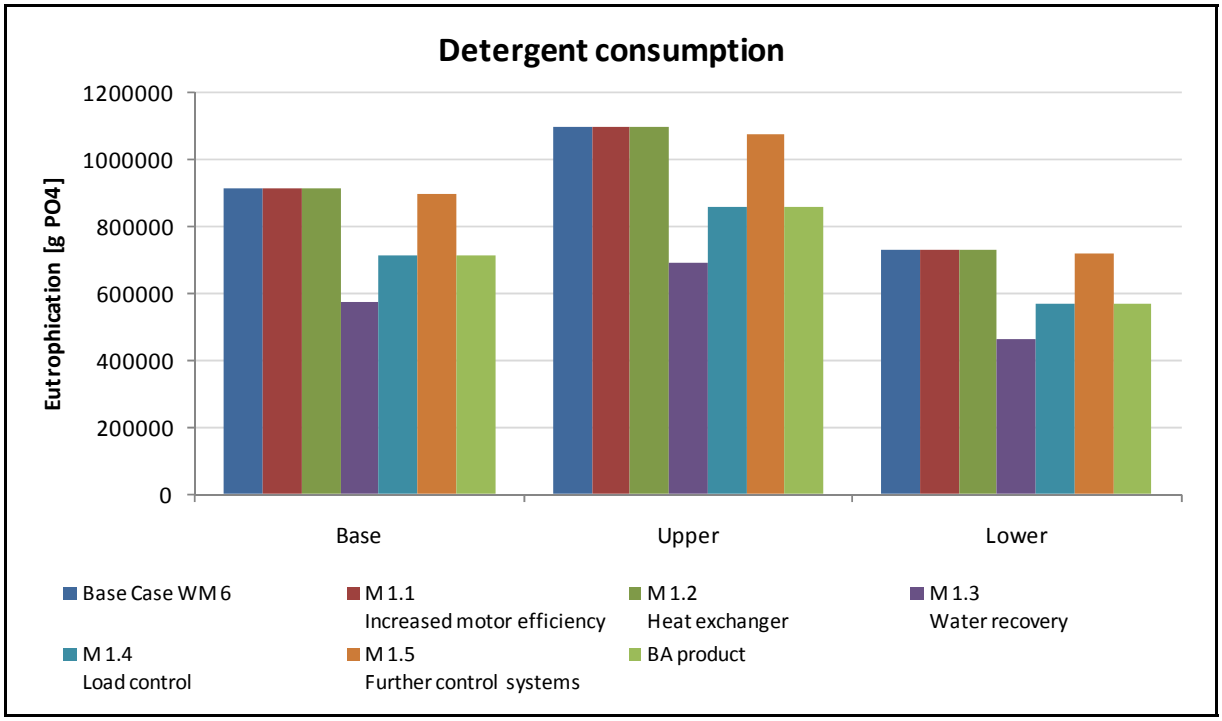


Figure 61 Base case WM 6 and improvement options – impact of detergent consumption on eutrophication over life time by product

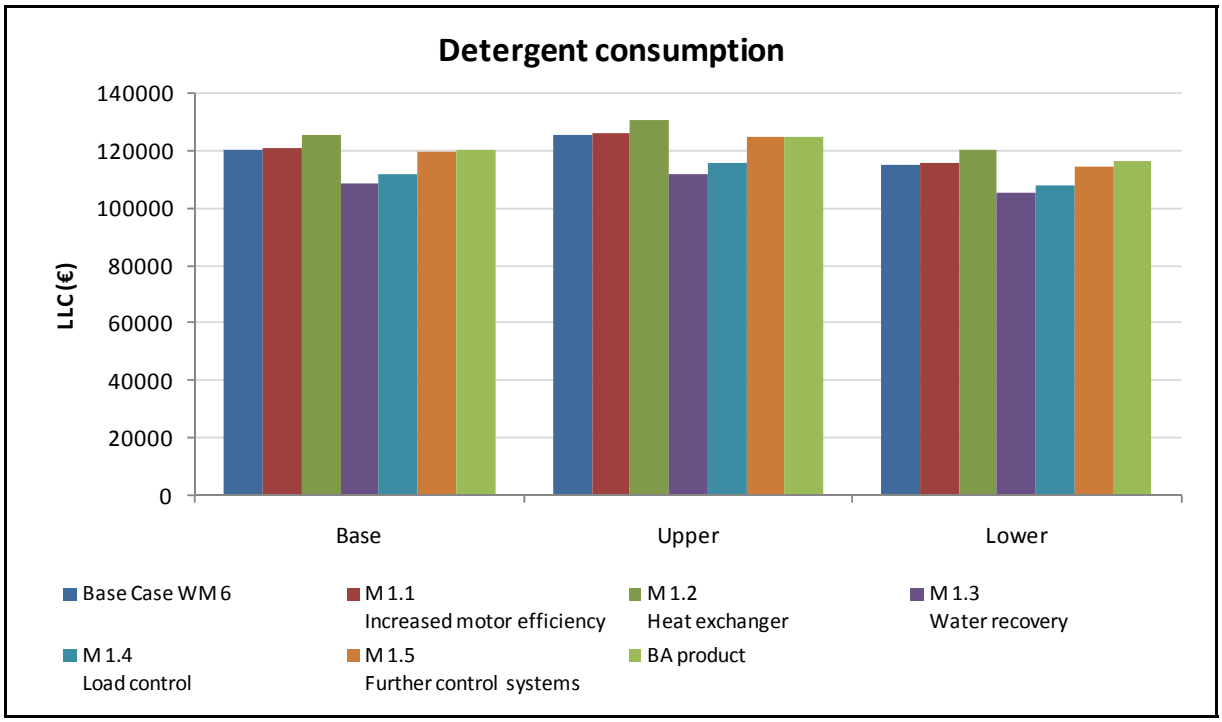


Figure 62 Base case WM 6 and improvement options – impact of detergent consumption on LCC by product

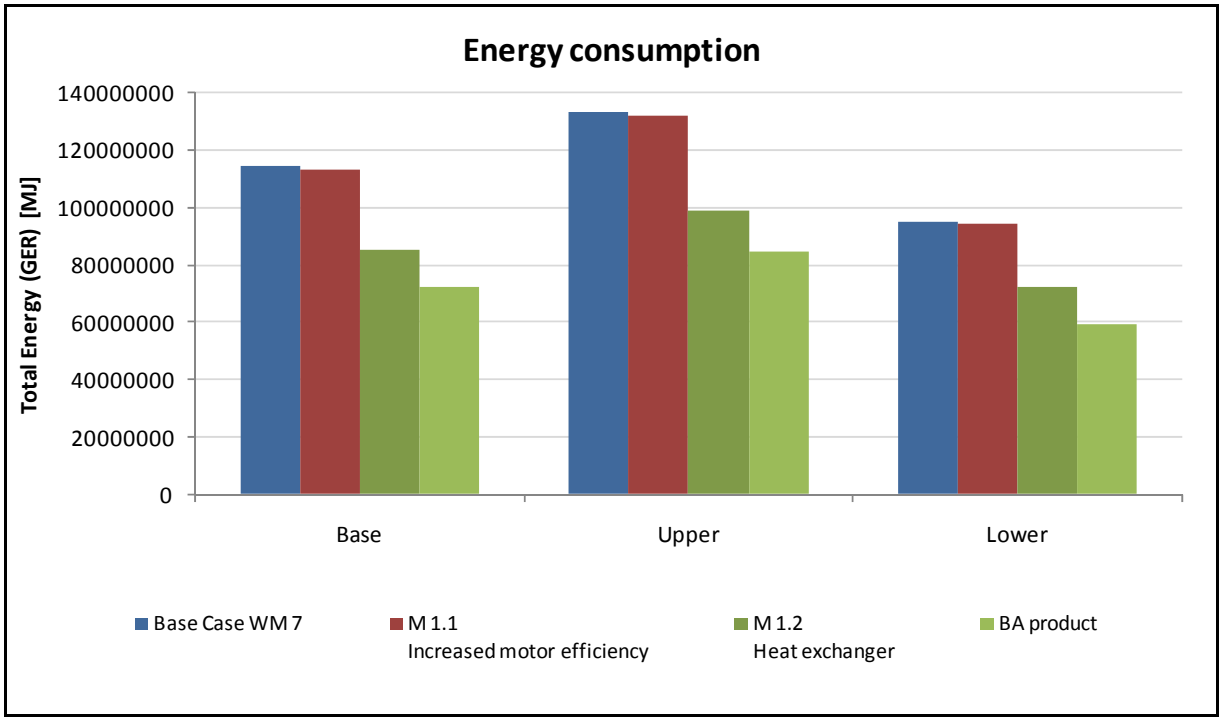


Figure 63 Base case WM 7 and improvement options – impact of energy consumption on total energy over life time by product

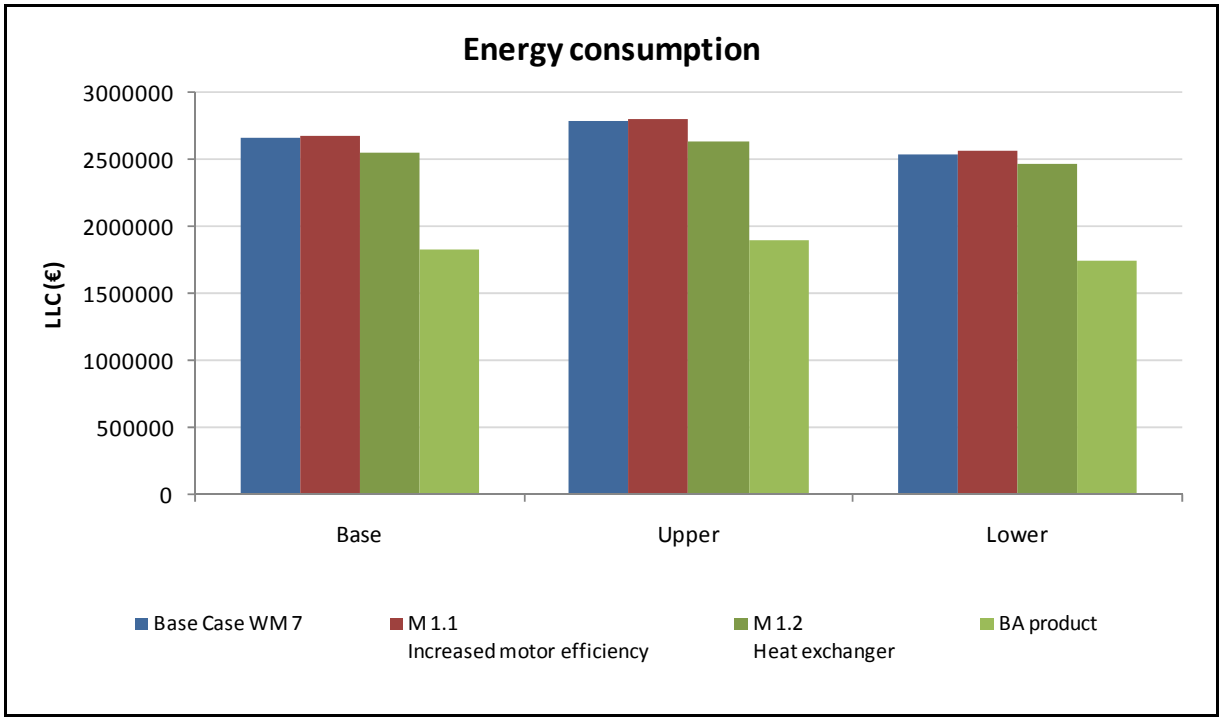


Figure 64 Base case WM 7 and improvement options – impact of energy consumption on LCC by product

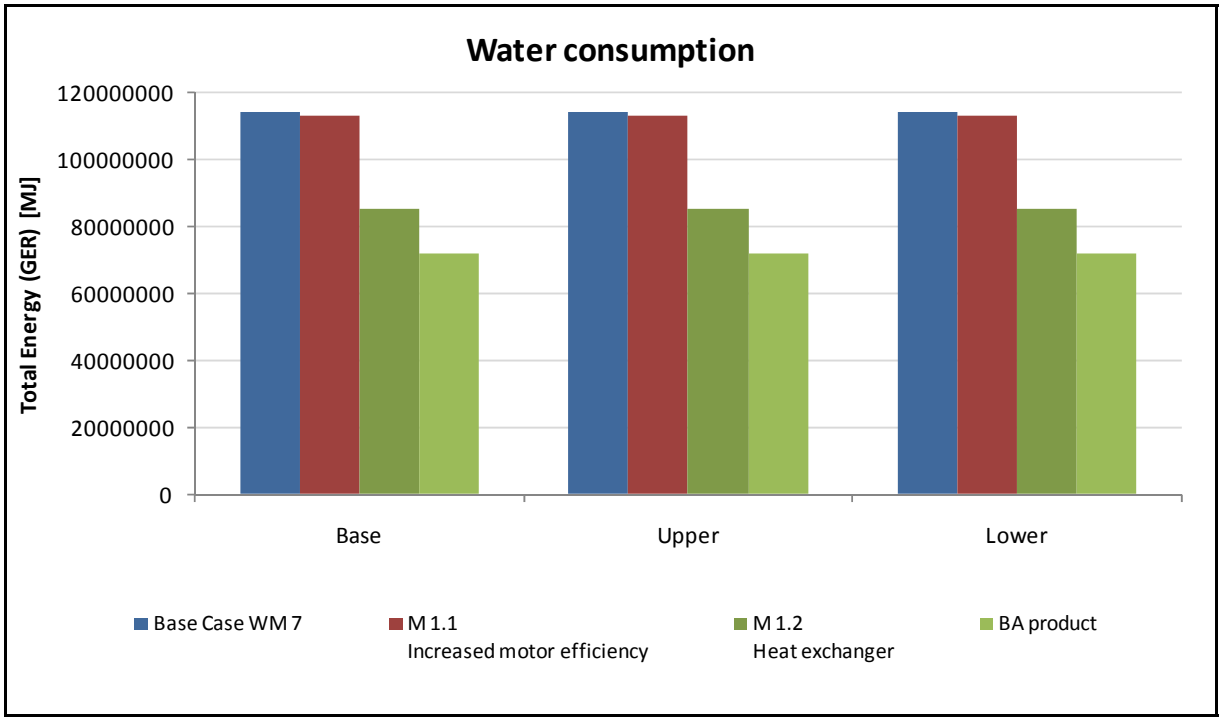


Figure 65 Base case WM 7 and improvement options – impact of water consumption on total energy over life time by product

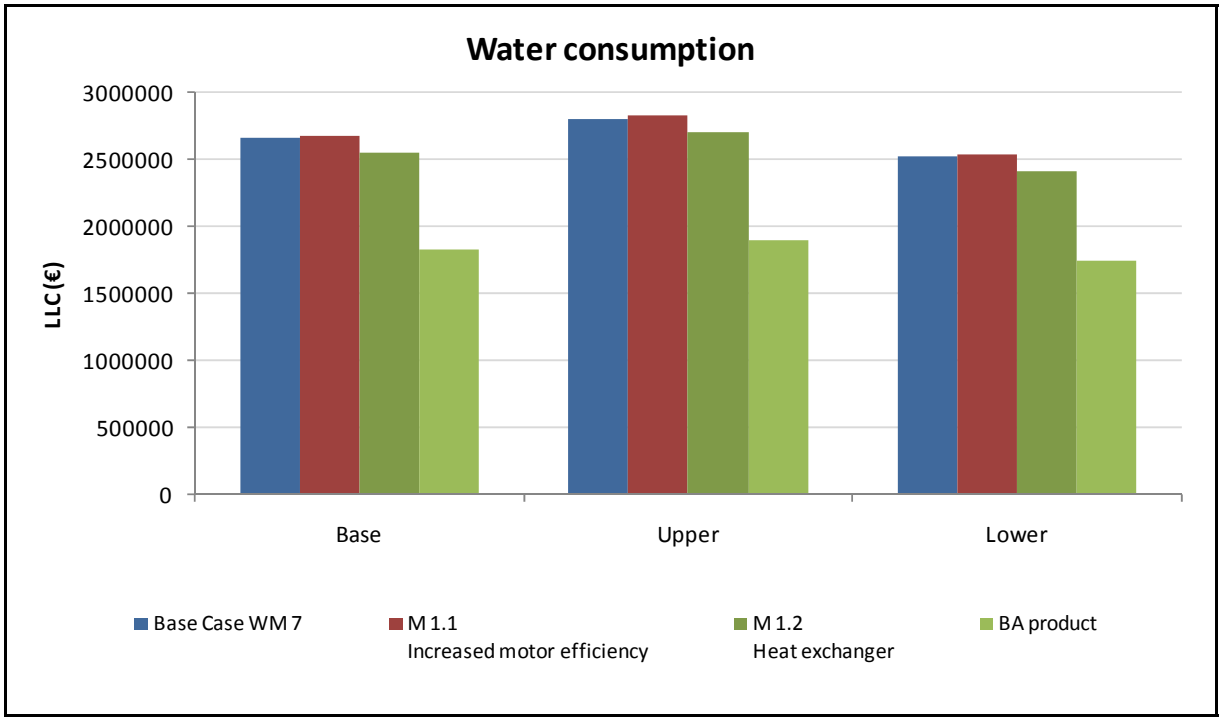


Figure 66 Base case WM 7 and improvement options – impact of water consumption on LCC by product

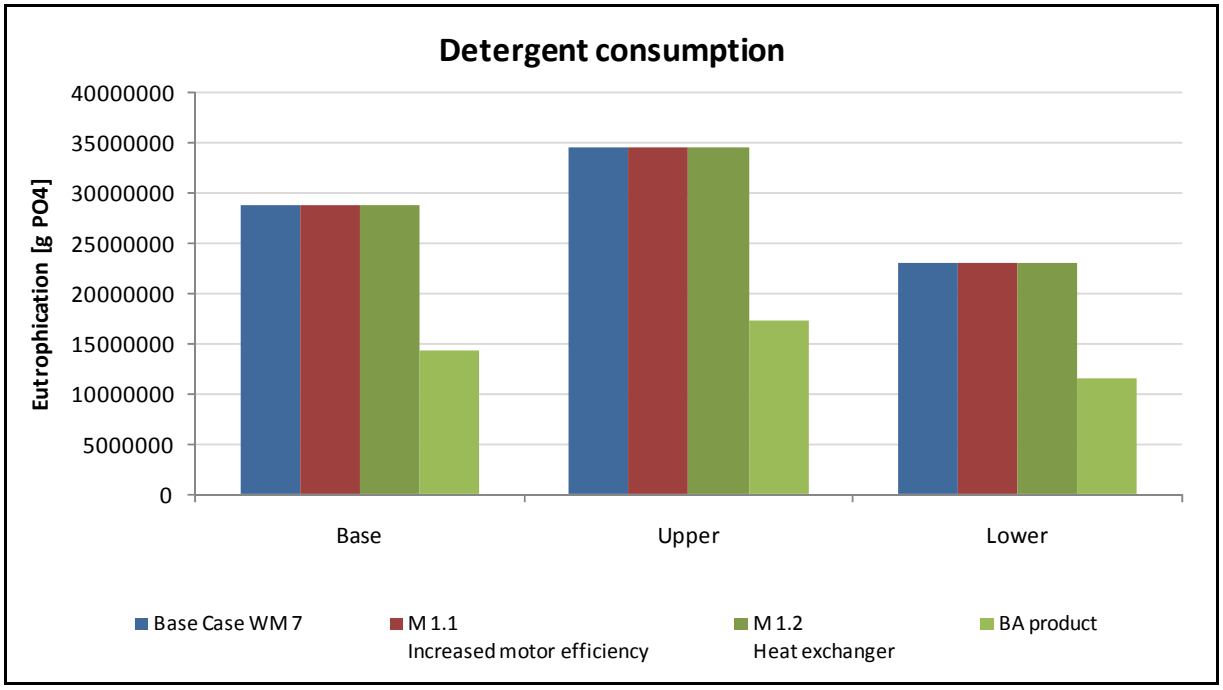


Figure 67 Base case WM 7 and improvement options – impact of detergent consumption on eutrophication over life time by product

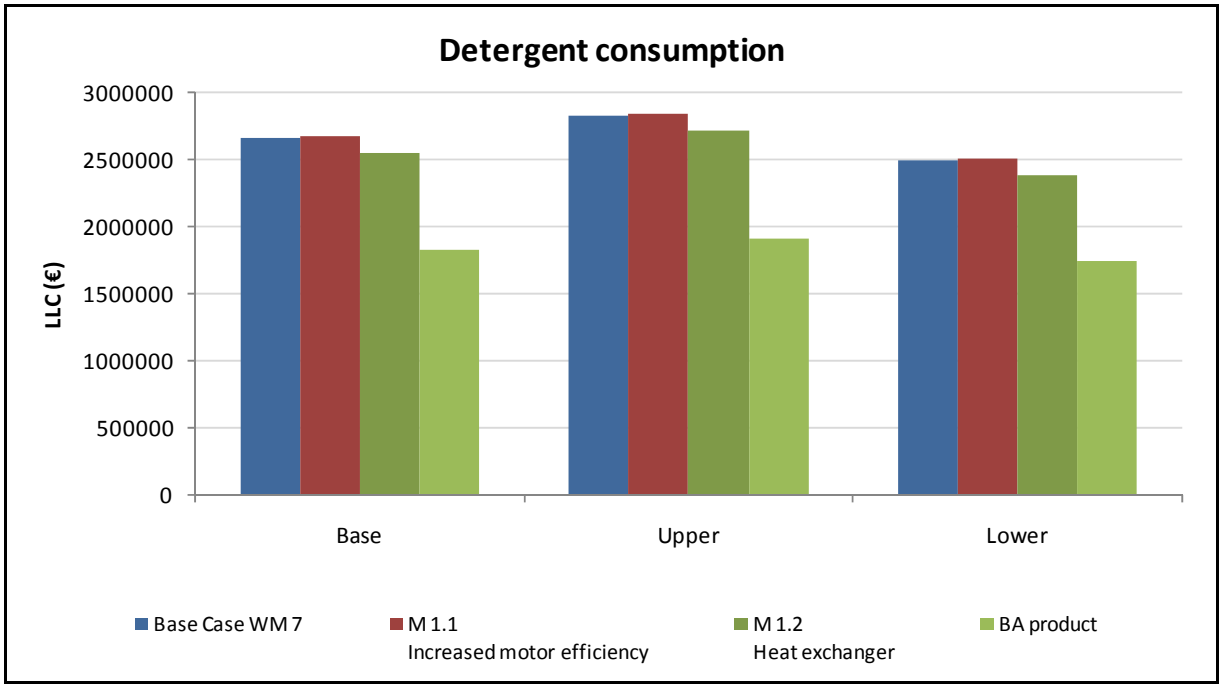


Figure 68 Base case WM 7 and improvement options – impact of detergent consumption on LCC by product

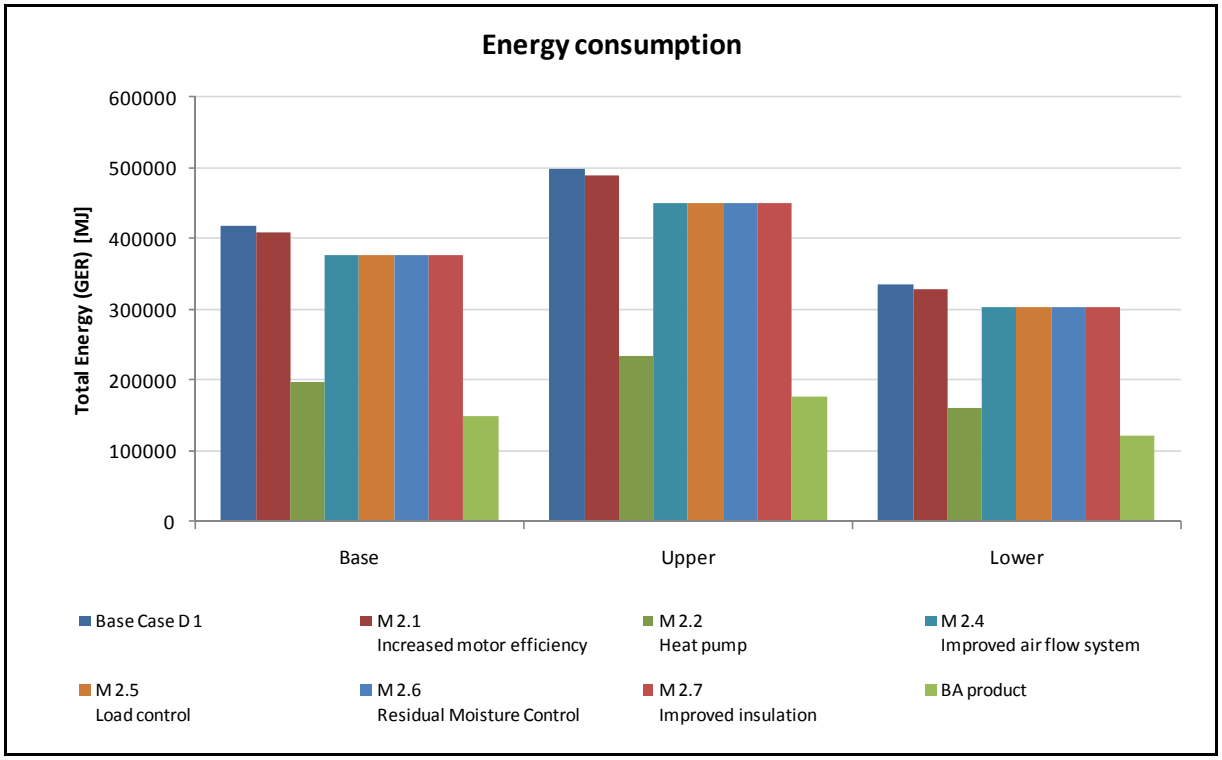


Figure 69 Base case D 1 and improvement options – impact of energy consumption on total energy over life time by product

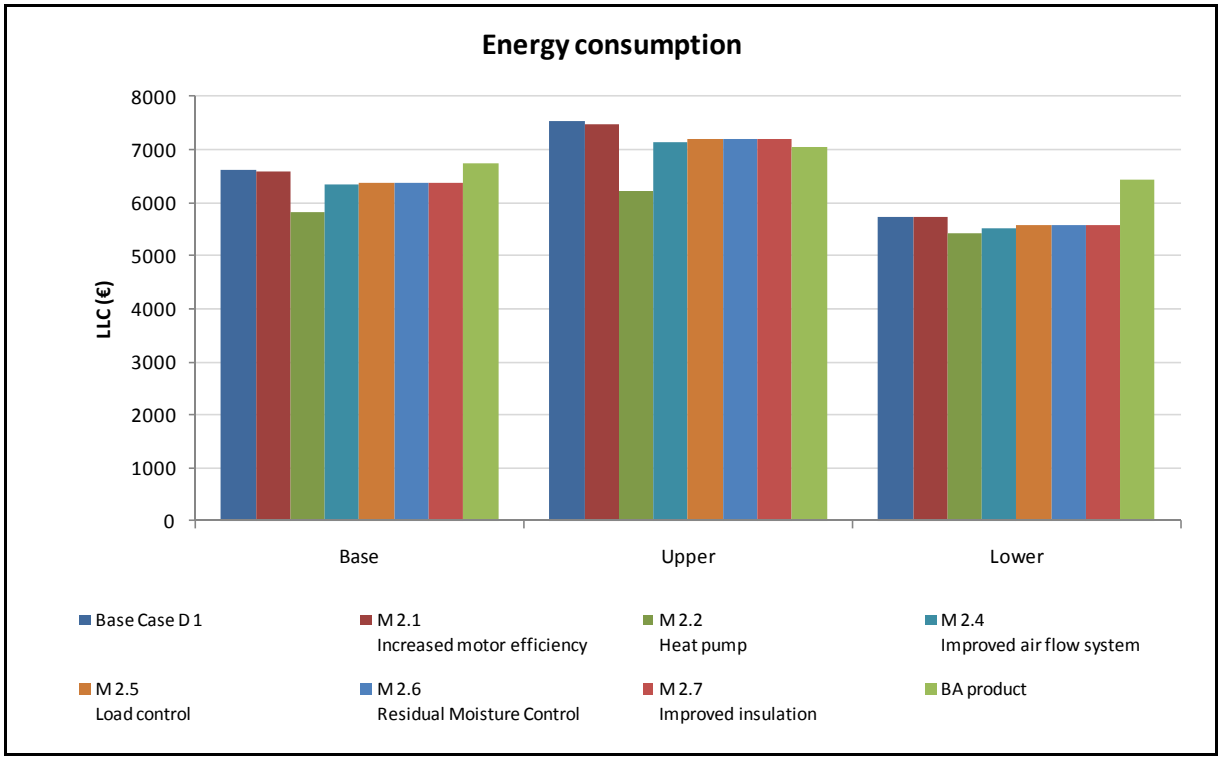


Figure 70 Base case D 1 and improvement options – impact of energy consumption on LCC by product

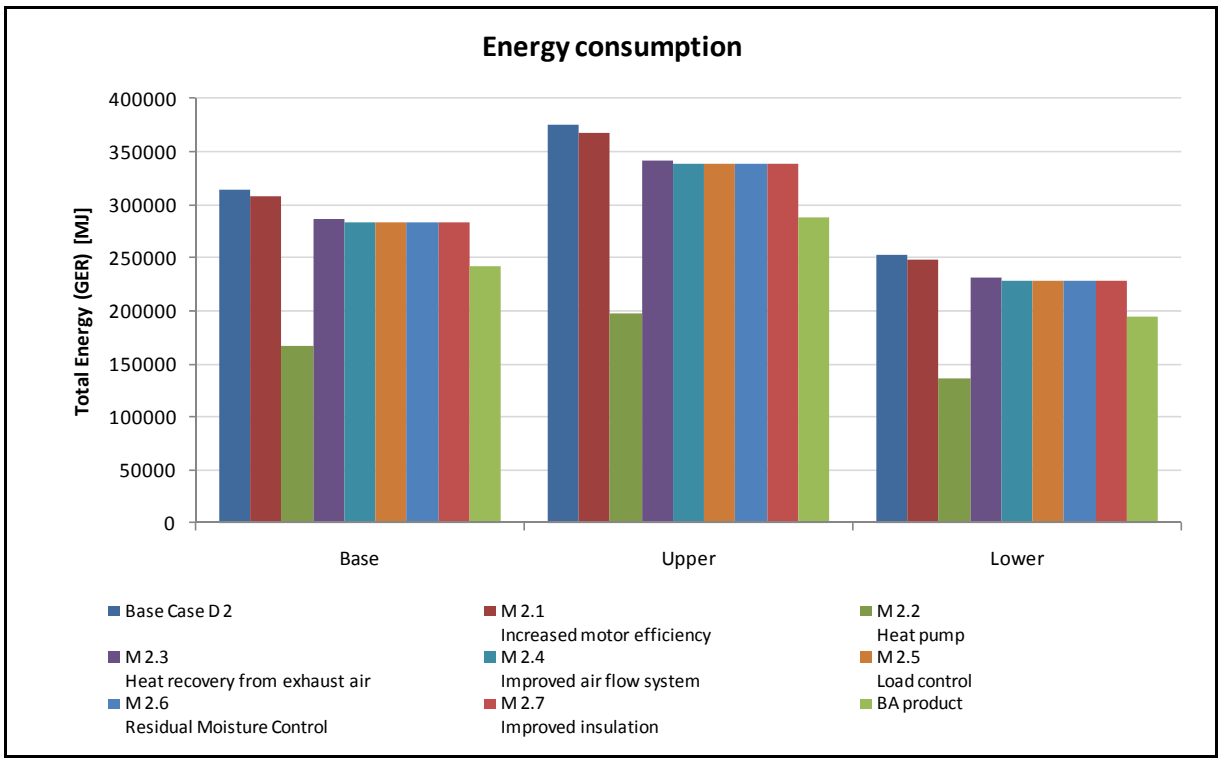


Figure 71 Base case D 2 and improvement options – impact of energy consumption on total energy over life time by product

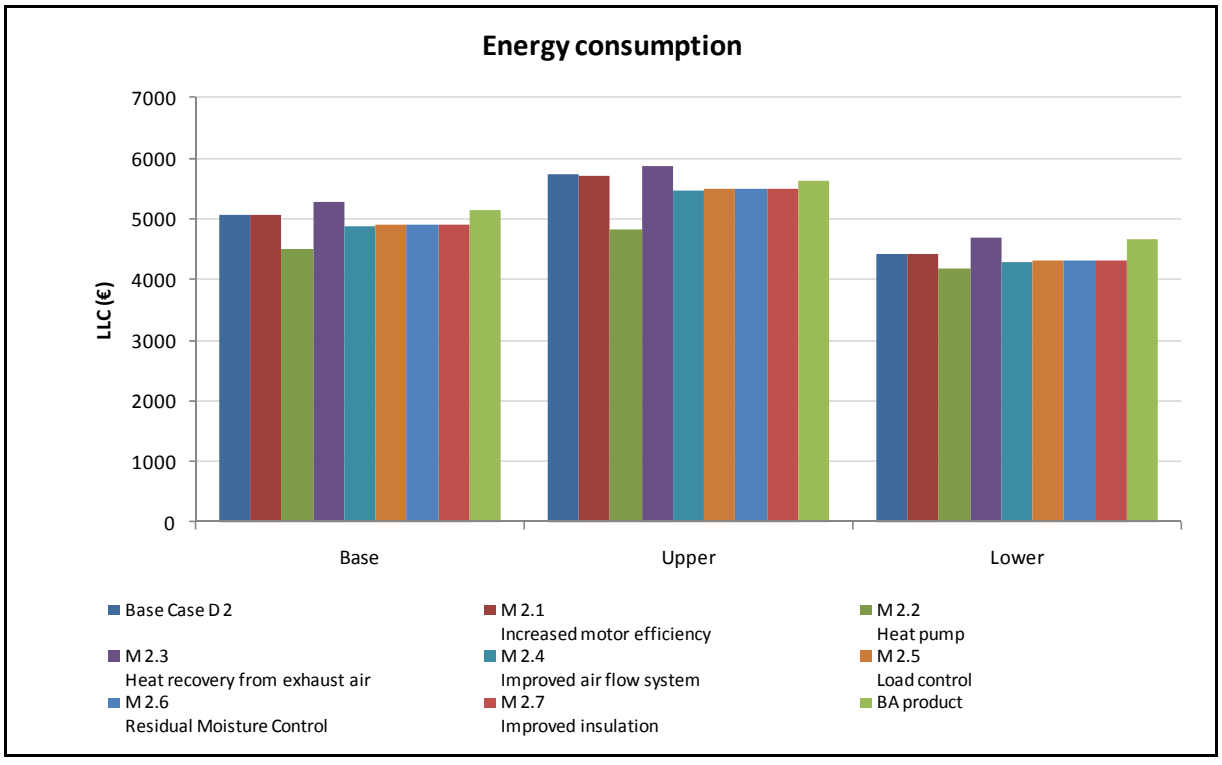


Figure 72 Base case D 2 and improvement options – impact of energy consumption on LCC by product

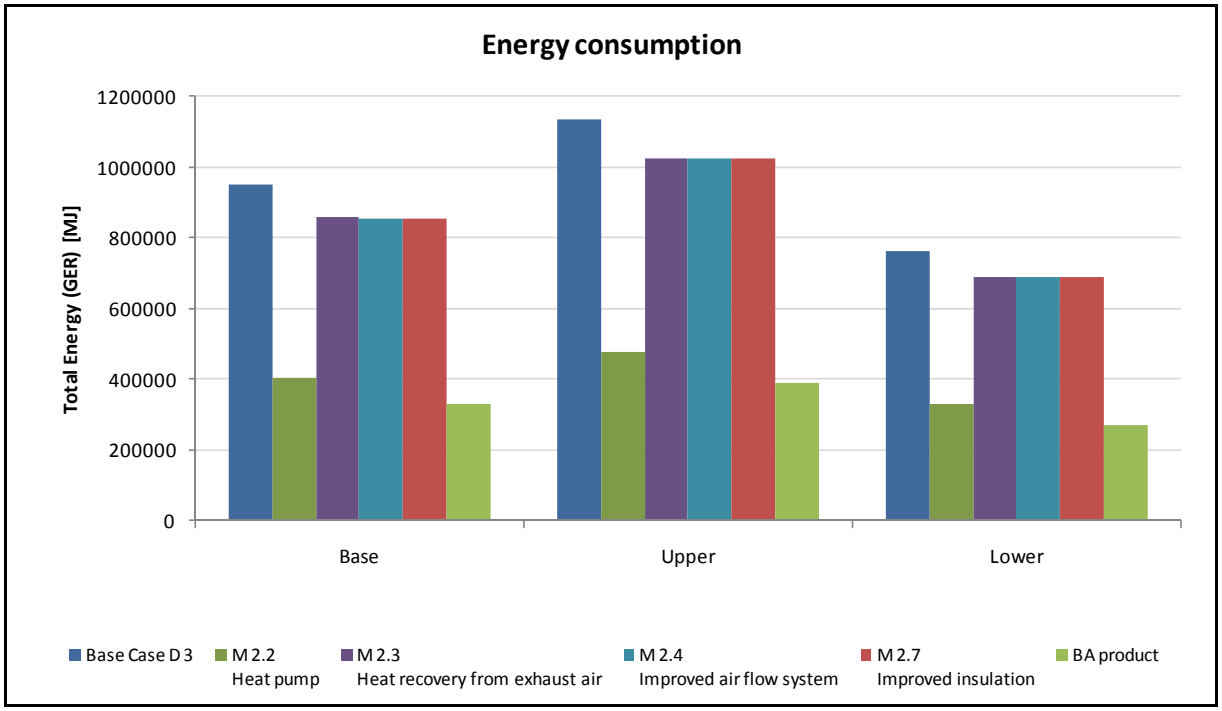


Figure 73 Base case D 3 and improvement options – impact of energy consumption on total energy over life time by product

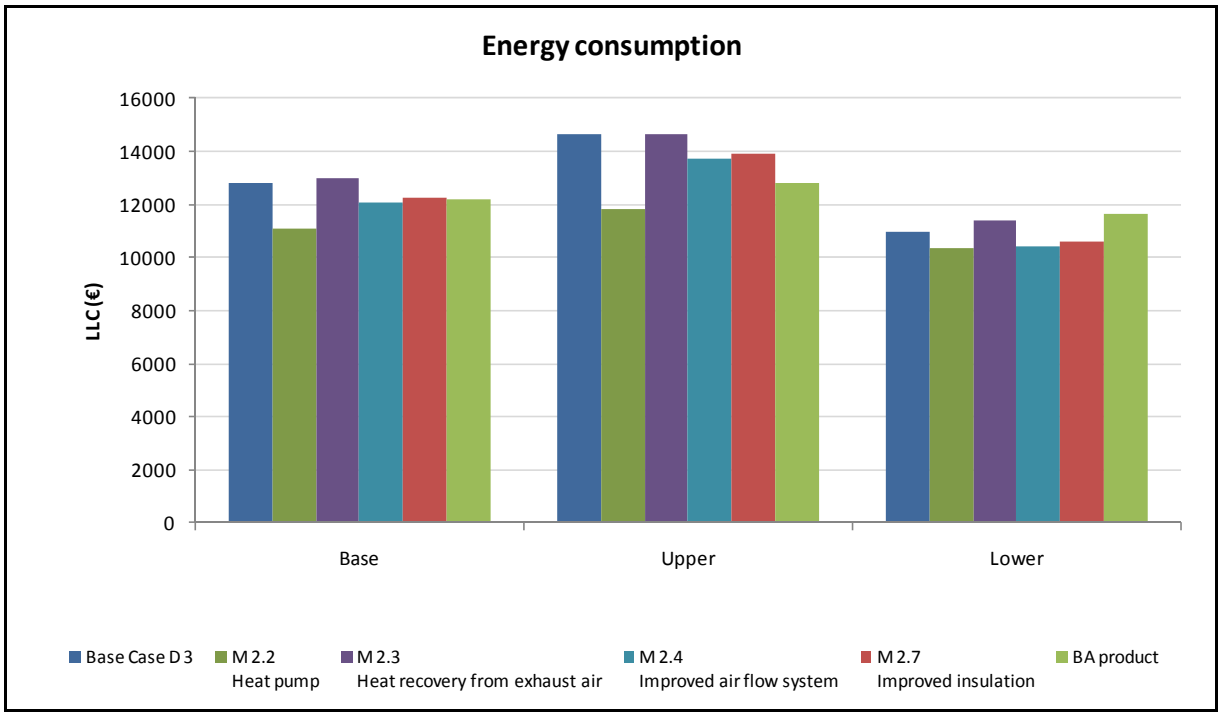


Figure 74 Base case D 3 and improvement options – impact of energy consumption on LCC by product

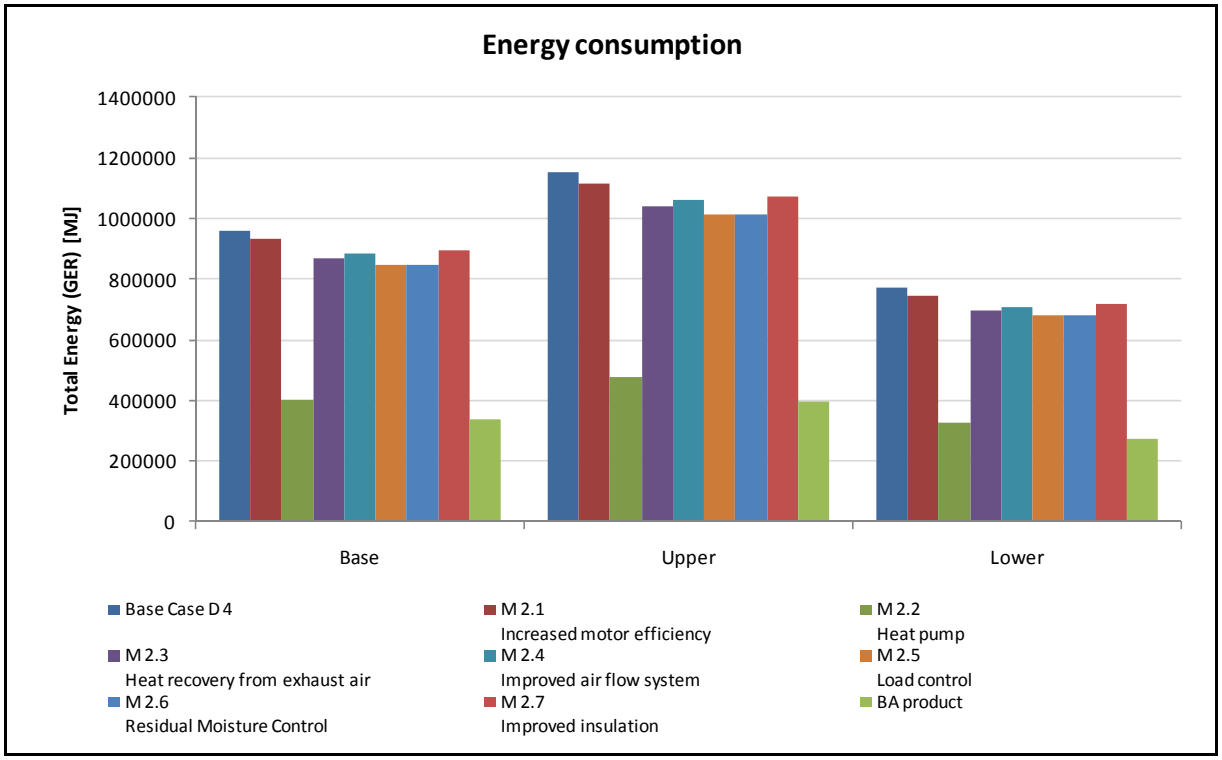


Figure 75 Base case D 4 and improvement options – impact of energy consumption on total energy over life time by product

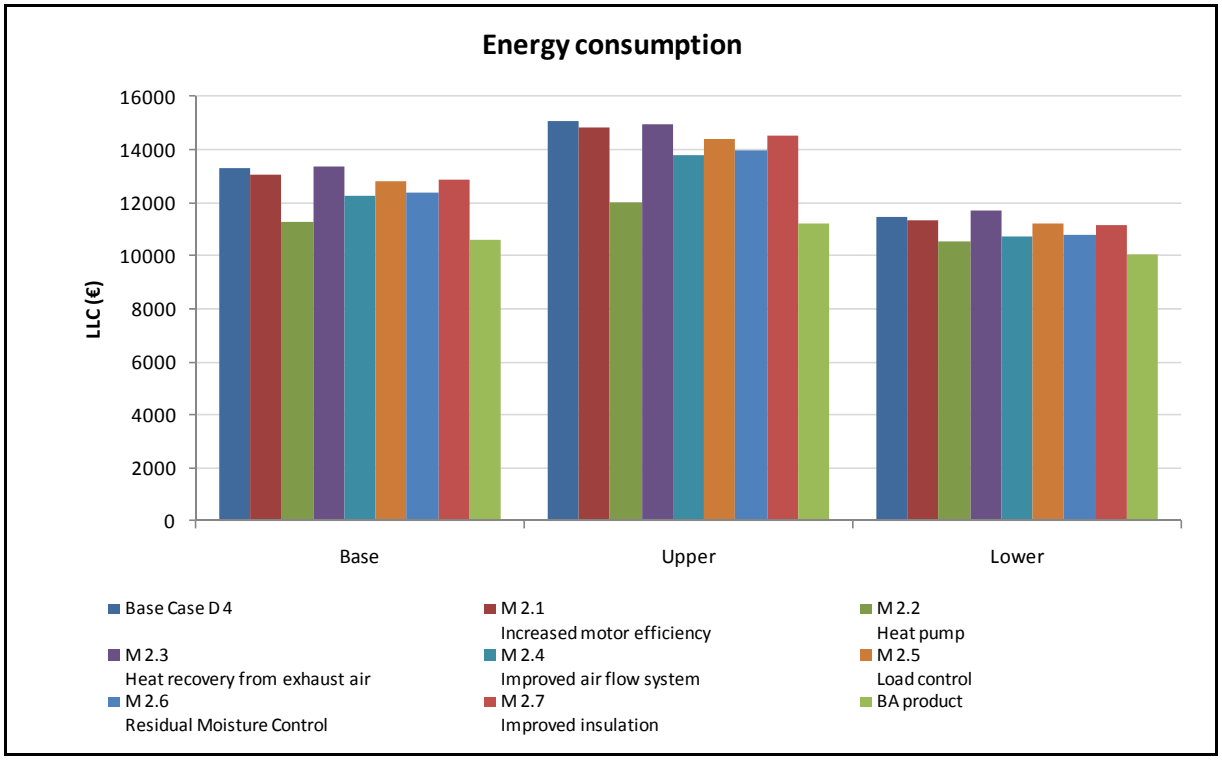


Figure 76 Base case D 4 and improvement options – impact of energy consumption on LCC by product

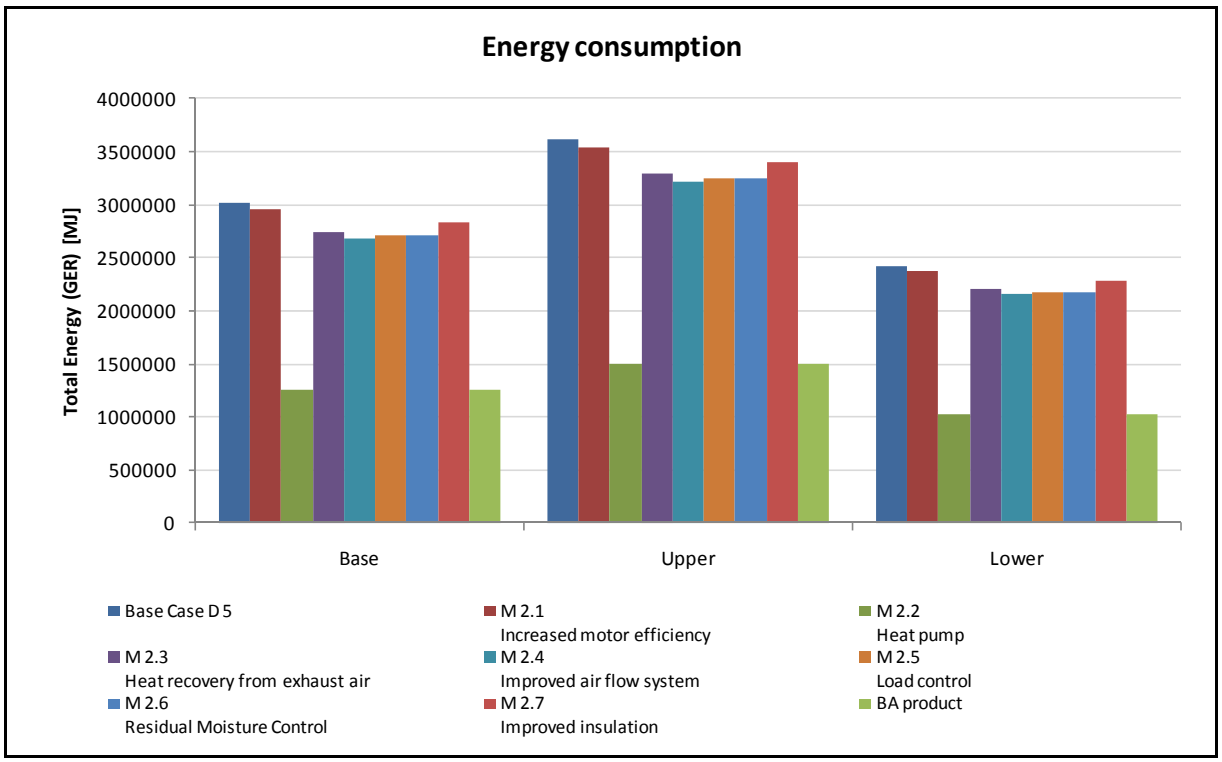


Figure 77 Base case D 5 and improvement options – impact of energy consumption on total energy over life time by product

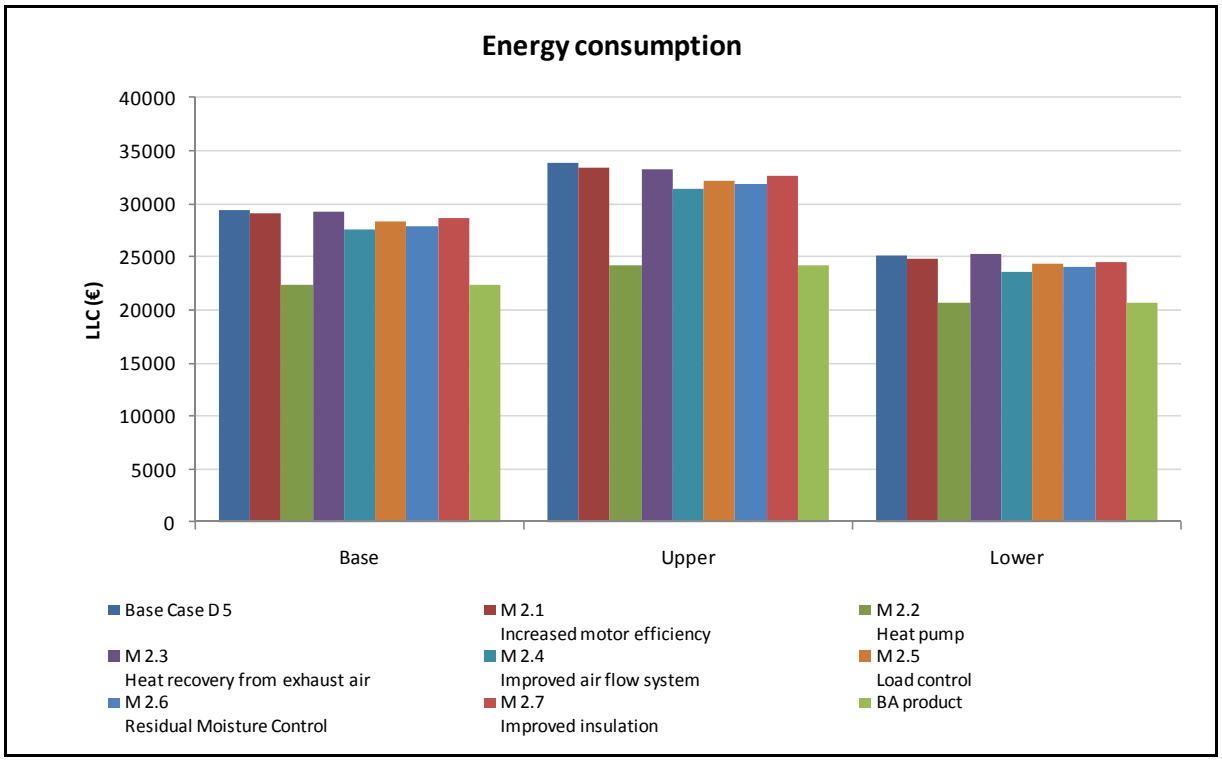


Figure 78 Base case D 5 and improvement options – impact of energy consumption on LCC by product

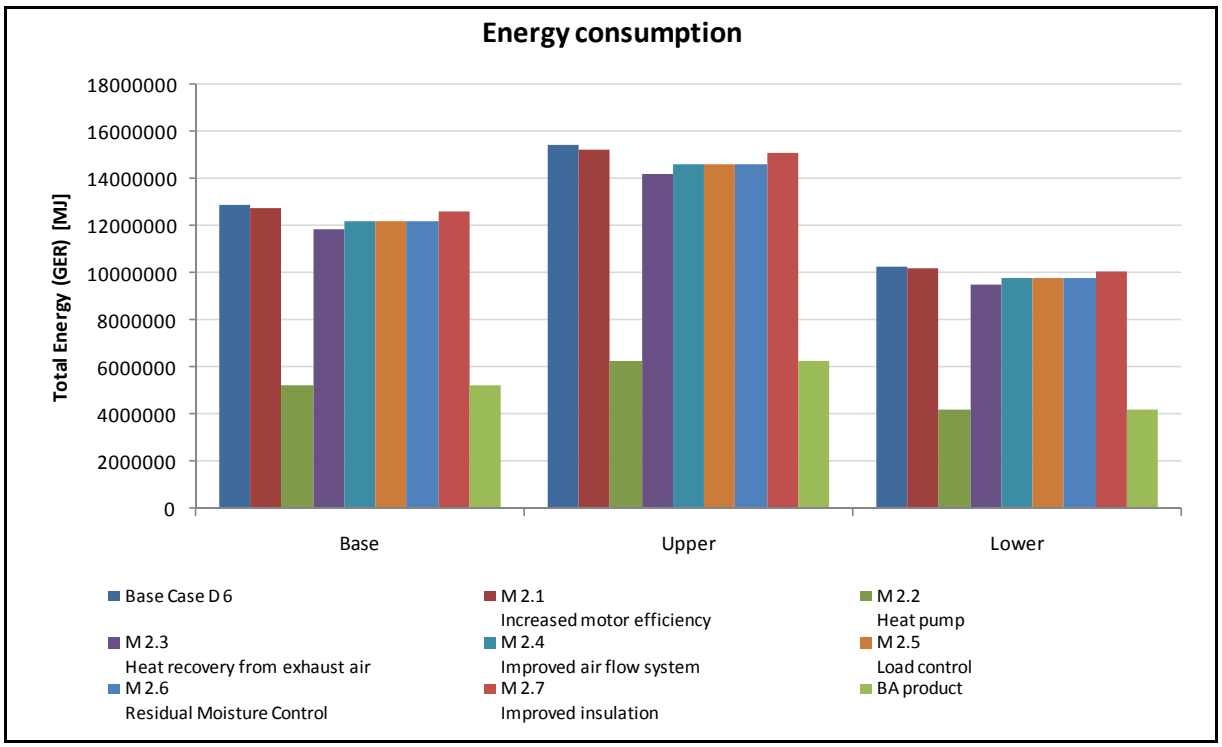


Figure 79 Base case D 6 and improvement options – impact of energy consumption on total energy over life time by product

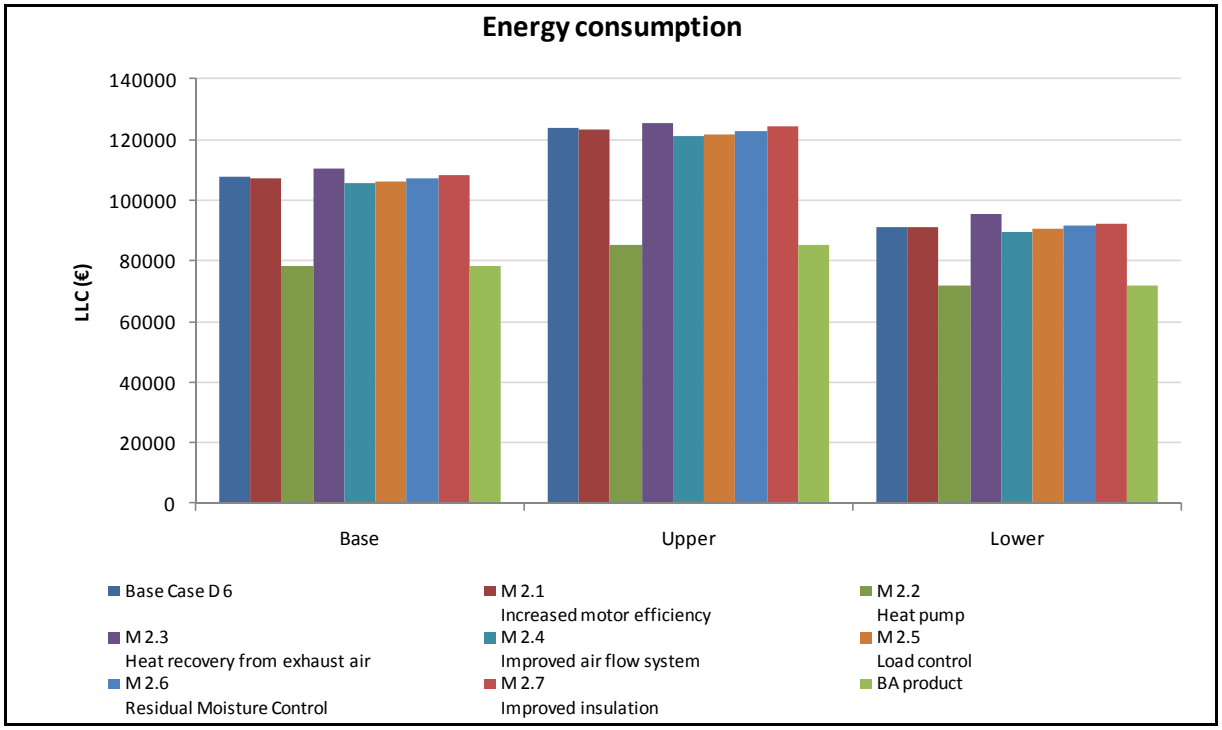


Figure 80 Base case D 6 and improvement options – impact of energy consumption on LCC by product

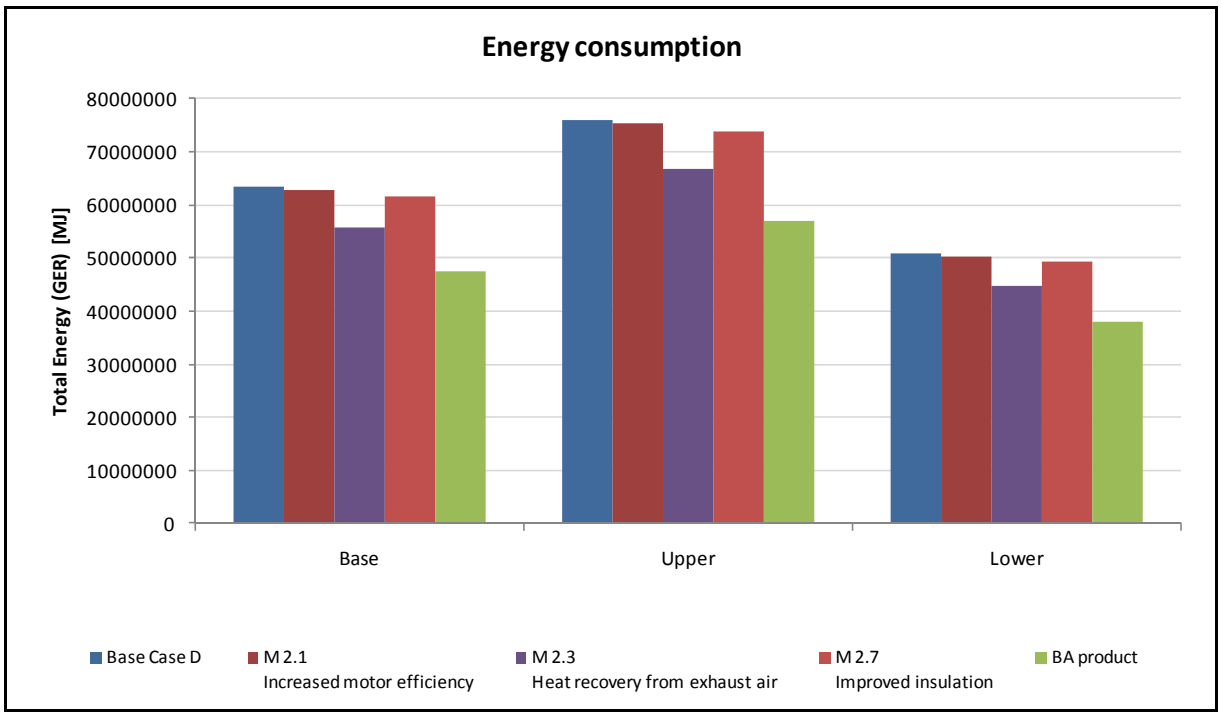


Figure 81 Base case D 7 and improvement options – impact of energy consumption on total energy over life time by product

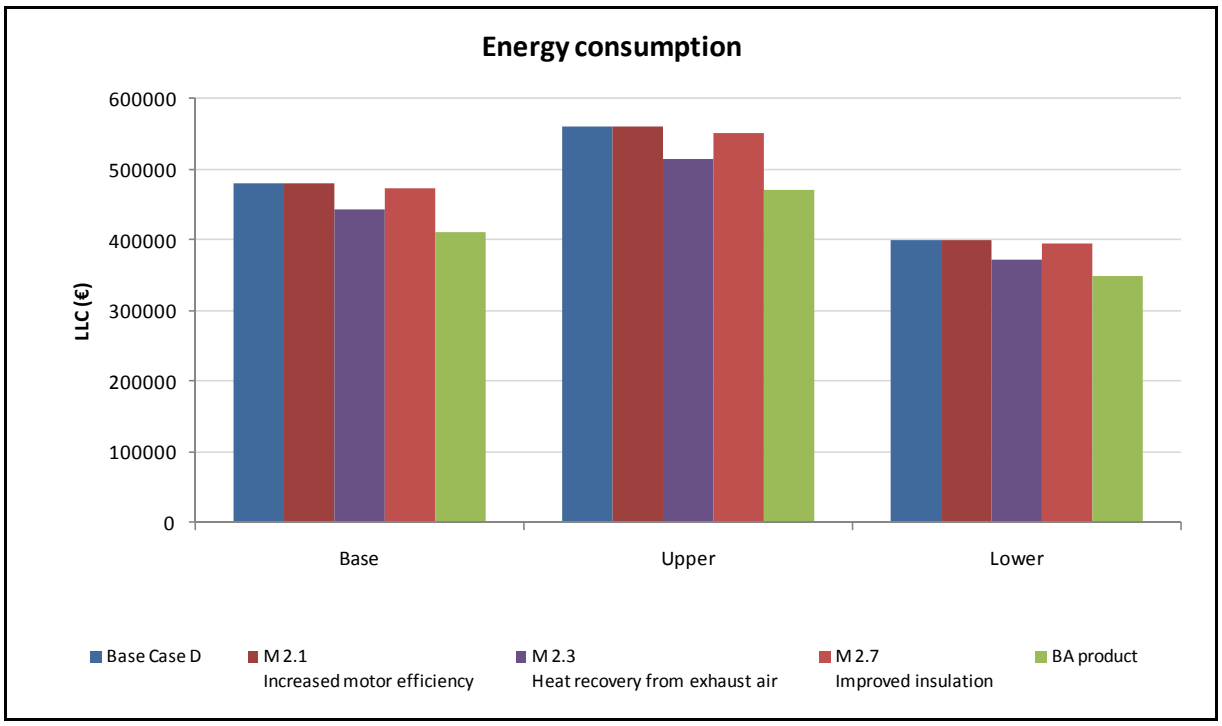


Figure 82 Base case D 7 and improvement options – impact of energy consumption on LCC by product

4.2 Intensity of use

4.2.1 Assumptions

In Task 4, average energy, water and detergent consumption data were determined for the base cases. These parameters are directly dependent on the intensity of use of the machines (i.e. the number of kg of laundry washed per year). This intensity can be variable depending on the end user and the type of application and assumptions on this parameter have been made in Task 4 (related to the main market segment considered).

The sensitivity analysis will consider an error margin of 20% on the given values, both for minimum and maximum values. The tested values are therefore presented in Table 19.

Table 20, Table 18 and Table 19 present the calculated values of the energy, water and detergent consumption corresponding to the minimum and maximum intensity of use: in contrast to Section 4.1, these consumption values now vary simultaneously in the analysis. The analysis is made only for professional washing machines as it would give the same results for dryers than the results in Section 4.1 (as only energy consumption occurs for dryers).

Table 19 Use intensity range for the sensitivity analysis

Base Case	Base typical use intensity (kg of laundry per year)	Min	Max
WM 1 - Semi-professional washer extractor	7 000	5 600	8 400
WM 2 - Professional washing extractor (<15 kg)	14 400	11 520	17 280
WM 3 - Professional washing extractor (15–40 kg)	42 200	33 760	50 640
WM 4 - Professional washing extractor (>40 kg)	194 400	155 520	233 280
WM 5 - Professional washer dryer	7 400	5 920	8 880
WM 6 - Professional barrier washer	56 300	45 040	67 560
WM 7 - Washing tunnel machine	3 825 000	3 060 000	4 590 000

Table 20 Energy consumption range corresponding to the use intensity range for the sensitivity analysis

Base case	Base total energy consumption (kWh per year)	Min	Max
WM 1 - Semi-professional washer extractor	1 332	1 066	1 598
WM 2 - Professional washing extractor (<15 kg)	3 026	2 421	3 631
WM 3 - Professional washing extractor (15–40 kg)	10 973	8 778	13 168
WM 4 - Professional washing extractor (>40 kg)	81 648	65 318	97 978
WM 5 - Professional washer dryer	7 400	5 920	8 880
WM 6 - Professional barrier washer	26 461	21 169	31 753
WM 7 - Washing tunnel machine	1 606 500	1 285 200	1 927 800

Table 21 Water consumption range corresponding to the use intensity range for the sensitivity analysis

Base case	Base water consumption (m^3 per year)	Min	Max
WM 1 - Semi-professional washer extractor	85	68	102
WM 2 - Professional washing extractor (<15 kg)	233	186	280
WM 3 - Professional washing extractor (15–40 kg)	741	593	889
WM 4 - Professional washing extractor (>40 kg)	3 266	2 613	3 919
WM 5 - Professional washer dryer	100	80	120
WM 6 - Professional barrier washer	1 081	865	1 297
WM 7 - Washing tunnel machine	27 540	22 032	33 048

Table 22 Detergent consumption range corresponding to the use intensity range for the sensitivity analysis

Base case	Base detergent consumption (kg per year)	Min	Max
WM 1 - Semi-professional washer extractor	161	129	193
WM 2 - Professional washing extractor (<15 kg)	330	264	396
WM 3 - Professional washing extractor (15–40 kg)	798	638	958
WM 4 - Professional washing extractor (>40 kg)	4 199	3 359	5 039
WM 5 - Professional washer dryer	140	112	168
WM 6 - Professional barrier washer	1 216	973	1 459
WM 7 - Washing tunnel machine	41 310	33 048	49 572

4.2.2 Results

Figure 83 to Figure 96 show the influence of the variation of the intensity of use on the total energy consumption and the life cycle costs of the different washing machine base cases and associated improvement options.

The option leading to the lowest energy consumption or life cycle costs always remain the same for a given base case, whatever the intensity use values considered (base, lower or upper). However, a few relative changes in the rankings of options happen, for instance:

- For base case WM 2, the LCC of M 1.3 option becomes higher than the LCC of the base case with the lower values;
- For base case WM 3, the LCC of M 1.3 option becomes higher than the LCC of the base case with the lower values;
- For base case WM 6, the LCC of the BA product becomes lower than the LCC of the base case with the upper values.

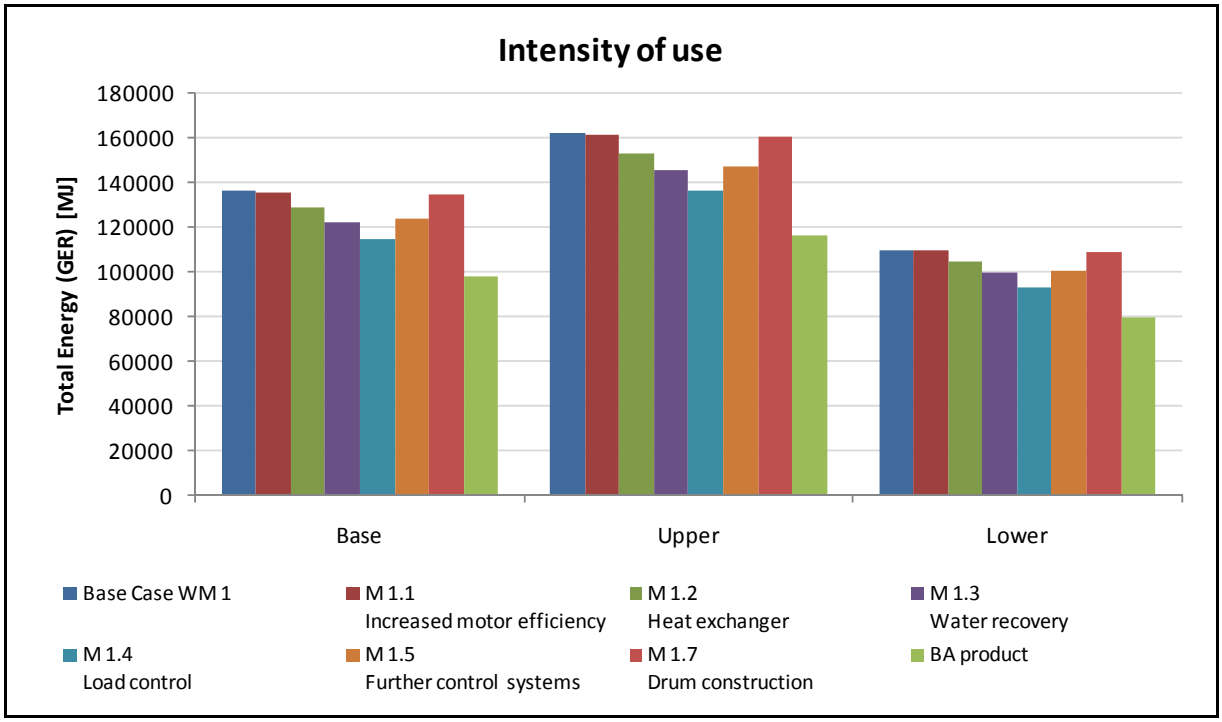


Figure 83 Base case WM 1 and improvement options – impact of intensity of use on total energy over life time by product

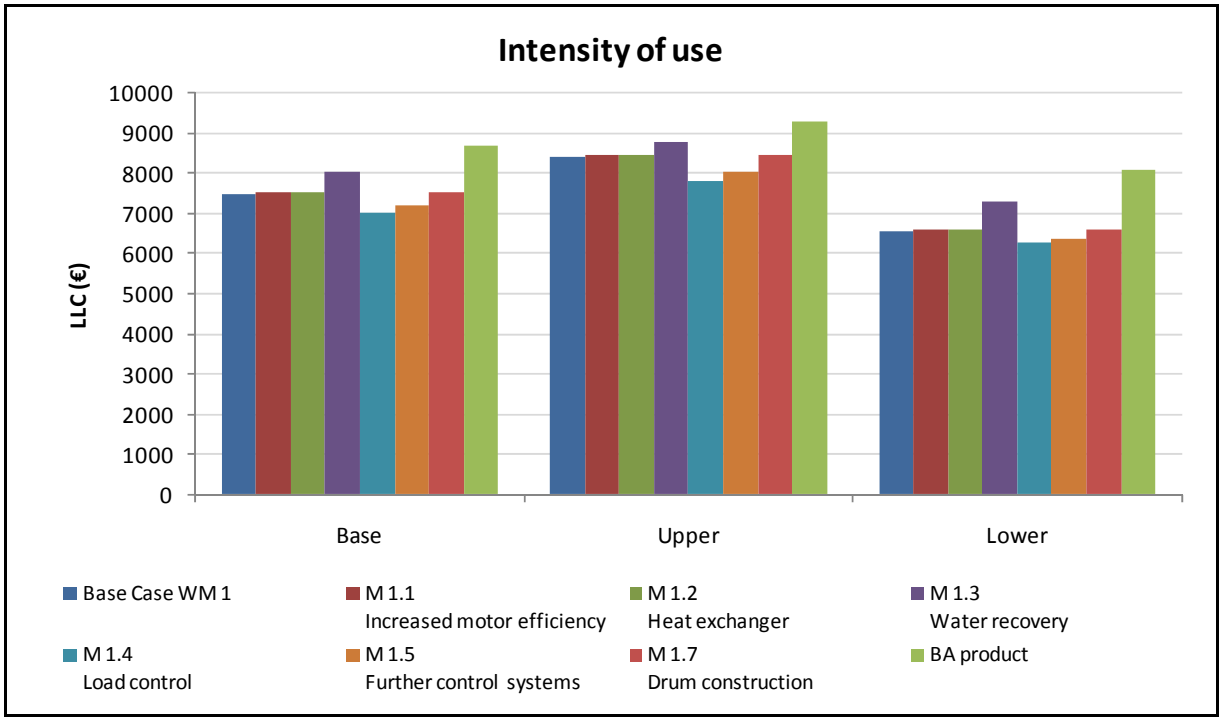


Figure 84 Base case WM 1 and improvement options – impact of intensity of use on LCC by product

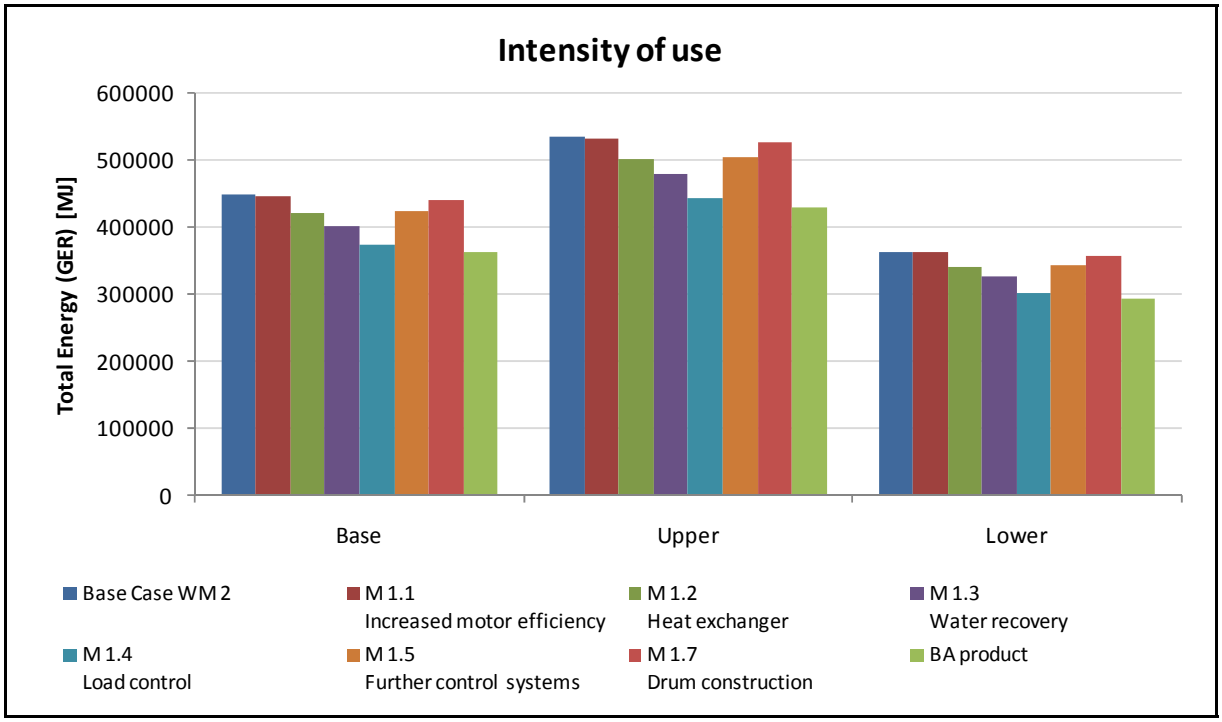


Figure 85 Base case WM 2 and improvement options – impact of intensity of use on total energy over life time by product.

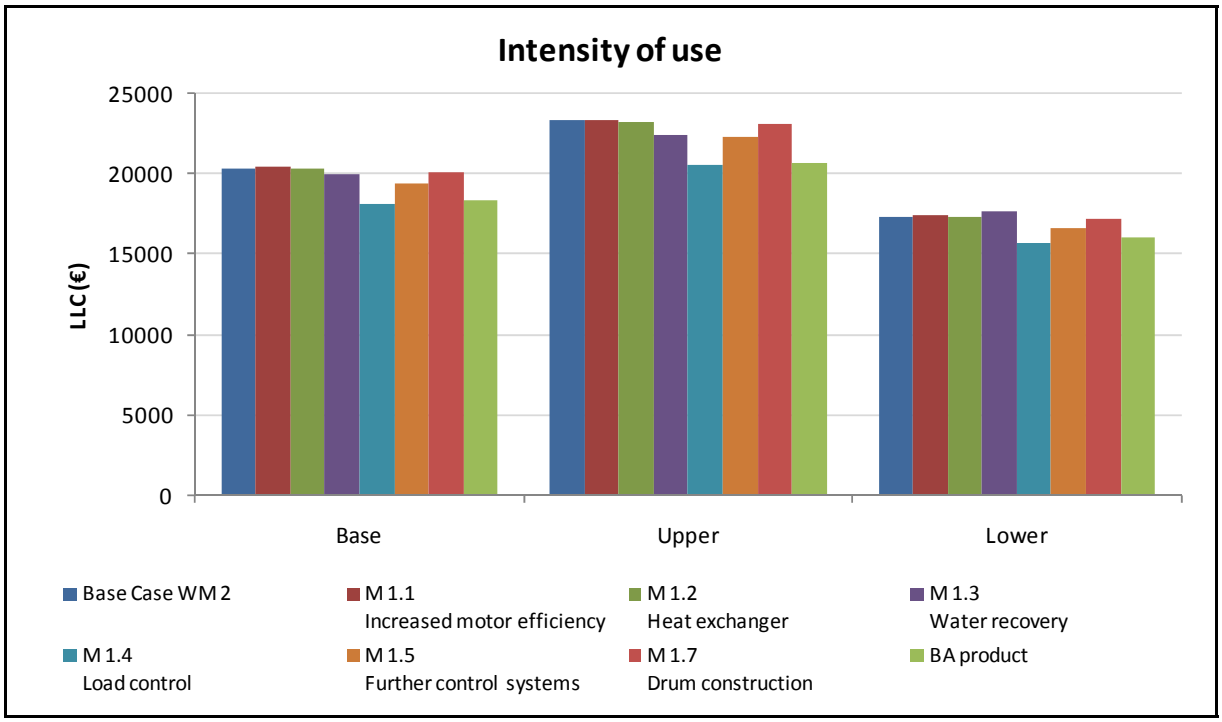


Figure 86 Base case WM 2 and improvement options – impact of intensity of use on LCC by product

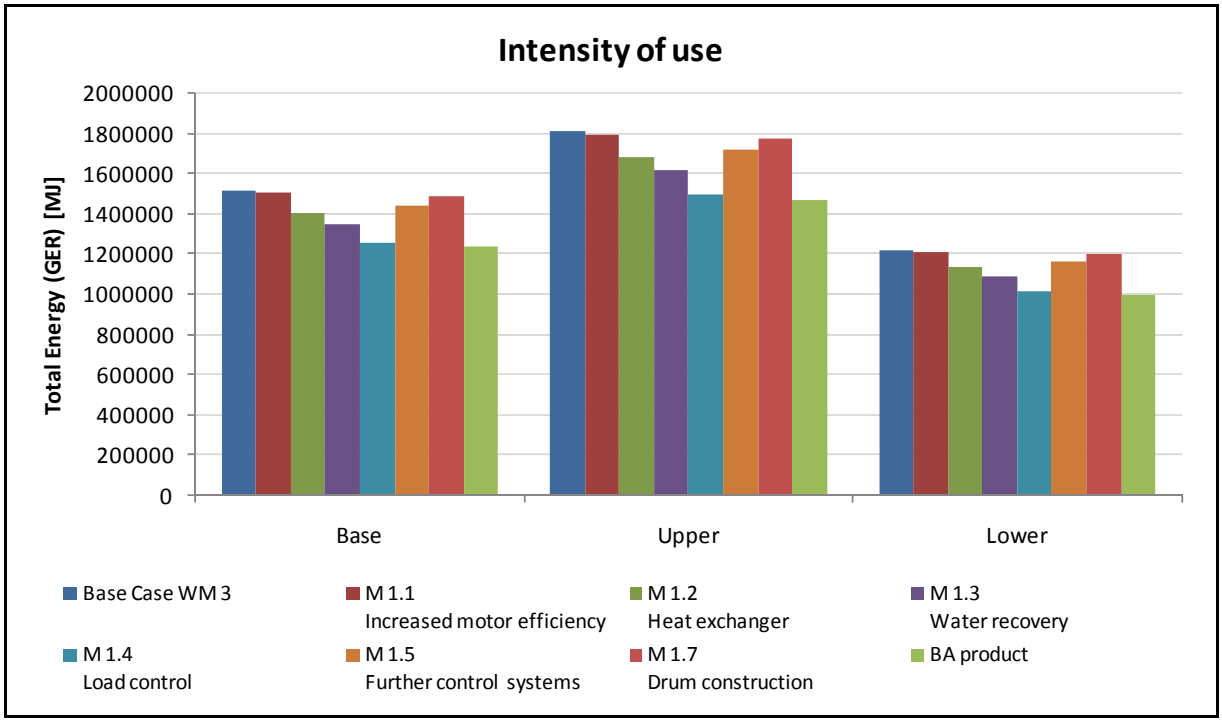


Figure 87 Base case WM 3 and improvement options – impact of intensity of use on total energy over life time by product

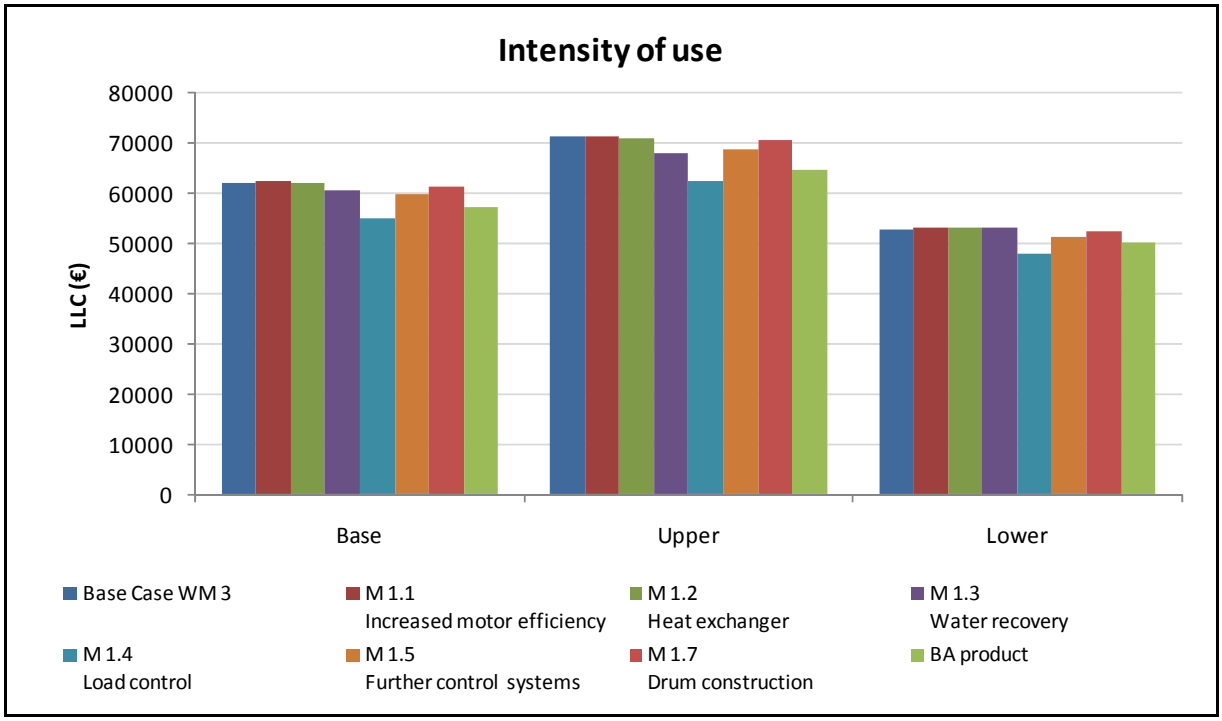


Figure 88 Base case WM 3 and improvement options – impact of intensity of use on LCC by product

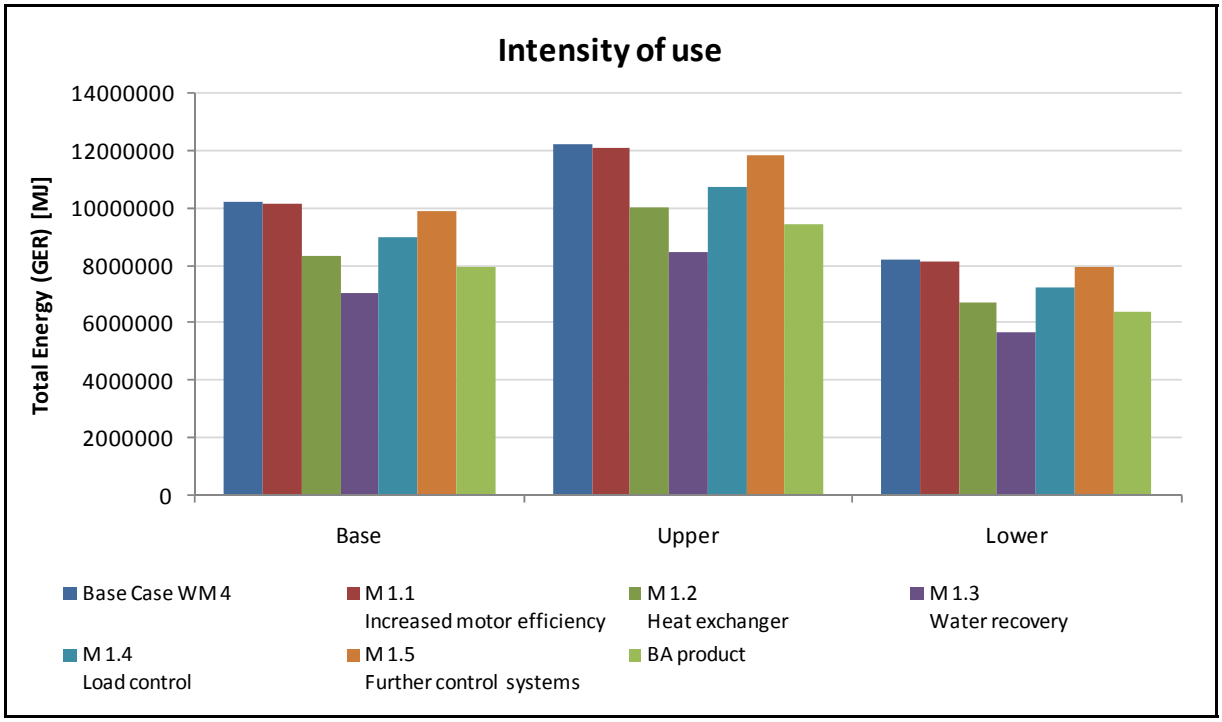


Figure 89 Base case WM 4 and improvement options – impact of intensity of use on total energy over life time by product

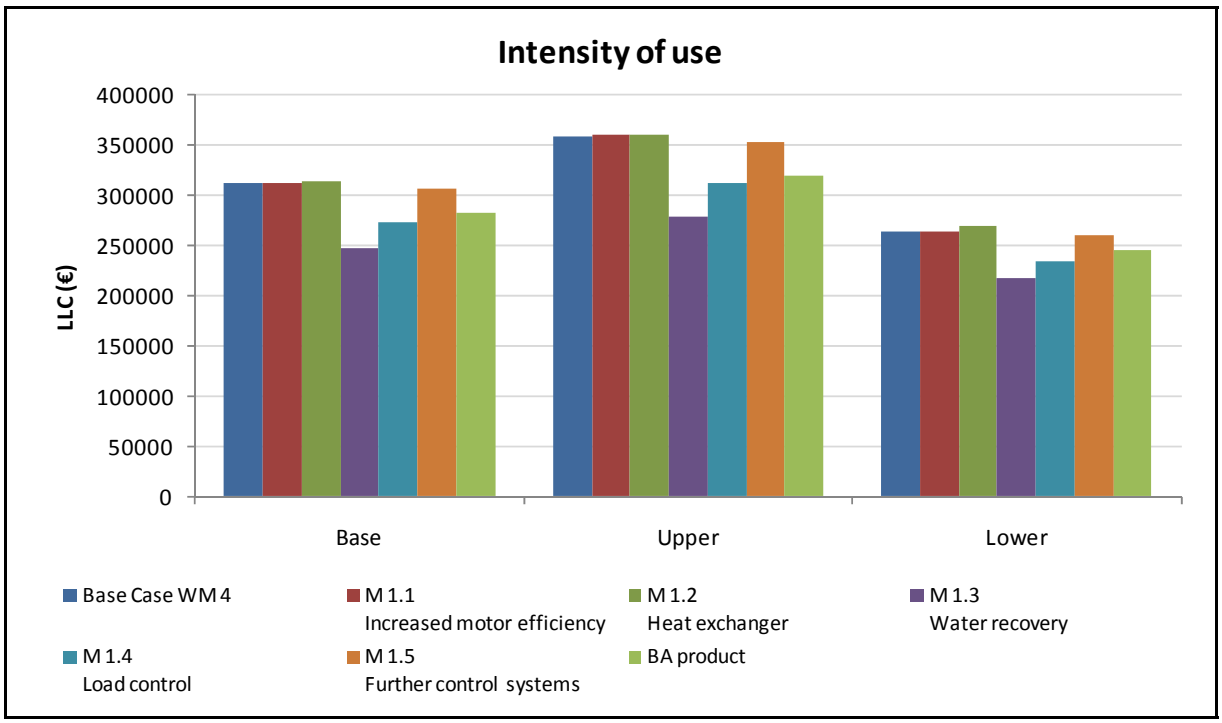


Figure 90 Base case WM 4 and improvement options – impact of intensity of use on LCC by product

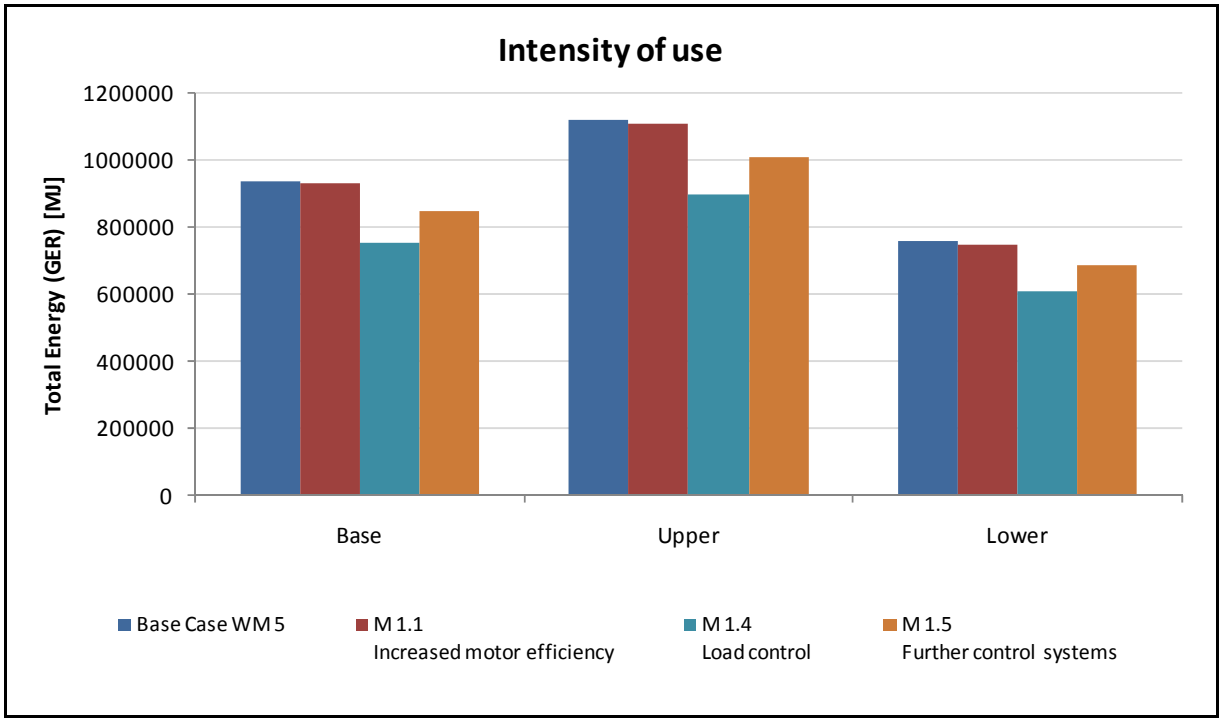


Figure 91 Base case WM 5 and improvement options – impact of intensity of use on total energy over life time by product

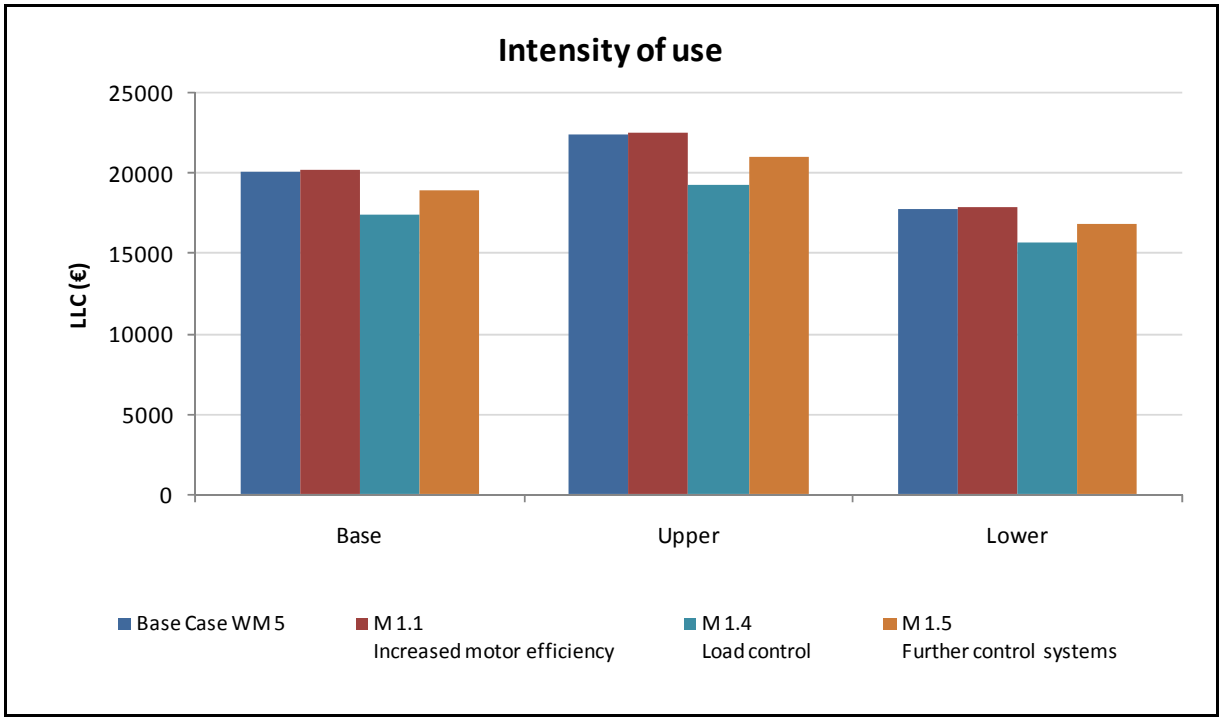


Figure 92 Base case WM 5 and improvement options – impact of intensity of use on LCC by product

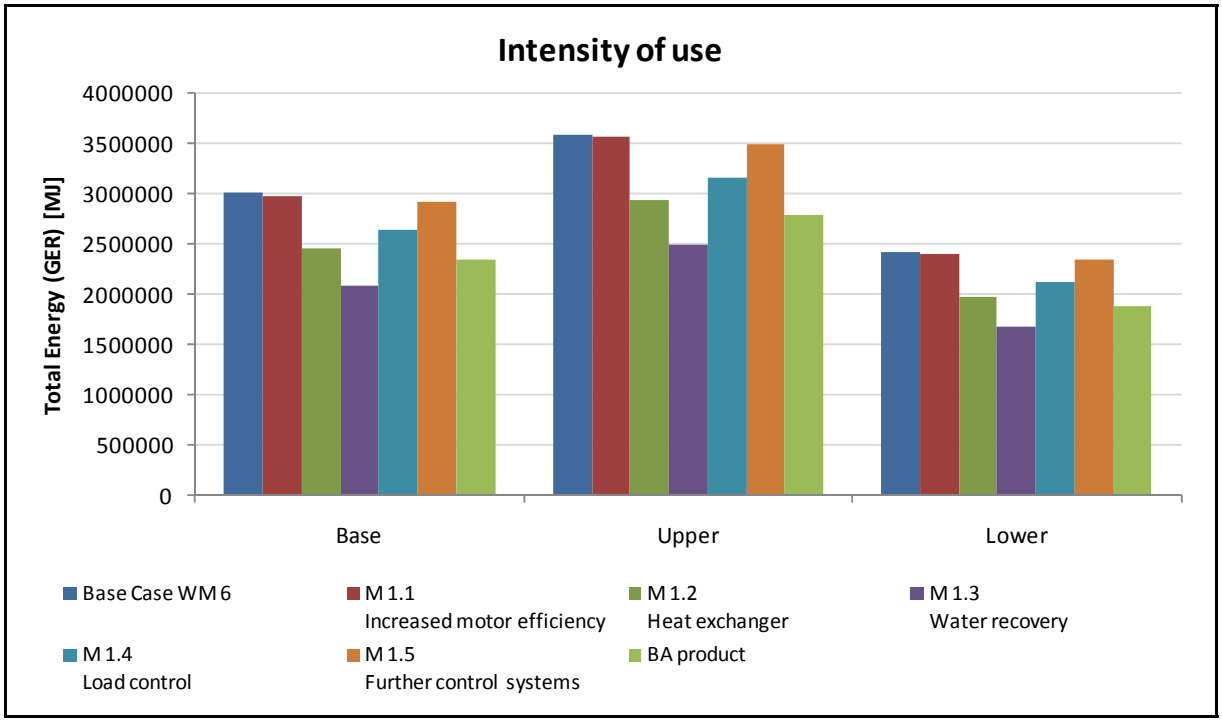


Figure 93 Base case WM 6 and improvement options – impact of intensity of use on total energy over life time by product

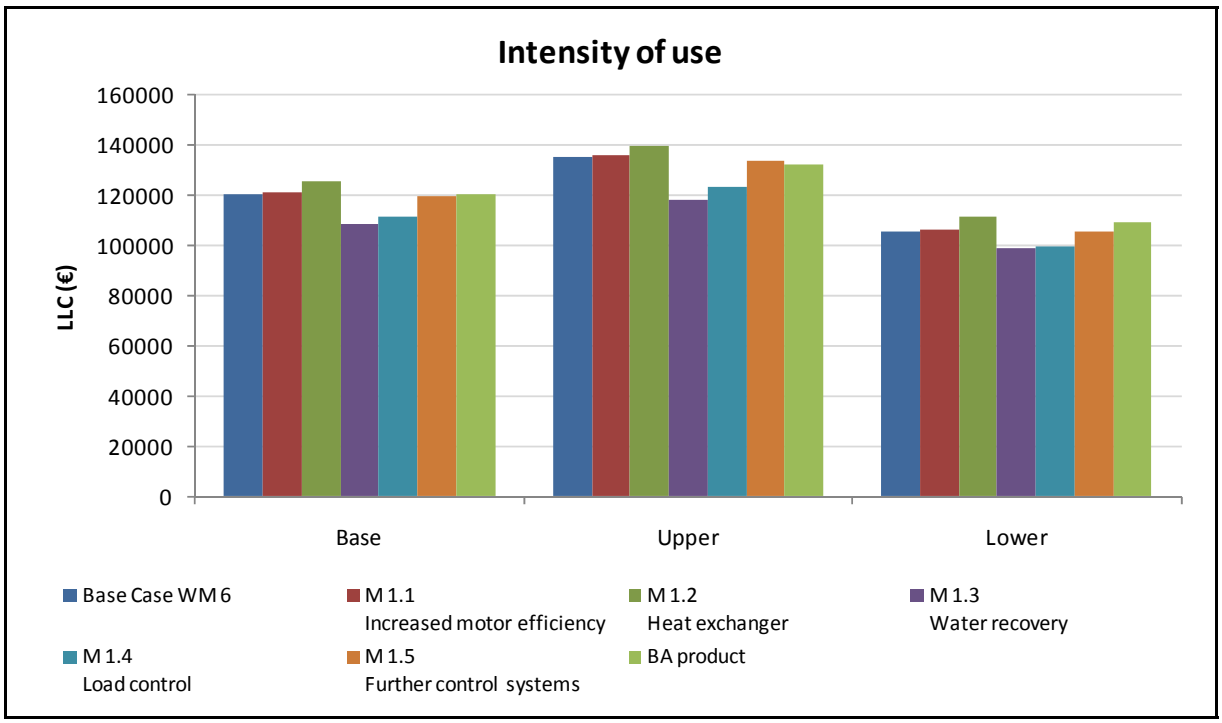


Figure 94 Base case WM 6 and improvement options – impact of intensity of use on LCC by product

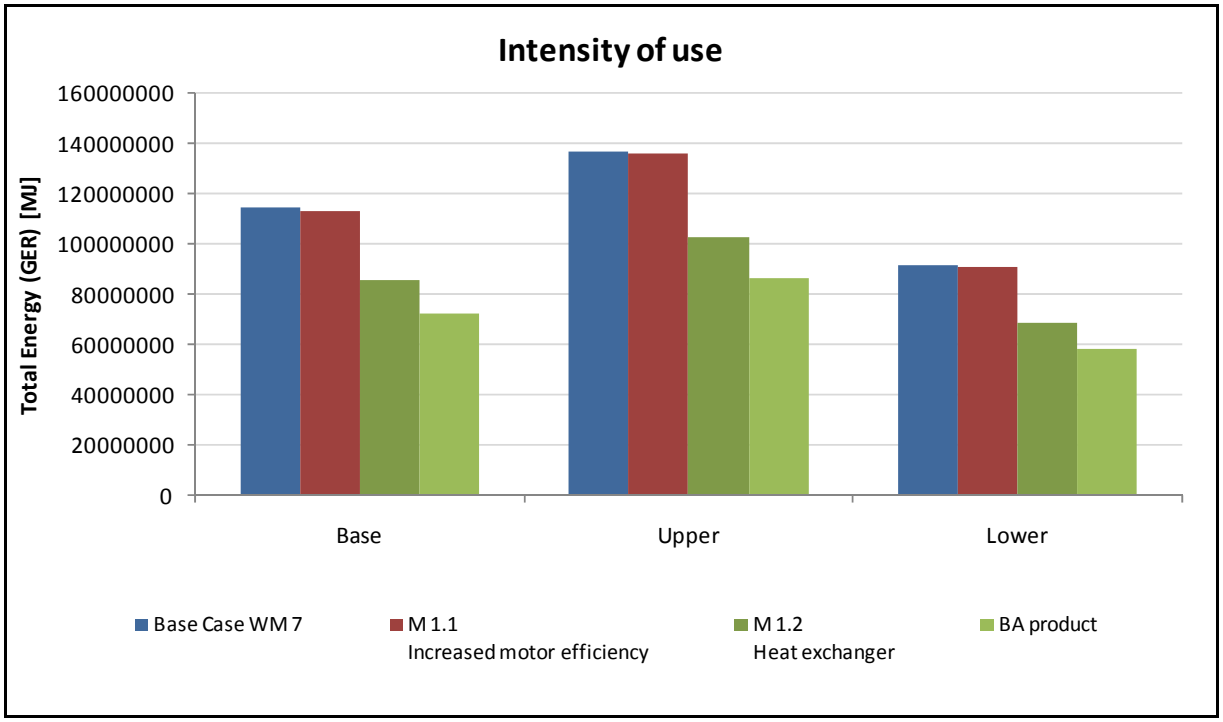


Figure 95 Base case WM 7 and improvement options – impact of intensity of use on total energy over life time by product

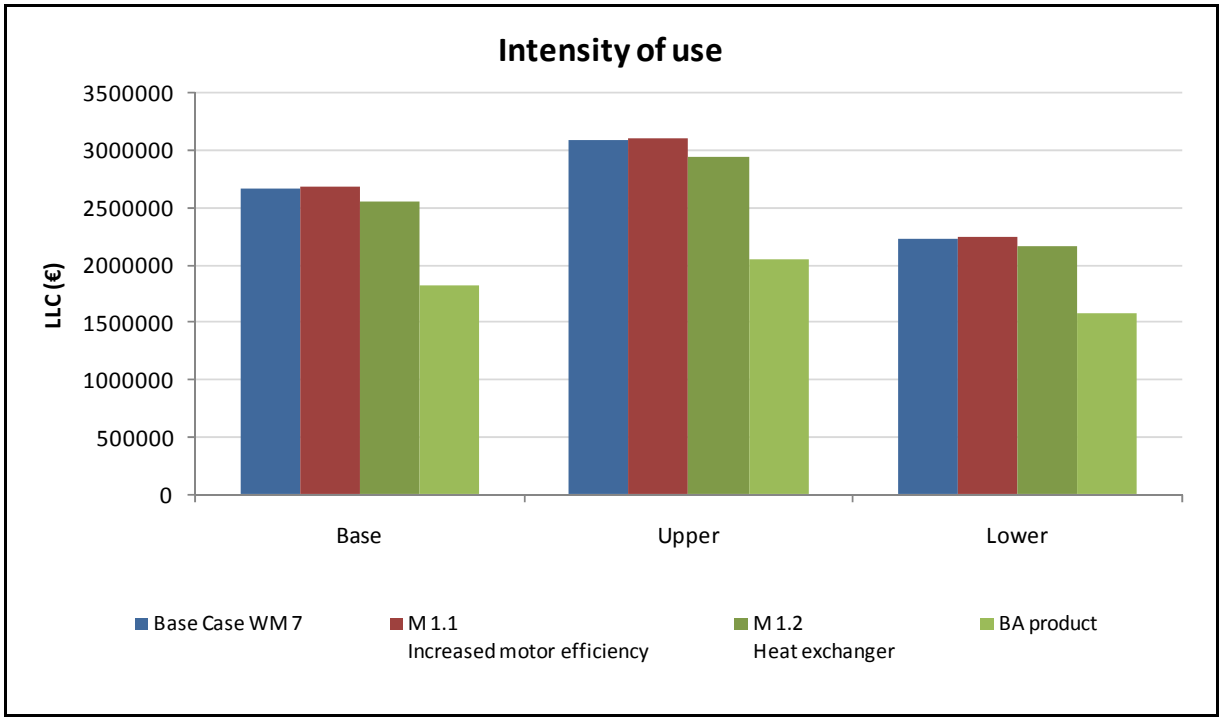


Figure 96 Base case WM 7 and improvement options – impact of intensity of use on LCC by product

4.3 Product life time

4.3.1 Assumptions

The product life time is a major assumption as it has an influence on both the environmental impacts (by increasing the impacts of the use phase) and the life cycle costs (by increasing the operating costs during the use phase). Given the importance of the use phase as discussed in Task 5, it is paramount to take this parameter into account in the sensitivity analysis. Table 23 presents the minimum and maximum values that will be used for each base case: an error of 2 years is assumed between extreme values and the average life times considered in the study.

Table 23 Product life time ranges for the sensitivity analysis

Base case	Base product life time (in years)	Min	Max
WM 1 - Semi-professional washer extractor	8	6	10
WM 2 - Professional washing extractor (<15 kg)	12	10	14
WM 3 - Professional washing extractor (15–40 kg)	14	12	16
WM 4 - Professional washing extractor (>40 kg)	15	13	17
WM 5 - Professional washer dryer	11	9	13
WM 6 - Professional barrier Washer	14	12	16
WM 7 - Washing tunnel machine	13	11	15
D 1 - Semi-professional dryer, condenser	8	6	10
D 2 - Semi- professional dryer, air vented	8	6	10
D 3 - Professional Cabinet dryer	15	13	17
D 4 - Professional air tumble dryer (<15 kg)	13	11	15
D 5 - Professional air tumble dryer (15–40 kg)	14	12	16
D 6 - Professional air tumble dryer (>40 kg)	13	11	15
D 7 - Industrial pass-through (transfer) tumble dryer	13	11	15

4.3.2 Results

Figure 97 to Figure 124 show the influence of the variation of the life time on the total energy consumption and the life cycle costs of the different base cases and associated improvement options.

The option leading to the lowest energy consumption or life cycle costs always remain the same for a given base case, whatever the life time values considered (base, lower or upper). However, a few relative changes in the rankings of options happen, for instance:

- For base case WM 2, the LCC of M 1.3 option becomes higher than the LCC of the base case with the lower values;
- For base case WM 6, the LCC of the BA product becomes lower than the LCC of the base case with the upper values;
- For base case D 1, the LCC of the BA product becomes lower than the LCC of the base case with the upper values.

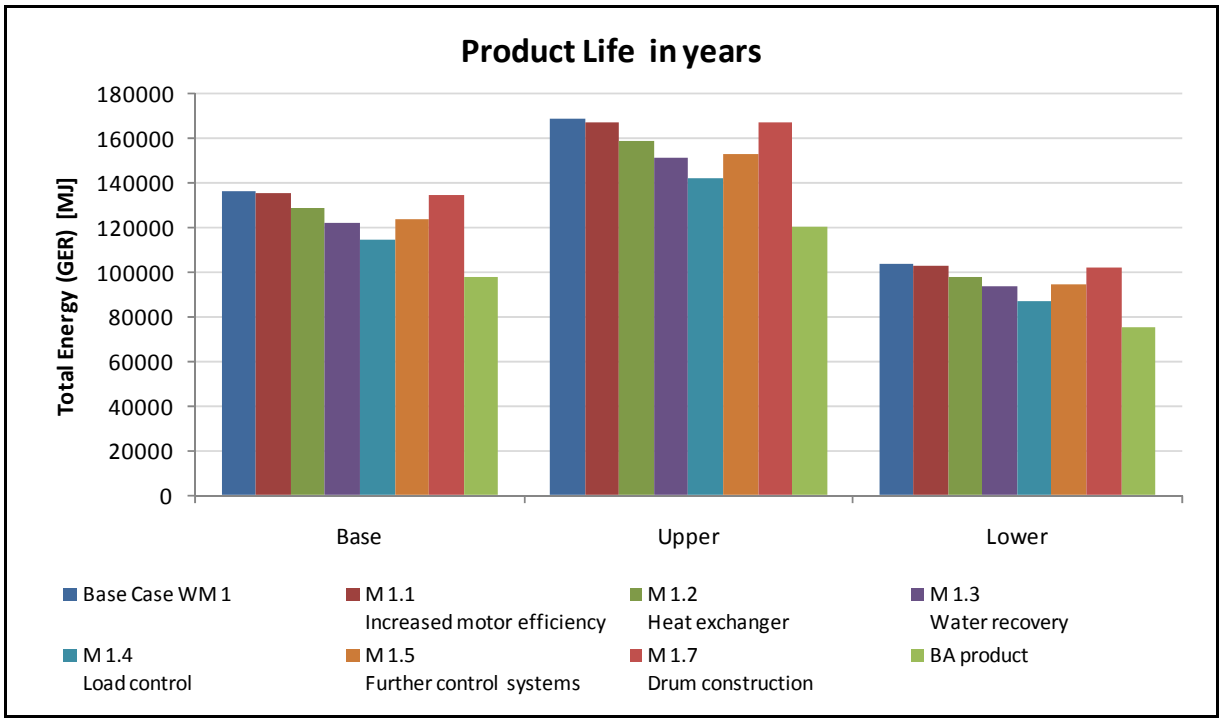


Figure 97 Base case WM 1 and improvement options – impact of life time on total energy over life time by product

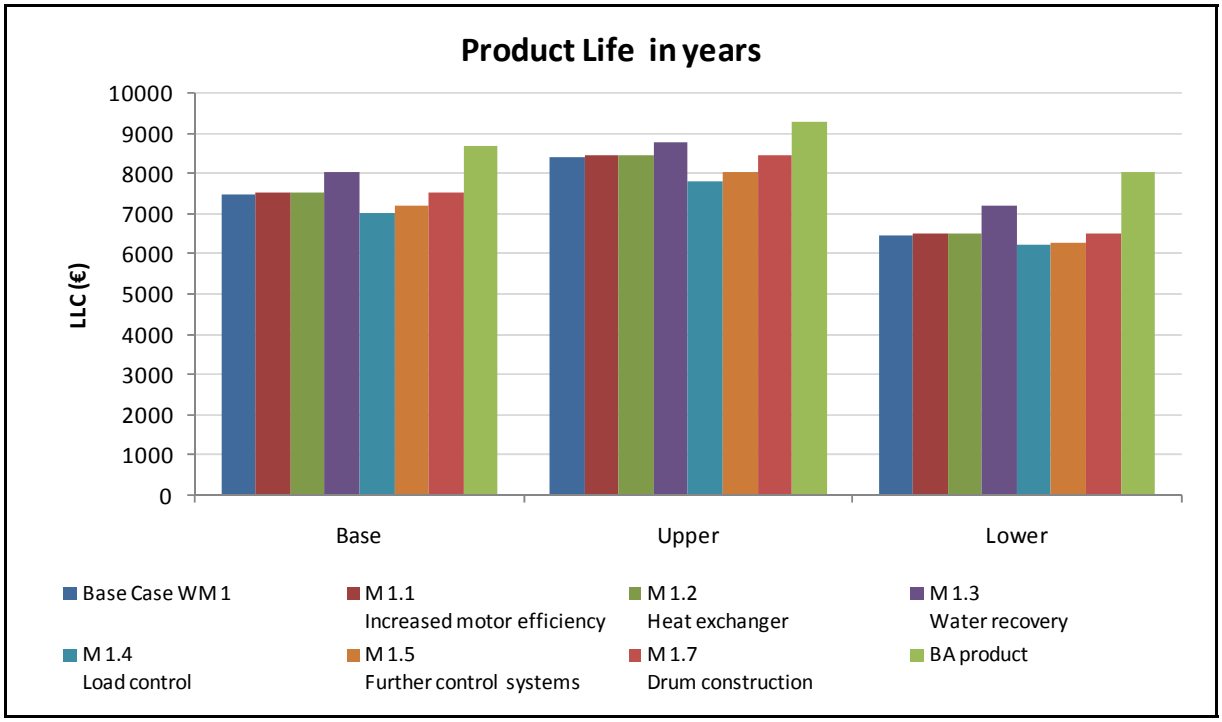


Figure 98 Base case WM 1 and improvement options – impact of life time on LCC by product

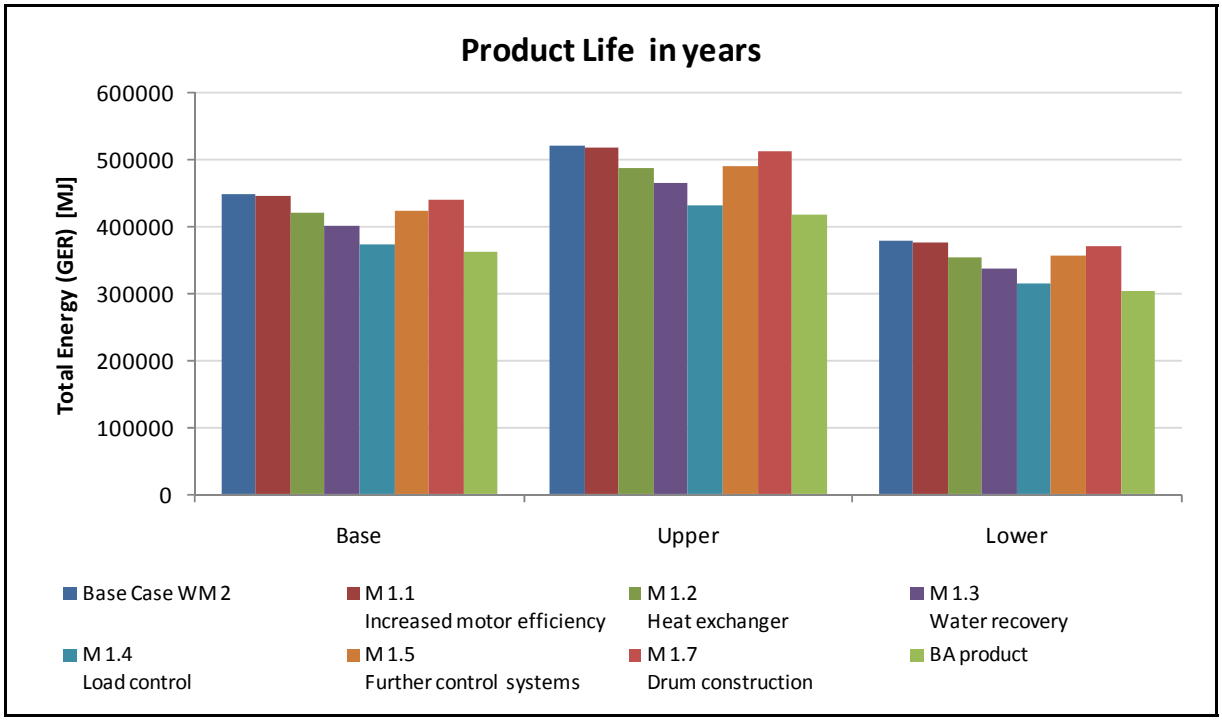


Figure 99 Base case WM 2 and improvement options – impact of life time on total energy over life time by product

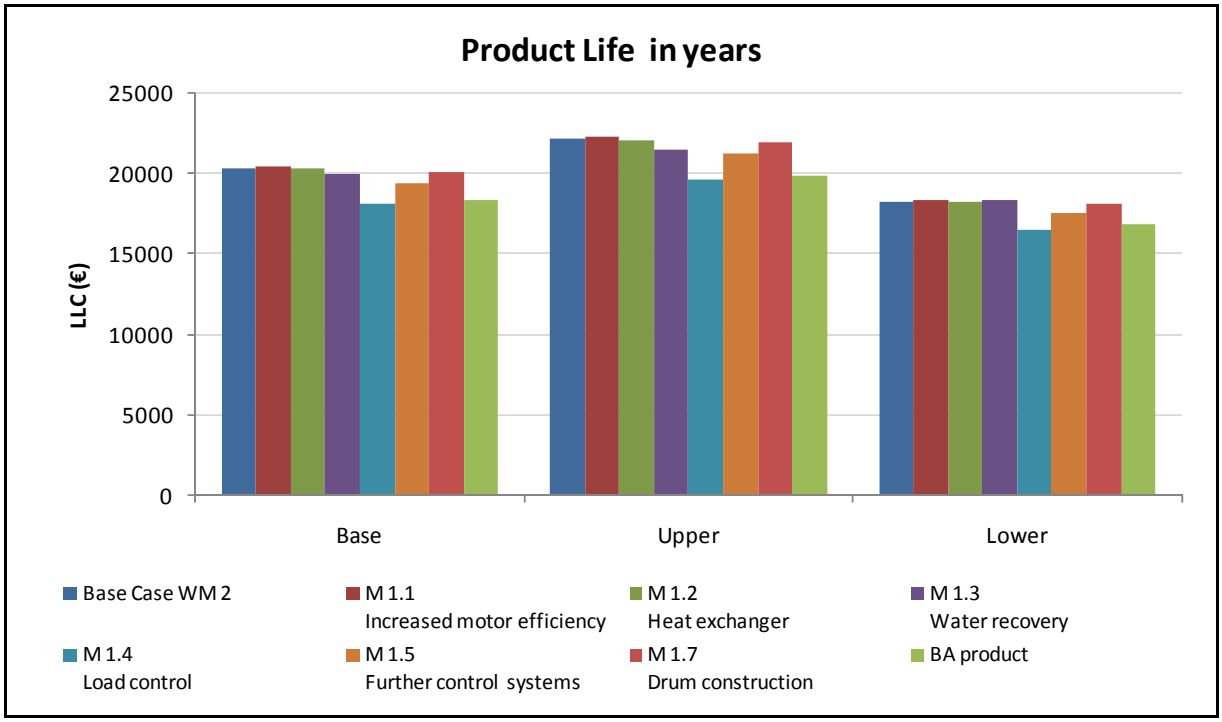


Figure 100 Base case WM 2 and improvement options – impact of life time on LCC by product

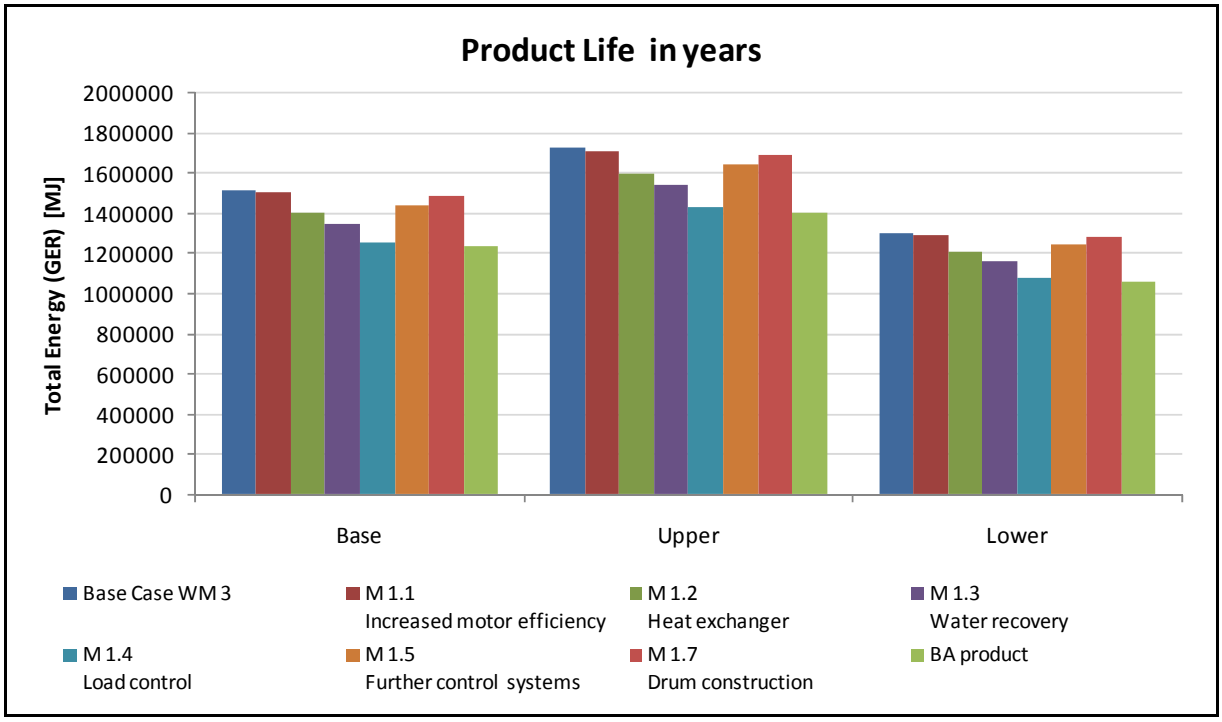


Figure 101 Base case WM 3 and improvement options – impact of life time on total energy over life time by product

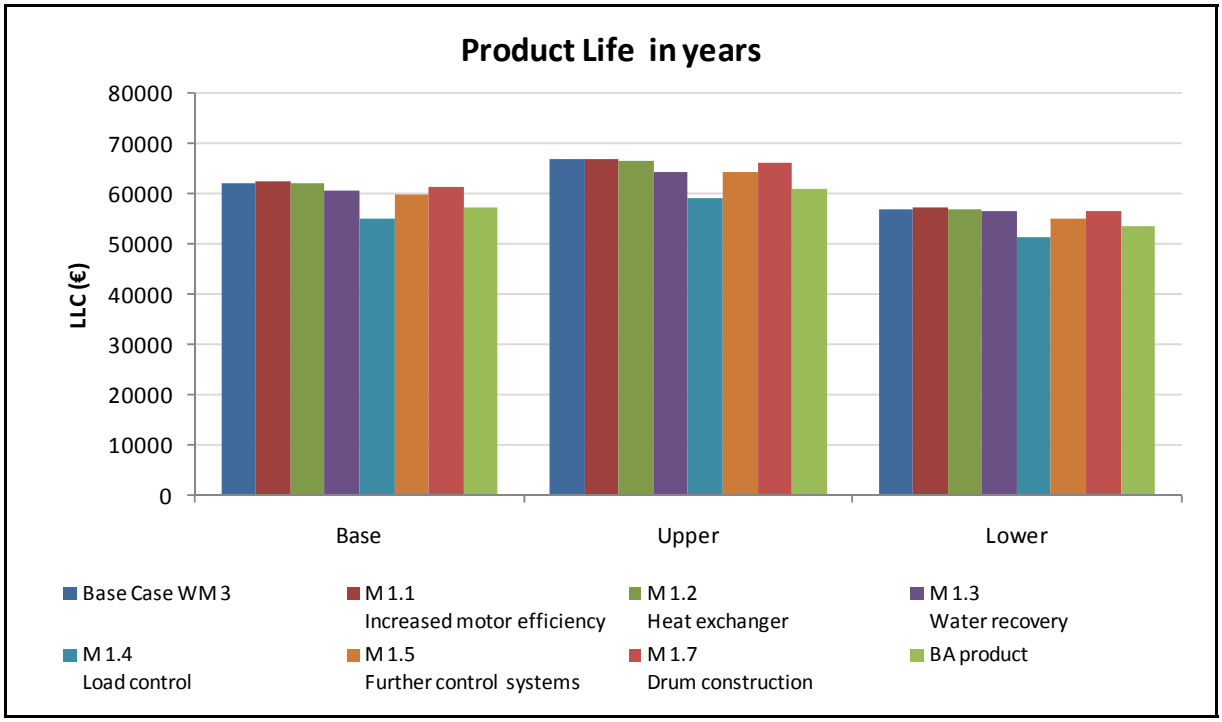


Figure 102 Base case WM 3 and improvement options – impact of life time on LCC by product

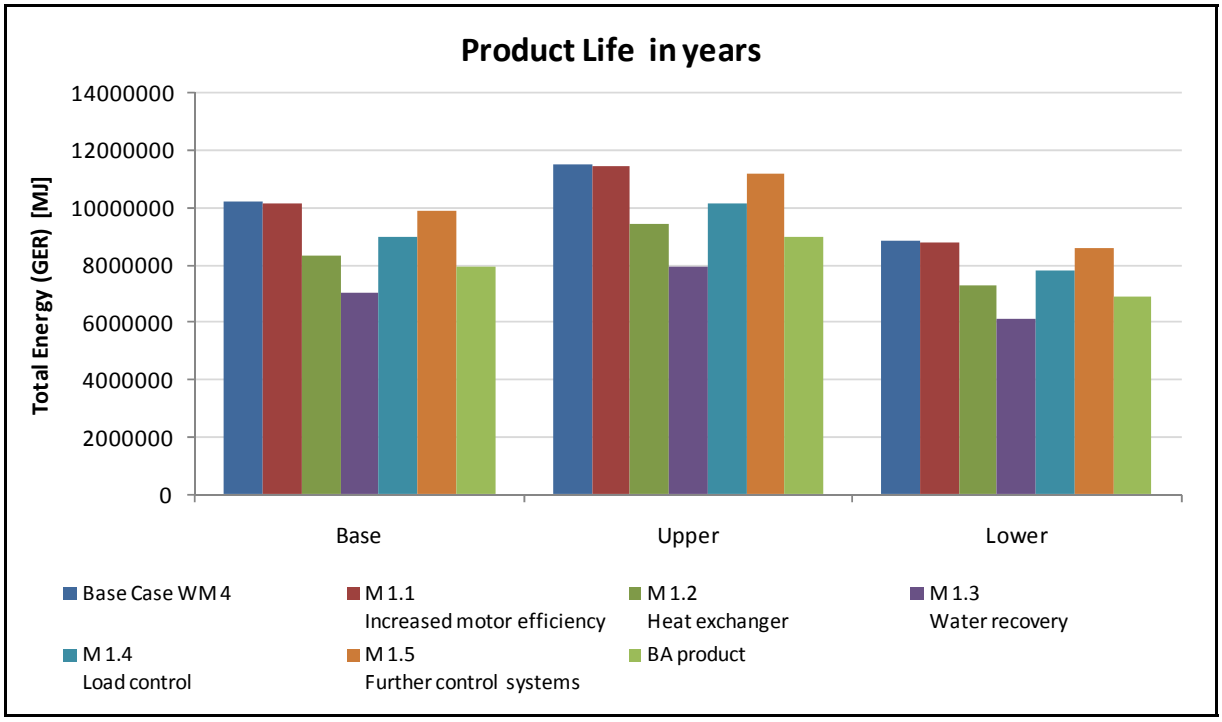


Figure 103 Base case WM 4 and improvement options – impact of life time on total energy over life time by product

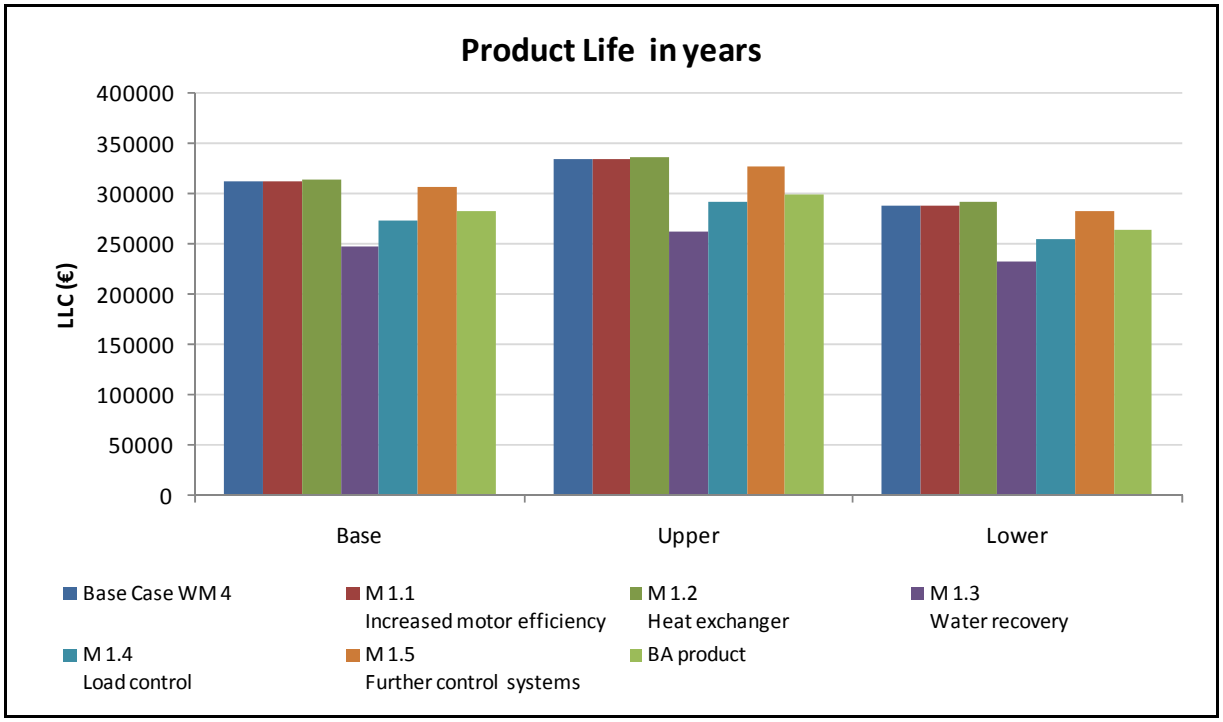


Figure 104 Base case WM 4 and improvement options – impact of life time on LCC by product

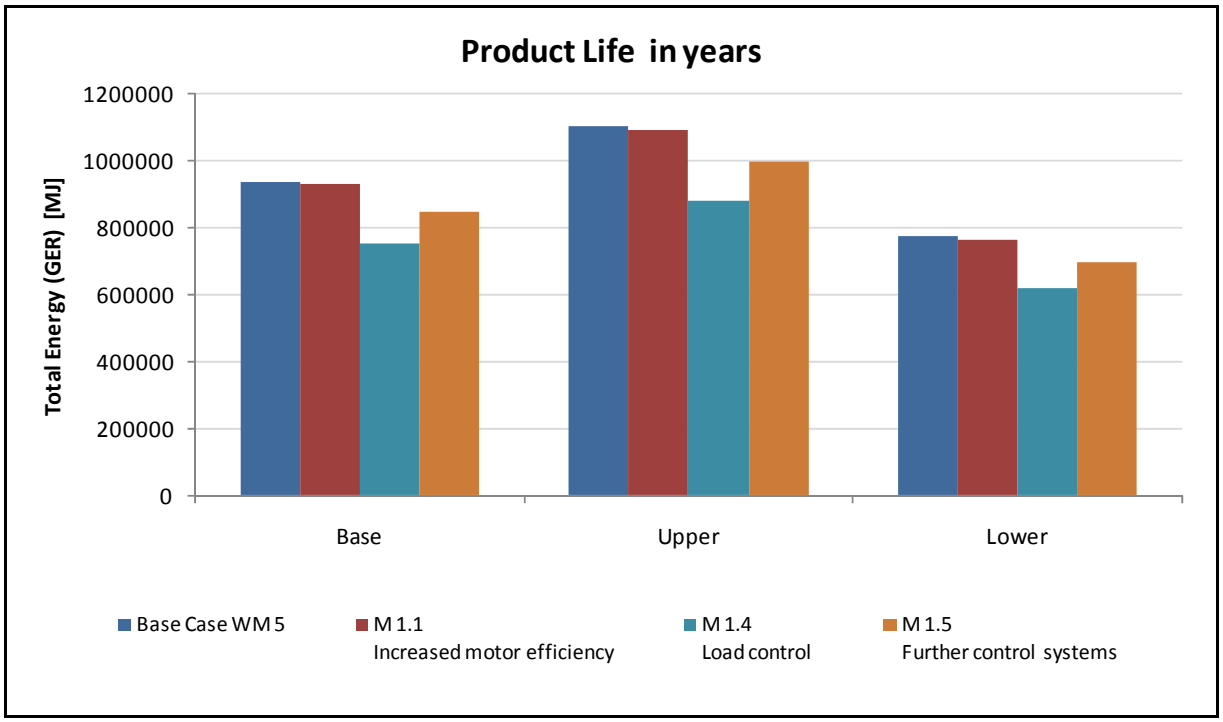


Figure 105 Base case WM 5 and improvement options – impact of life time on total energy over life time by product

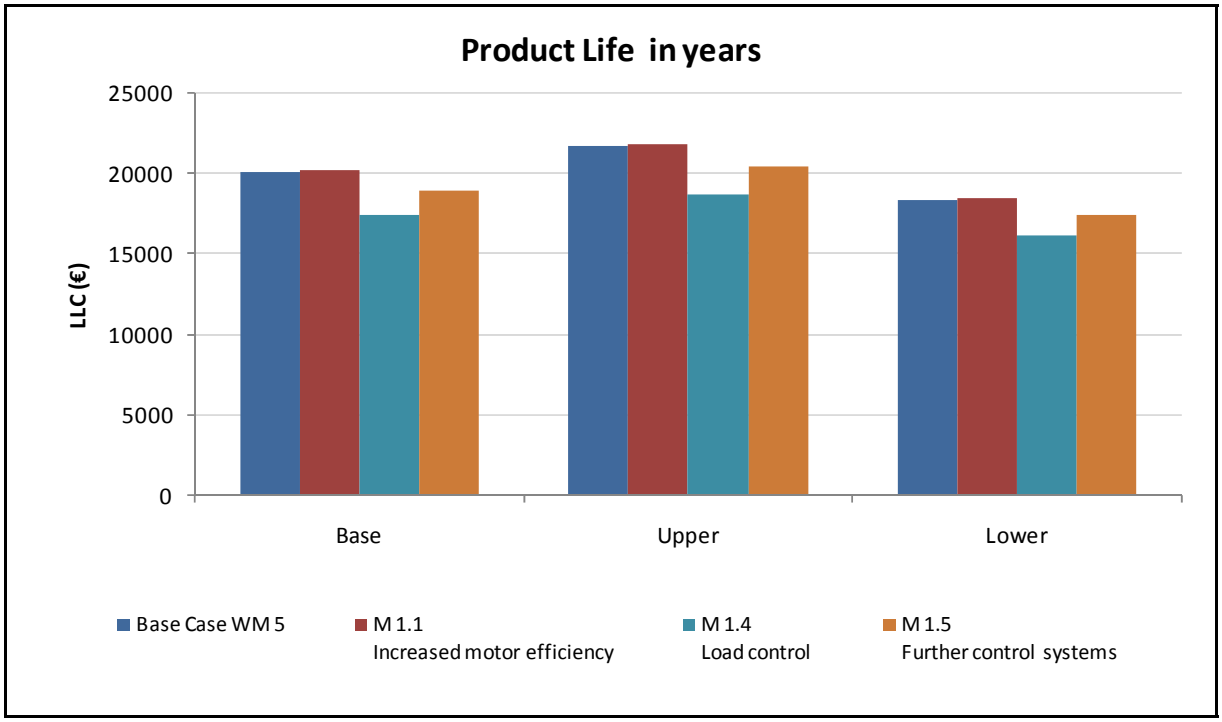


Figure 106 Base case WM 5 and improvement options – impact of life time on LCC by product

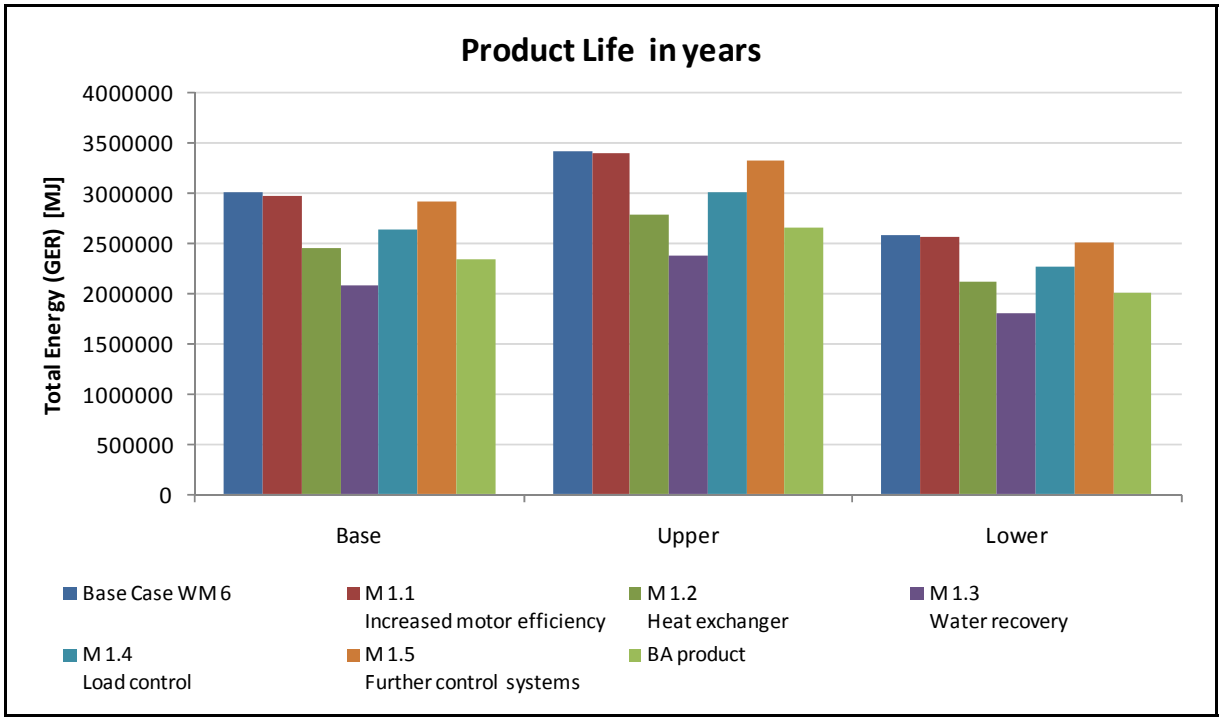


Figure 107 Base case WM 6 and improvement options – impact of life time on total energy over life time by product

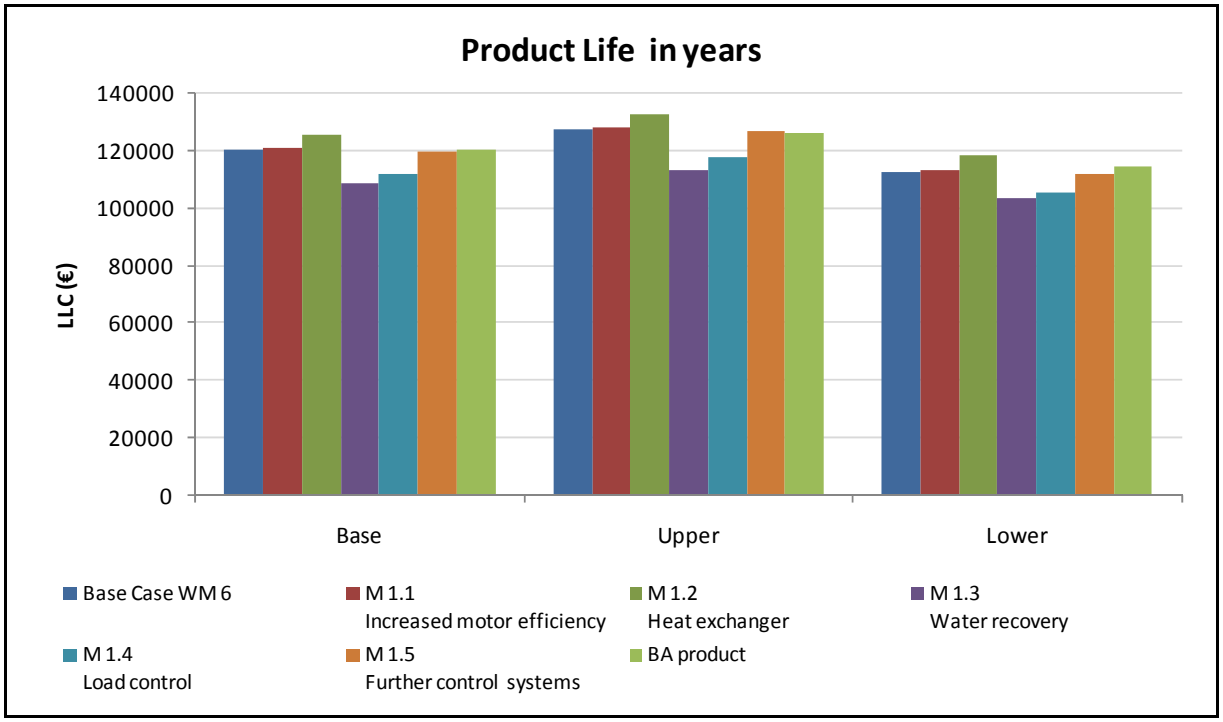


Figure 108 Base case WM 6 and improvement options – impact of life time on LCC by product

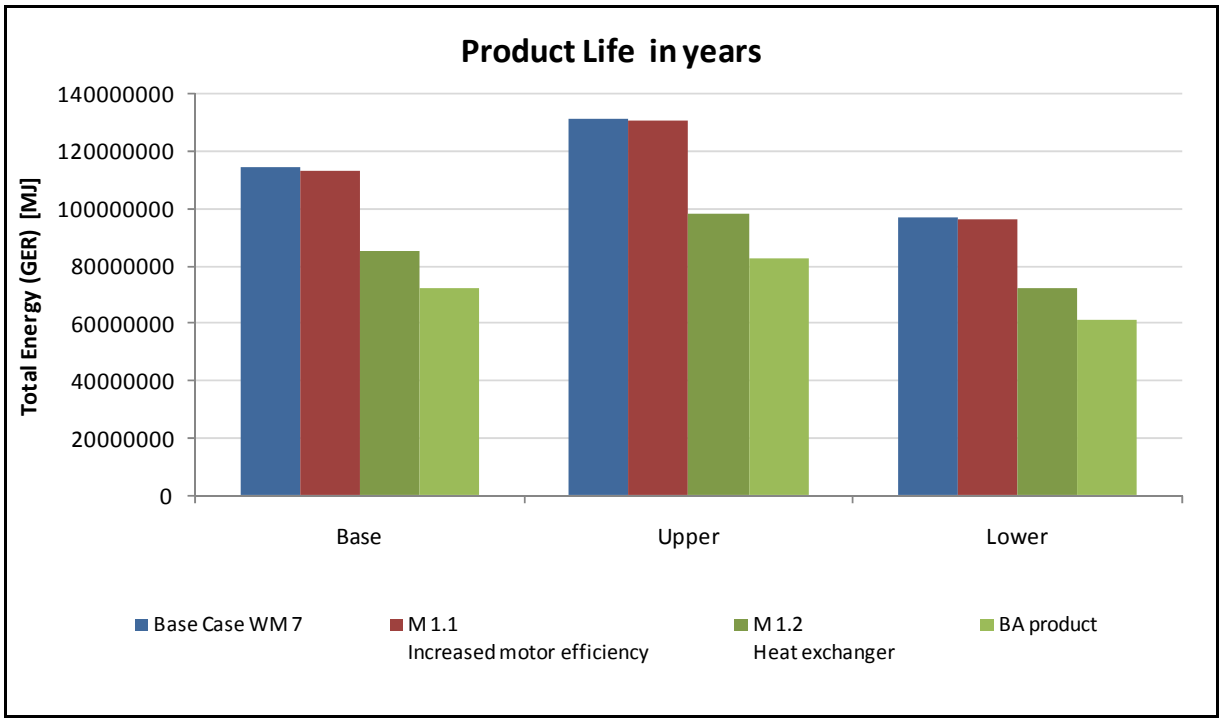


Figure 109 Base case WM 7 and improvement options – impact of life time on total energy over life time by product

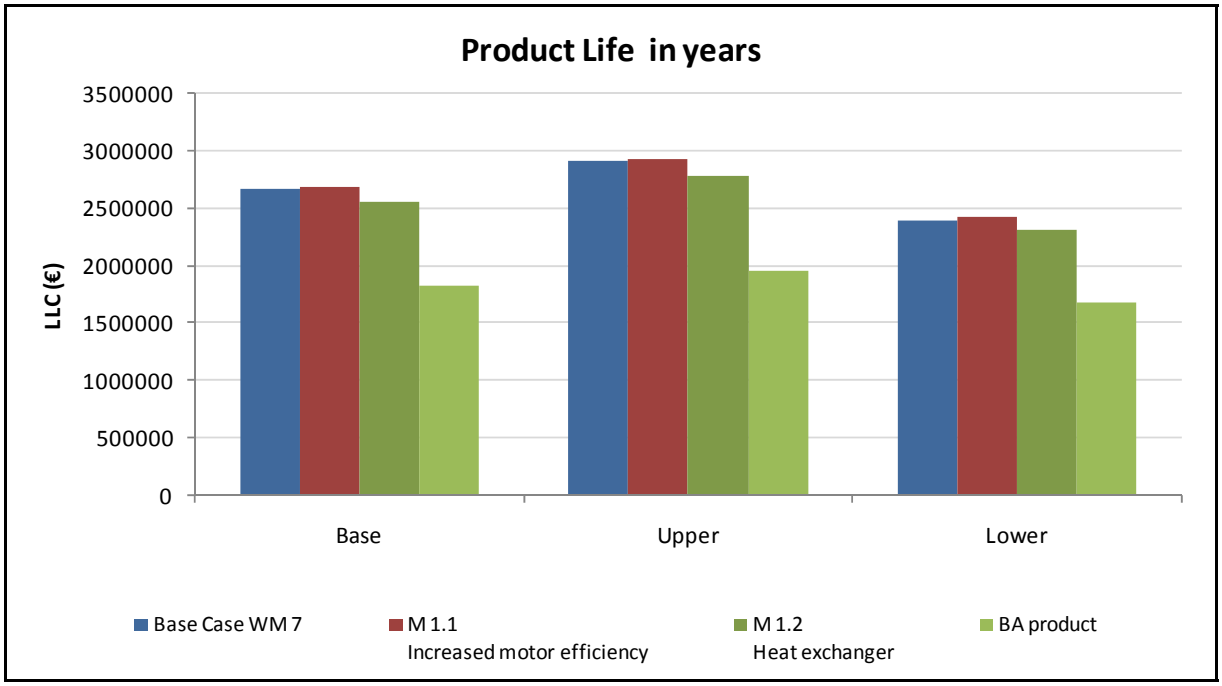


Figure 110 Base case WM 7 and improvement options – impact of life time on LCC by product

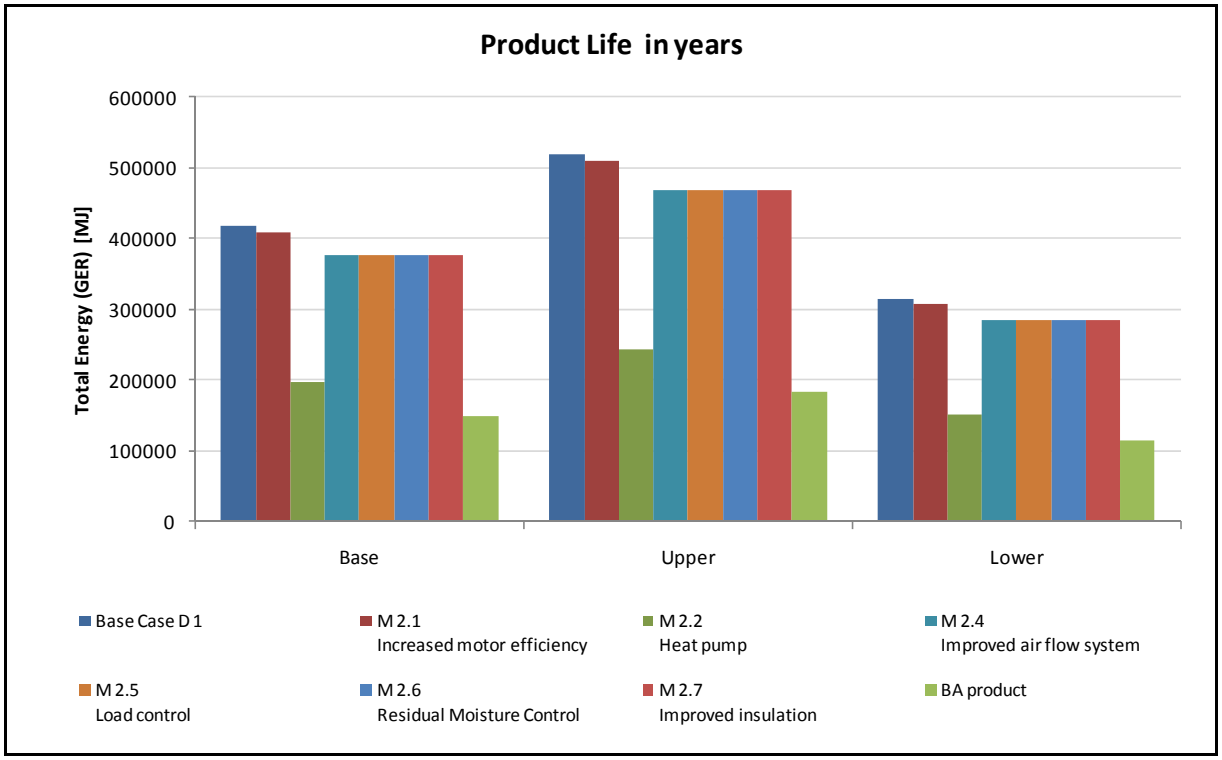


Figure 111 Base case D 1 and improvement options – impact of life time on total energy over life time by product

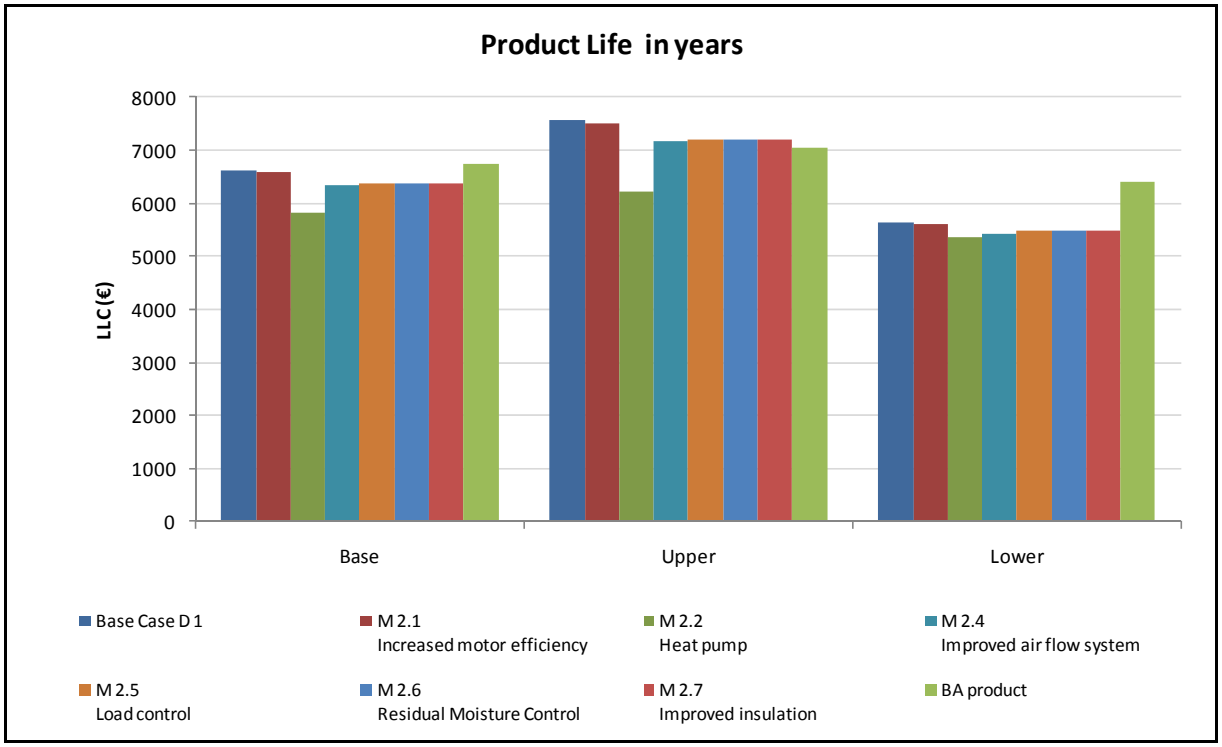


Figure 112 Base case D 1 and improvement options – impact of life time on LCC by product

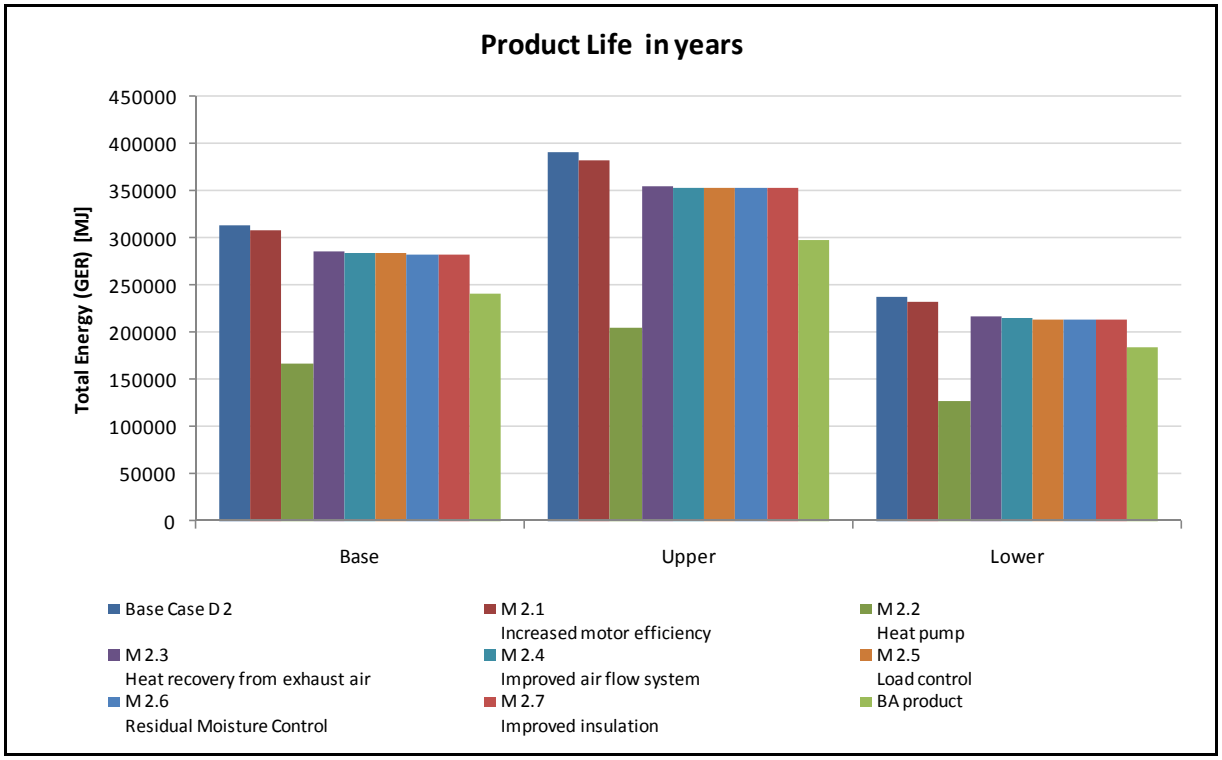


Figure 113 Base case D 2 and improvement options – impact of life time on total energy over life time by product

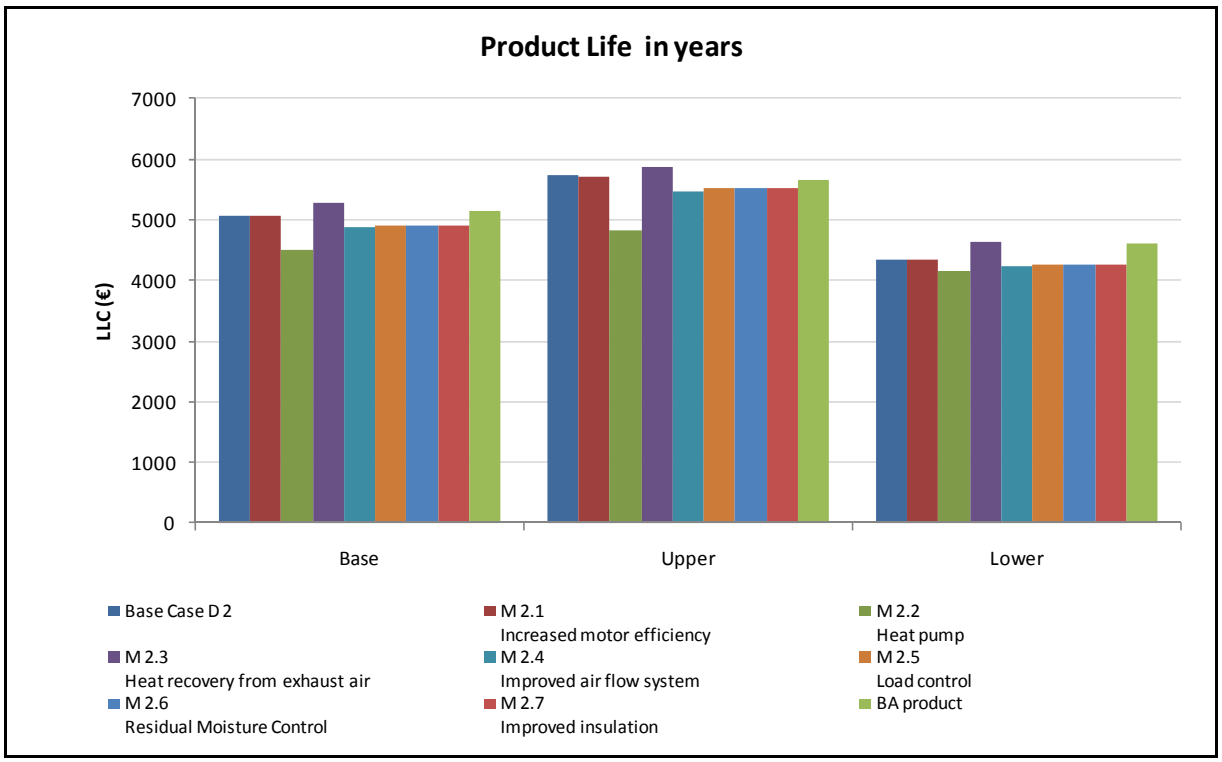


Figure 114 Base case D 2 and improvement options – impact of life time on LCC by product

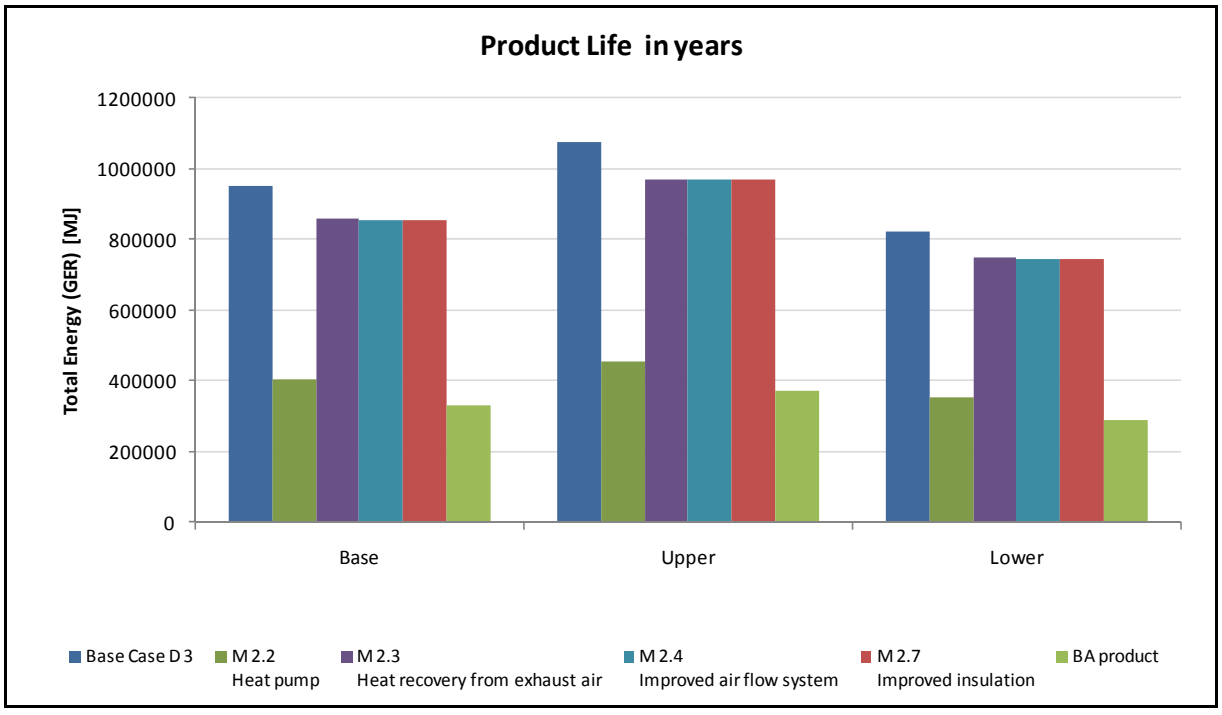


Figure 115 Base case D 3 and improvement options – impact of life time on total energy over life time by product

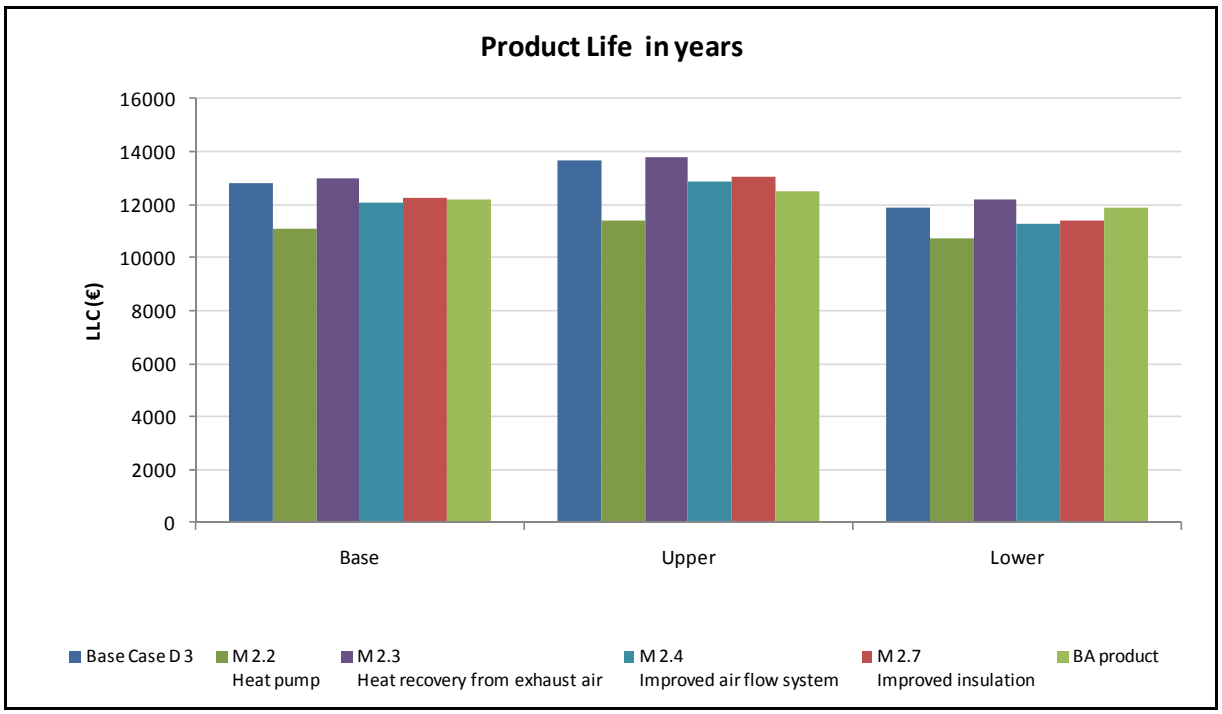


Figure 116 Base case D3 and improvement options – impact of life time on LCC by product

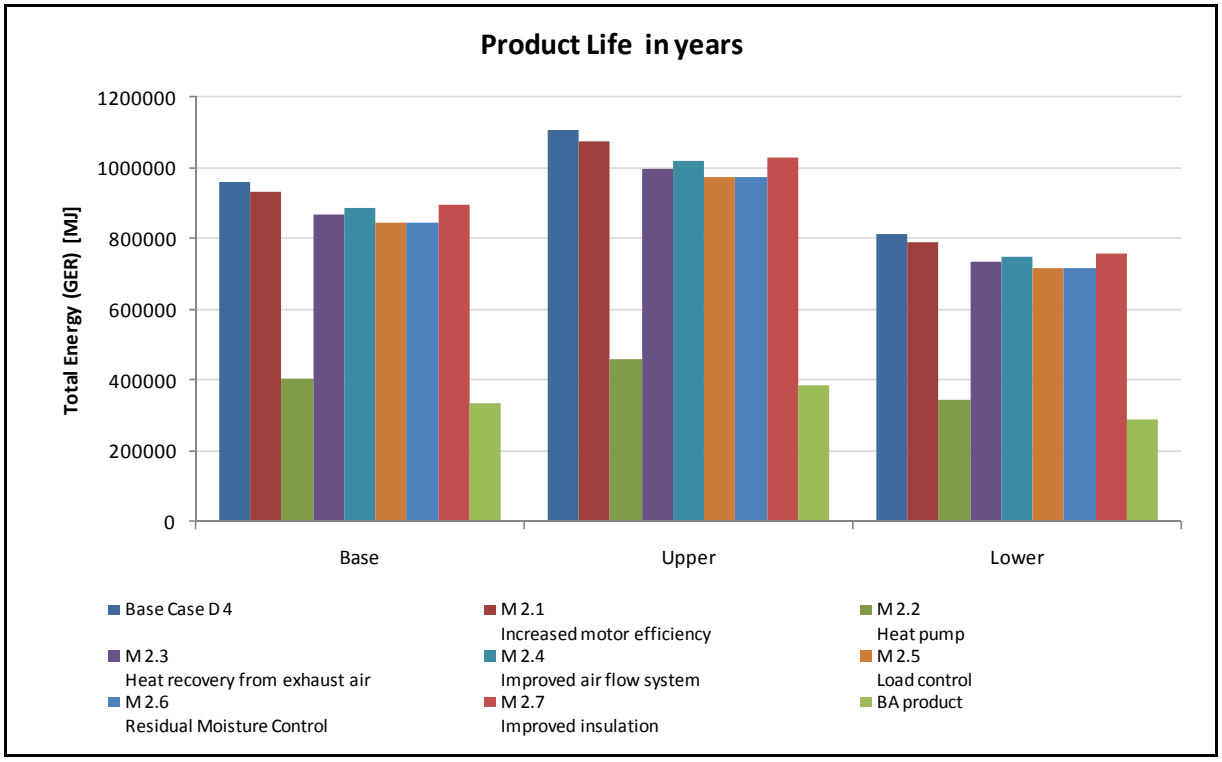


Figure 117 Base case D 4 and improvement options – impact of life time on total energy over life time by product

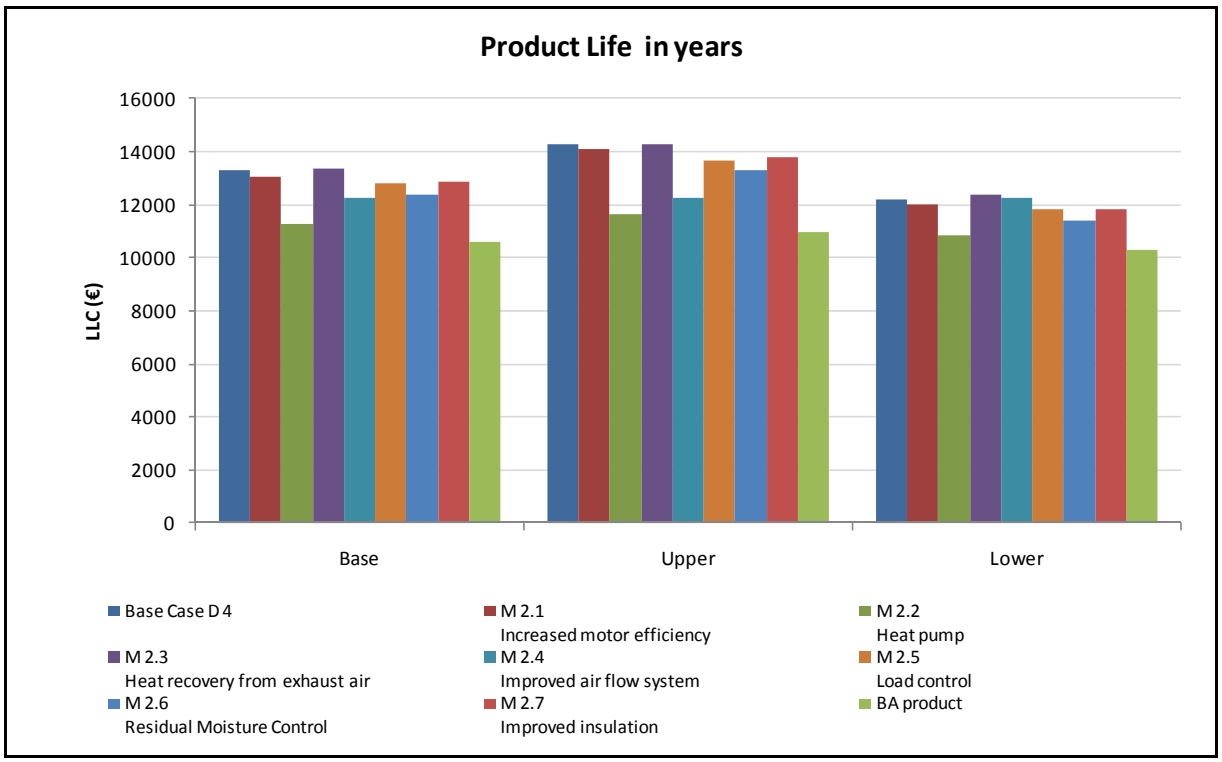


Figure 118 Base case D 4 and improvement options – impact of life time on LCC by product

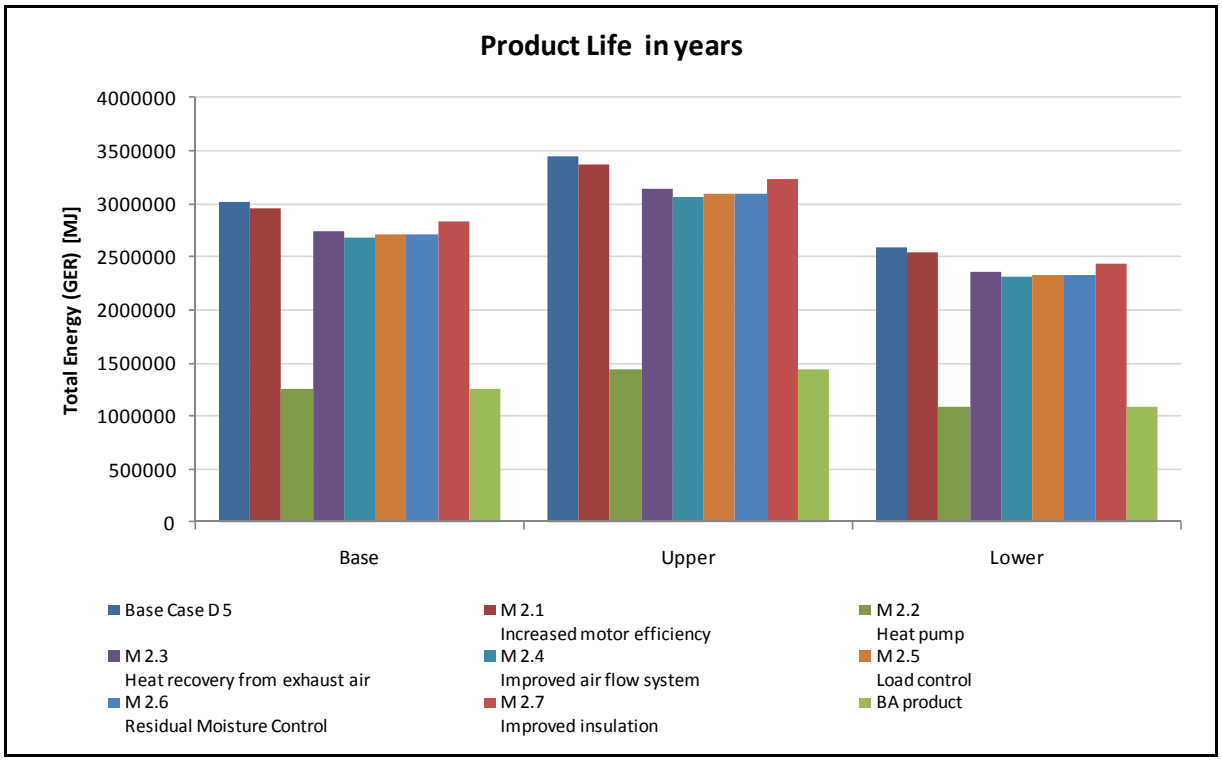


Figure 119 Base case D 5 and improvement options – impact of life time on total energy over life time by product

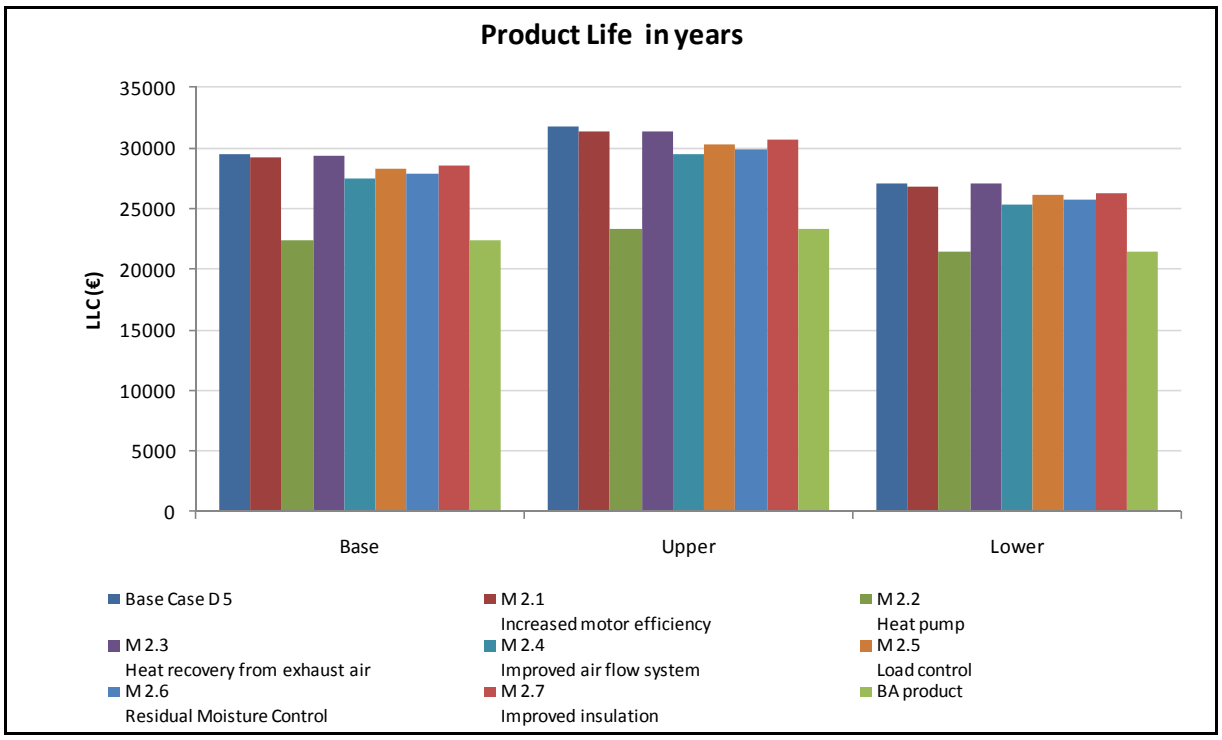


Figure 120 Base case D 5 and improvement options – impact of life time on LCC by product

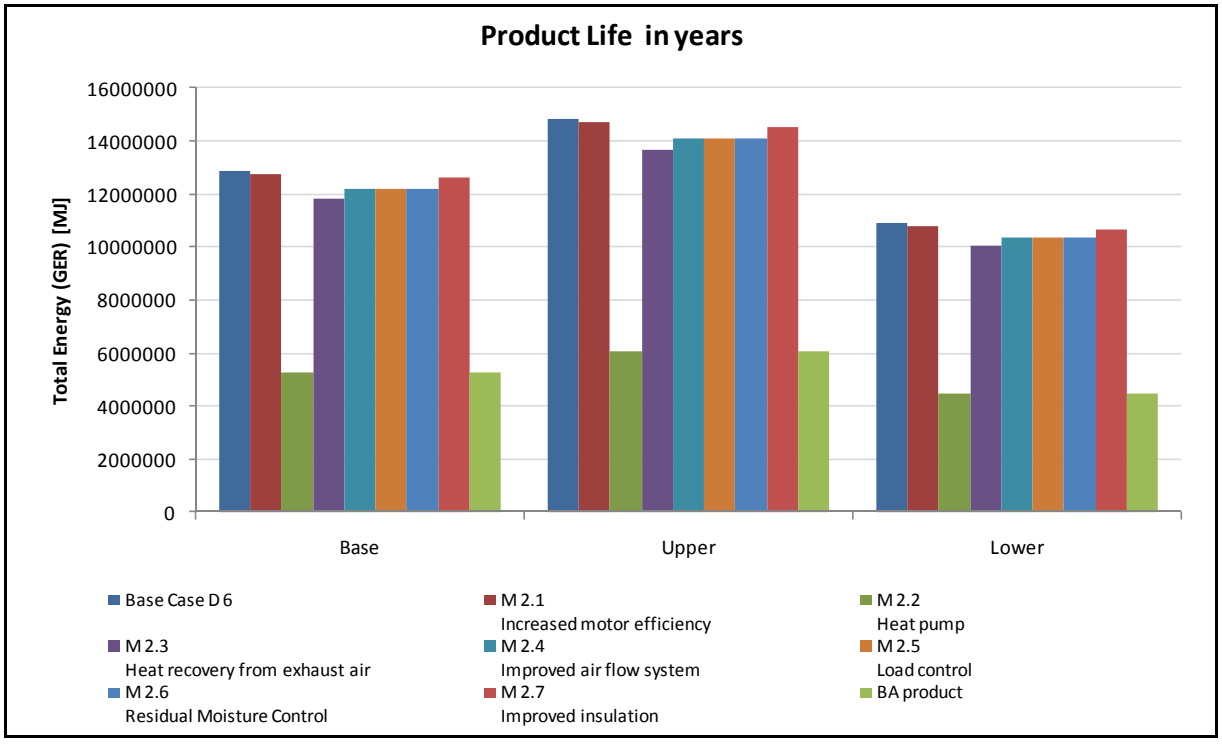


Figure 121 Base case D 6 and improvement options – impact of life time on total energy over life time by product

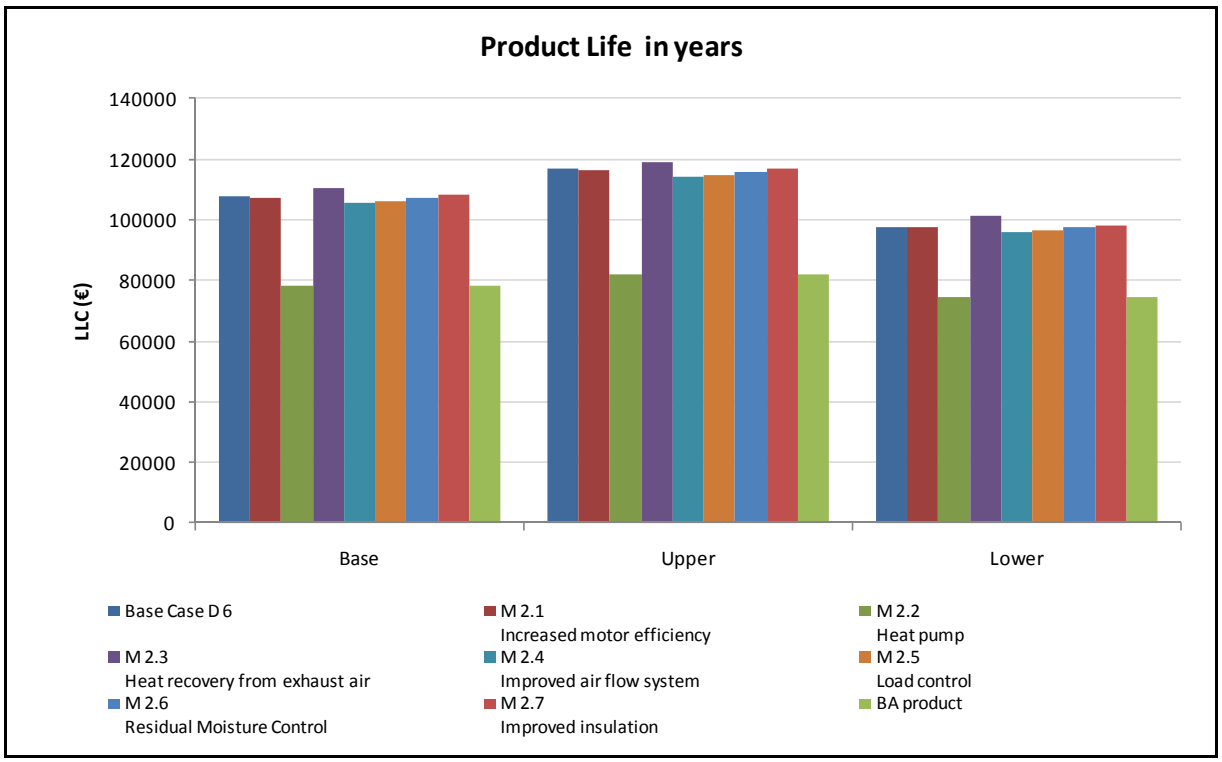


Figure 122 Base case D 6 and improvement options – impact of life time on LCC by product

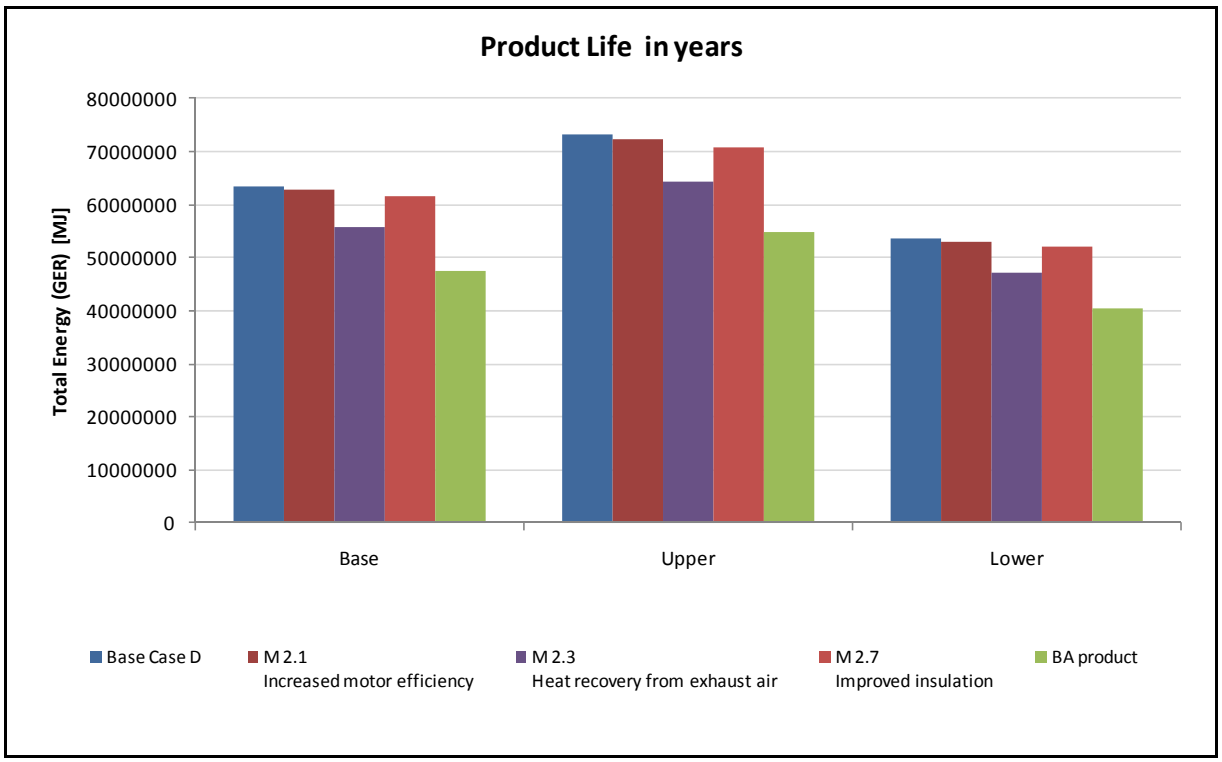


Figure 123 Base case D 7 and improvement options – impact of life time on total energy over life time by product

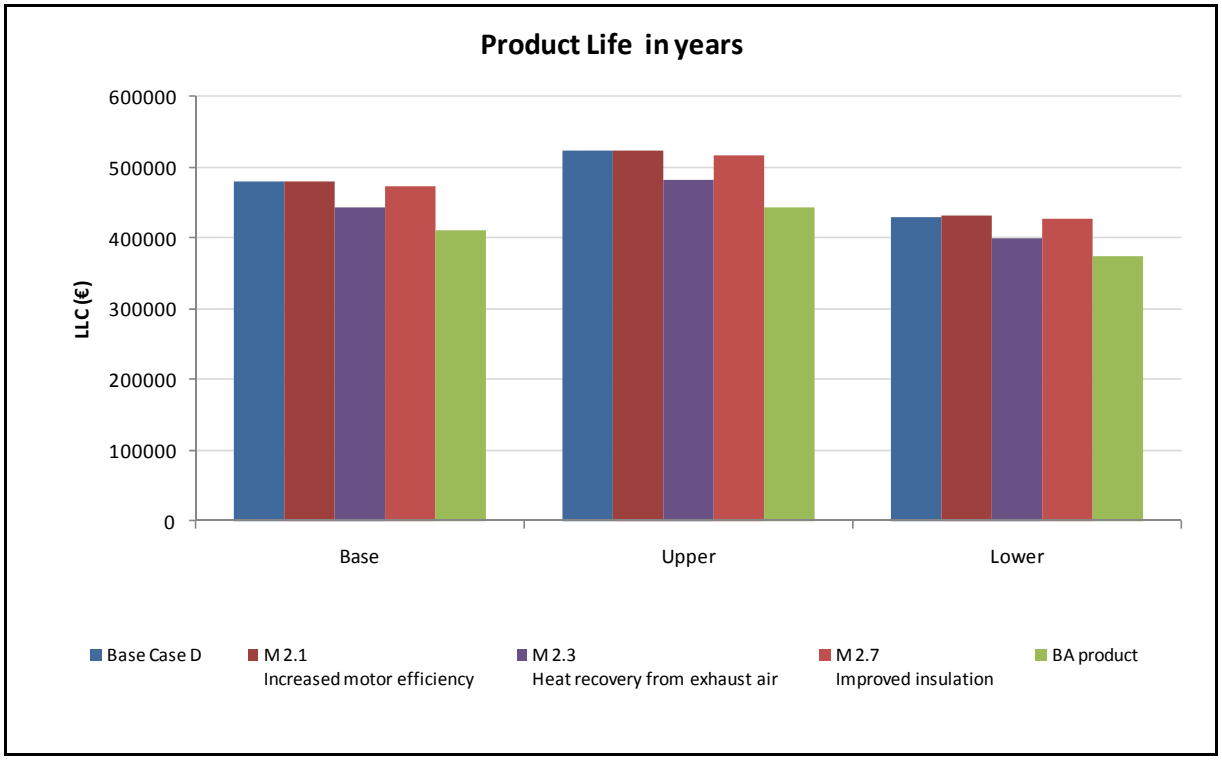


Figure 124 Base case D 7 and improvement options – impact of life time on LCC by product

4.4 Resources and consumable rates

4.4.1 Assumptions

Table 24, Table 25, and Table 26 present the range for the resources and consumables prices that will be used for the sensitivity analysis. These parameters only have an economic influence on the outcomes so that only the influence on LCC is displayed in Figure 125 to Figure 128.

The minimum and maximum electricity and gas values correspond to the extreme values found in Eurostat statistics (see Task 2). Because the base cases products were sometimes a weighted average between different energy sources (electricity and gas), the influence of the energy rates will be studied by changing simultaneously the electricity and the gas rates. For water, they were also extracted from extreme values found during the estimation of the EU average price (see Task 2). For detergent, a wide range was deliberately chosen given the high variability of types of detergent available (see Task 2).

Again, we use average EU prices for all calculations but there are significant differences between Member States.

Table 24 Electricity rate ranges for the sensitivity analysis

Base case	Base electricity rate (€/kWh)	Min	Max
WM 1 - Semi-professional washer extractor	0.138	0.071 (Estonia)	0.185 (Slovakia)
WM 2 - Professional washing extractor (<15 kg)			
WM 3 - Professional washing extractor (15–40 kg)	0.105	0.059 (Estonia)	0.160 (Cyprus)
WM 4 - Professional washing extractor (>40 kg)	0.090	0.055 (Estonia)	0.144 (Cyprus)
WM 5 - Professional washer dryer	0.105	0.059 (Estonia)	0.160 (Cyprus)
WM 6 - Professional barrier washer			
WM 7 - Washing tunnel machine	0.090	0.055 (Estonia)	0.144 (Cyprus)
D 1 - Semi-professional dryer, condenser	0.138	0.071 (Estonia)	0.185 (Slovakia)
D 2 - Semi-professional dryer, air vented			
D 3 - Professional cabinet dryer			
D 4 - Professional air tumble dryer (<15 kg)			
D 5 - Professional air tumble dryer (15–40 kg)	0.105	0.059 (Estonia)	0.160 (Cyprus)
D 6 - Professional air tumble dryer (>40 kg)	0.090	0.055 (Estonia)	0.144 (Cyprus)
D 7 - Industrial pass-through (transfer) tumble dryer			

Table 25 Gas rate ranges for the sensitivity analysis

Base case	Base gas rate (€/GJ)	Min	Max
WM 1 - Semi-professional washer extractor	11.2115	5.5257 (Romania)	14.7633 (Sweden)
WM 2 - Professional washing extractor (<15 kg)			
WM 3 - Professional washing extractor (15–40 kg)	10.0097	5.5080 (Romania)	13.1448 (Sweden)
WM 4 - Professional washing extractor (>40 kg)	8.7921	5.6072 (Romania)	11.2499 (Sweden)
WM 5 - Professional washer dryer	10.0097	5.5080 (Romania)	13.1448 (Sweden)
WM 6 - Professional barrier washer			
WM 7 - Washing tunnel machine	8.7921	5.6072 (Romania)	11.2499 (Sweden)
D 1 - Semi-professional dryer, condenser	11.2115	5.5257 (Romania)	14.7633 (Sweden)
D 2 - Semi-professional dryer, air vented			
D 3 - Professional cabinet dryer			
D 4 - Professional air tumble dryer (<15 kg)			
D 5 - Professional air tumble dryer (15–40 kg)	10.0097	5.5080 (Romania)	13.1448 (Sweden)
D 6 - Professional air tumble dryer (>40 kg)	8.7921	5.6072 (Romania)	11.2499 (Sweden)
D 7 - Industrial pass-through (transfer) tumble dryer			

Table 26 Water and detergent rates ranges for the sensitivity analysis

Item	Base price (for all base cases)	Min	Max
Water	2.64 €/m^3	1.11 €/m^3 (Rome)	4.91 €/m^3 (Berlin)
Detergent	2.0 €/kg	1.5 €/kg	2.5 €/kg

4.4.2 Results

Figure 125 to Figure 166 show the influence of the variation of the resources and consumables rates on the the life cycle costs of the different base cases and associated improvement options.

The option leading to the lowest life cycle costs remain almost always the same for a given base case, whatever the values considered (base, lower or upper). However, this is not the case for:

- Base case D 1, D 2 and D 3 regarding the variation of electricity rate: option M 2.4 becomes the LLCC with the lower values, instead of option M 2.2.
- Base case D 4 regarding the variation of electricity rate: option M 2.4 becomes the LLCC with the lower values, instead of the BA product.

Besides, some relative changes in the rankings of options happen, for instance:

- For base case WM 4, the LCC of M 1.2 option becomes lower than the LCC of the base case with the upper electricity rate values;
- For base case WM 6, the LCC of the BA product becomes lower than the LCC of the base case with the upper electricity rate values;
- For base cases D 1, D 2 and D 3, the LCC of the BA product and option M 2.2 become higher than the LCC of the base case with the lower electricity rate values.

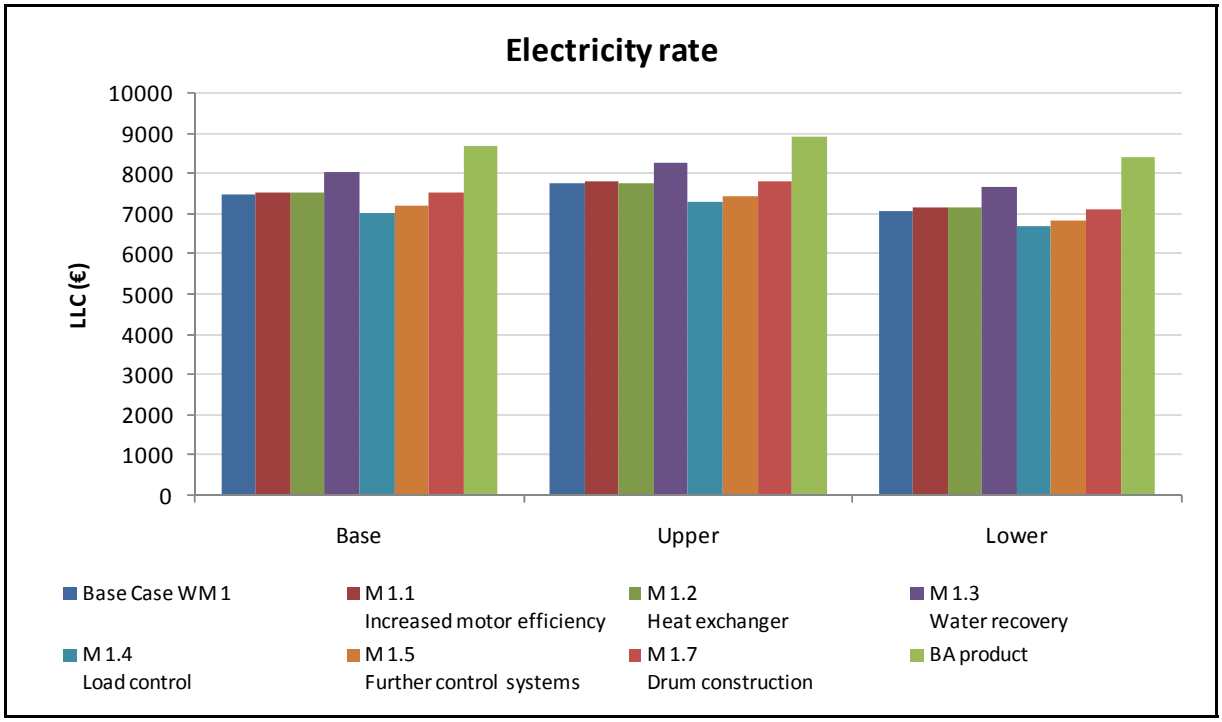


Figure 125 Base case WM 1 and improvement options – impact of electricty rates on LCC by product

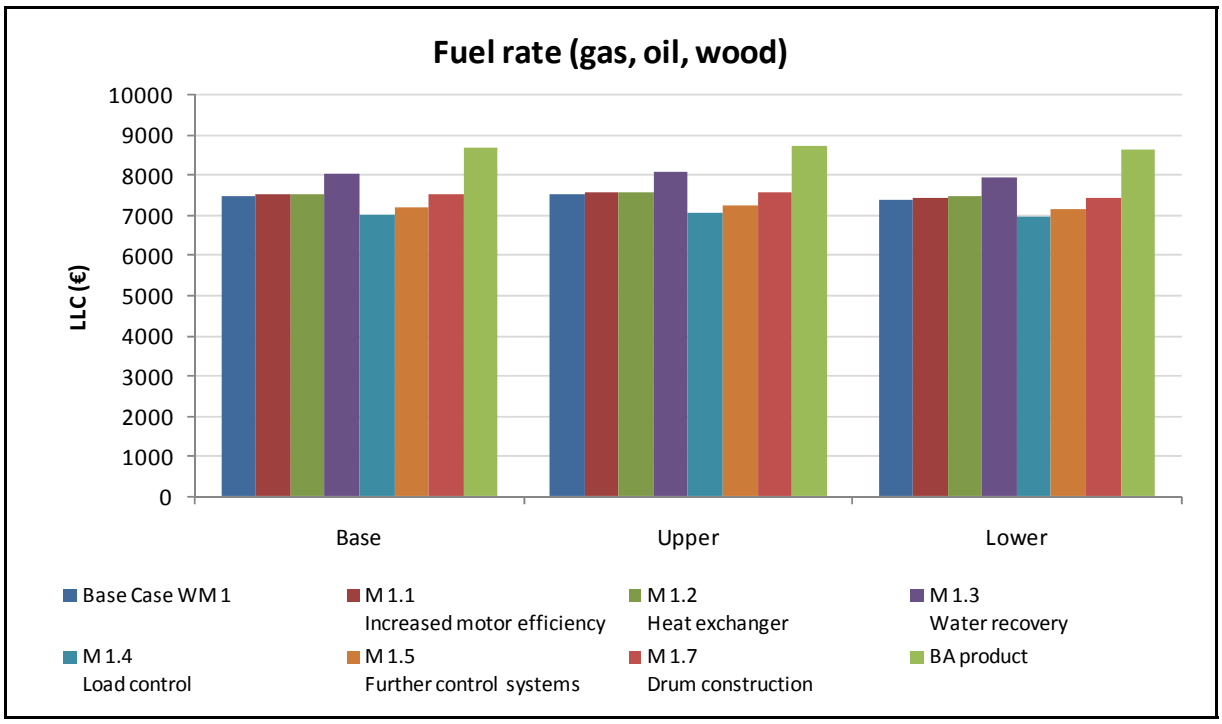


Figure 126 Base case WM 1 and improvement options – impact of gas rates on LCC by product

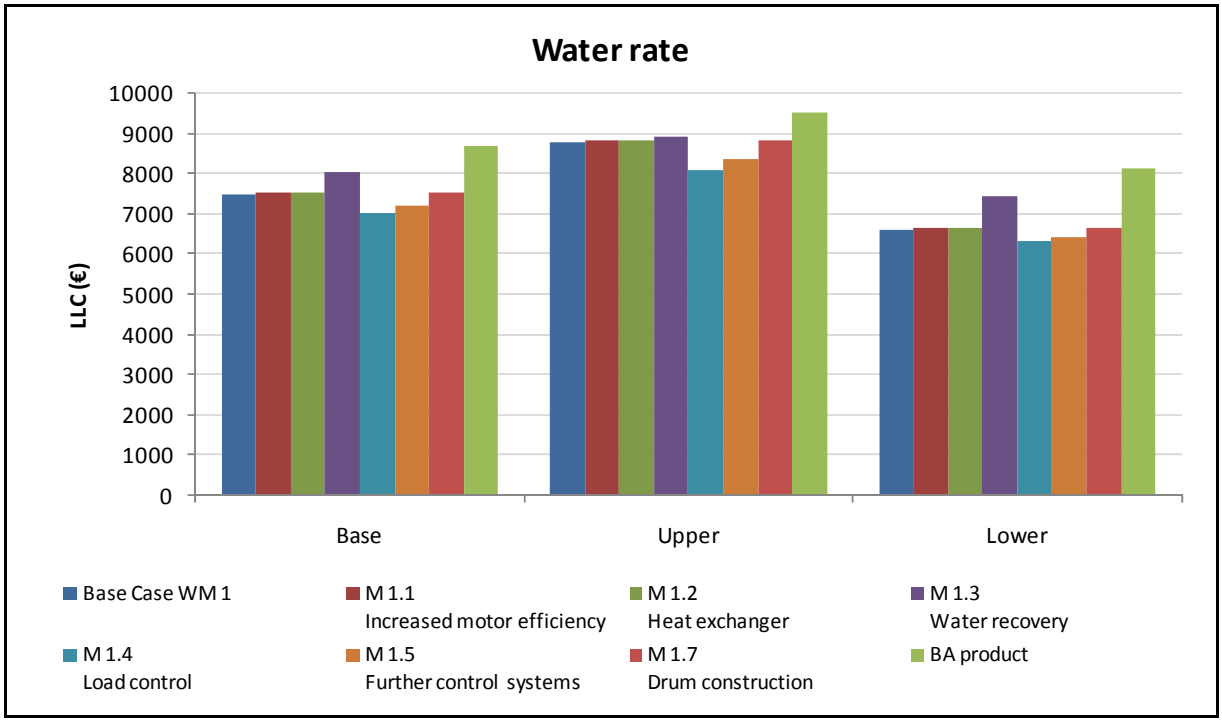


Figure 127 Base case WM 1 and improvement options – impact of water rate on LCC by product

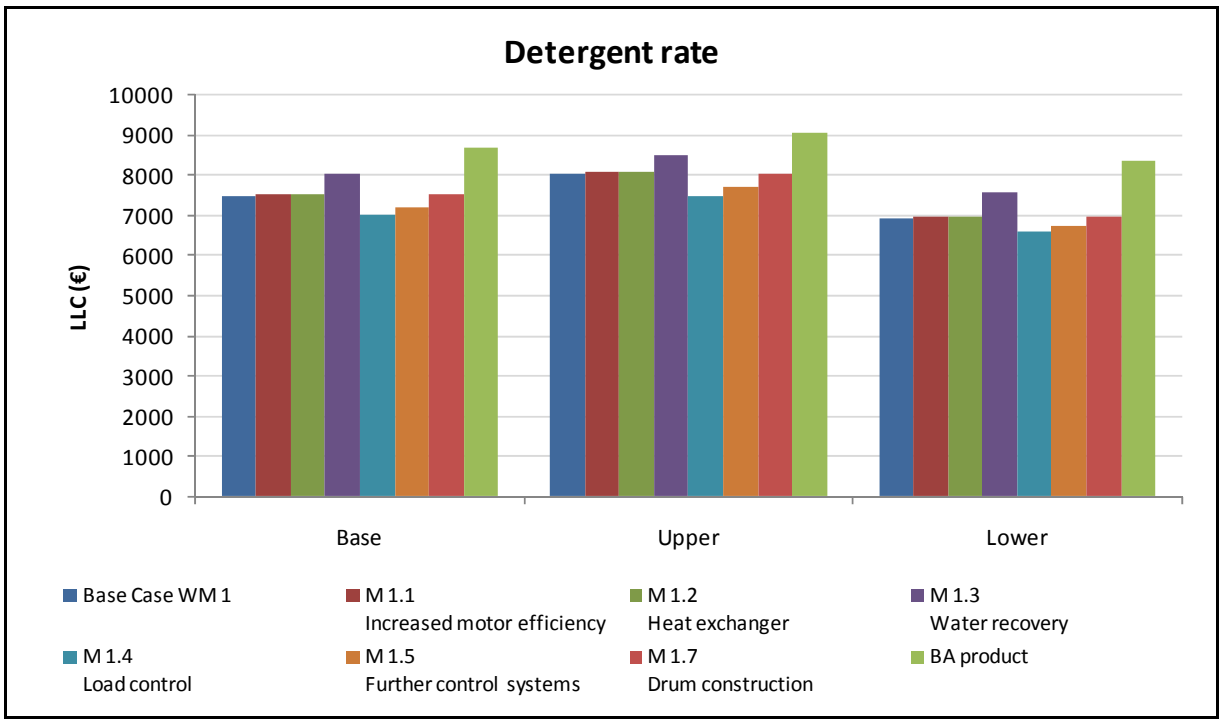


Figure 128 Base case WM 1 and improvement options – impact of detergent rate on LCC by product

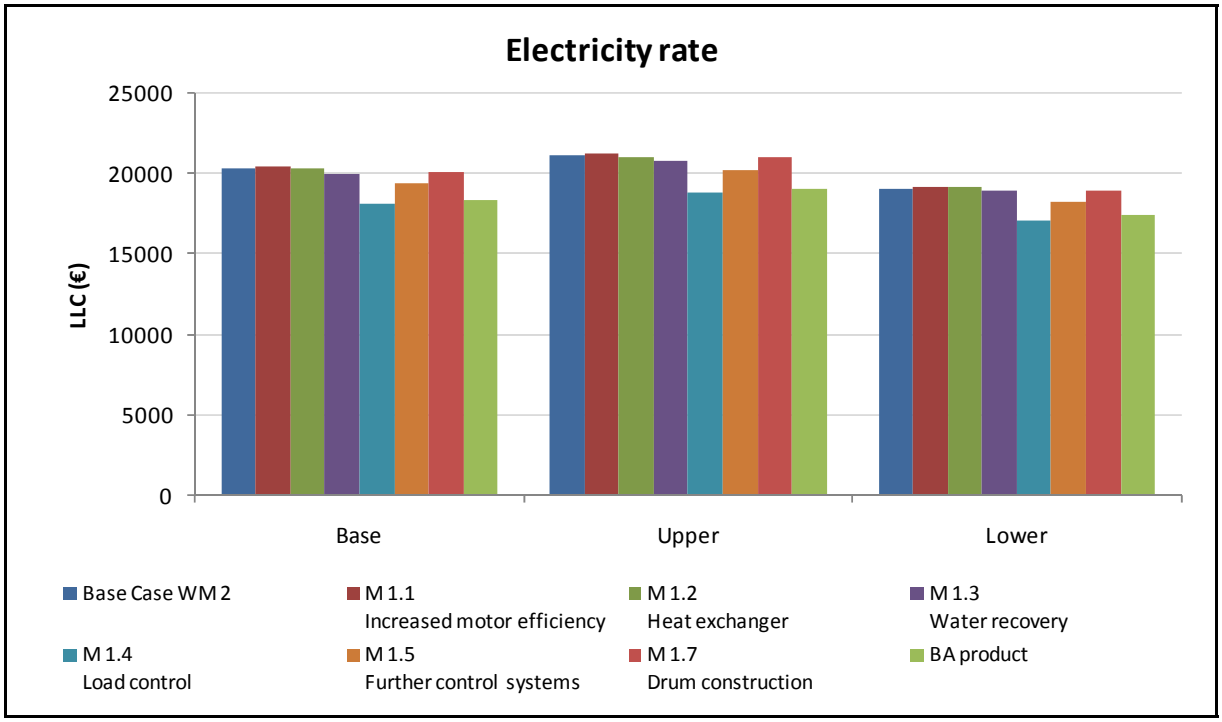


Figure 129 Base case WM 2 and improvement options – impact of electricty rates on LCC by product

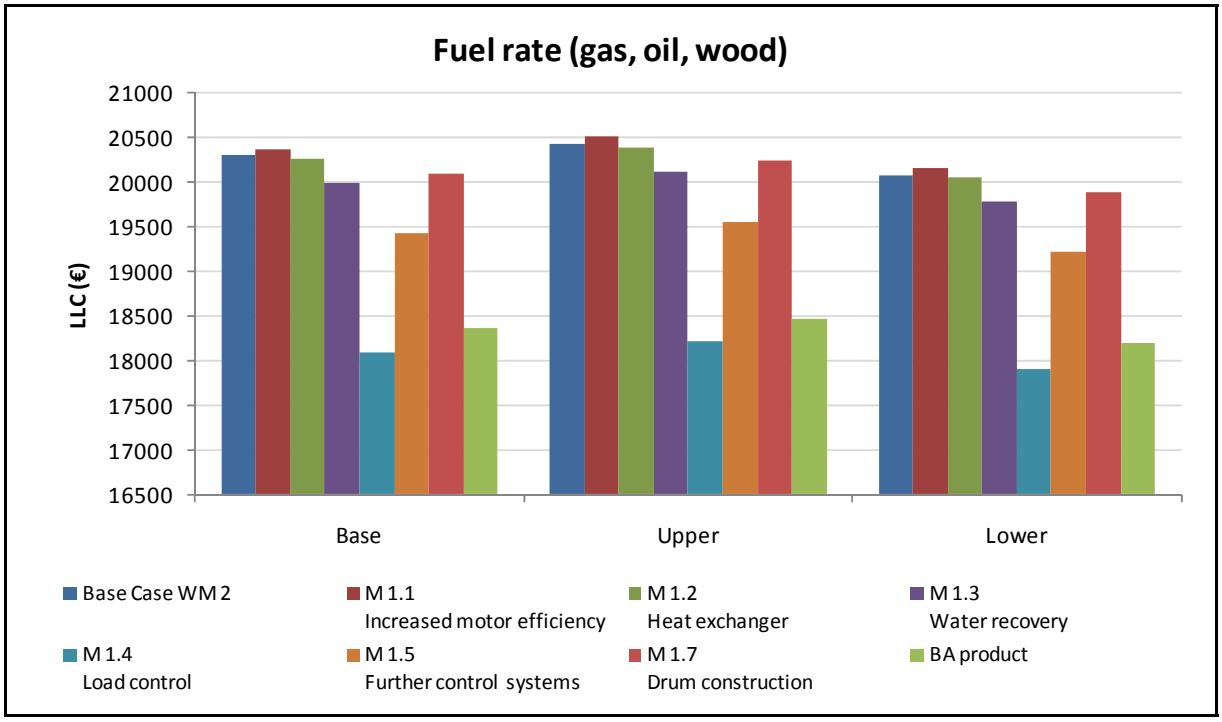


Figure 130 Base case WM 2 and improvement options – impact of gas rates on LCC by product

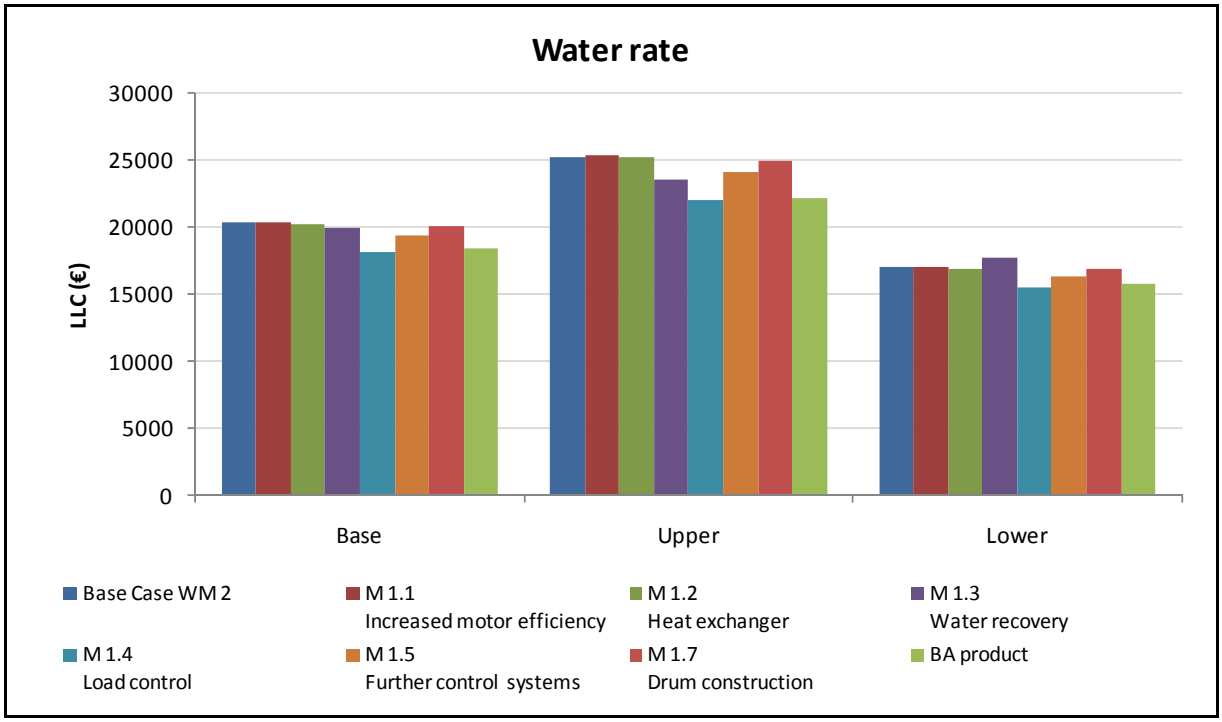


Figure 131 Base case WM 2 and improvement options – impact of water rate on LCC by product

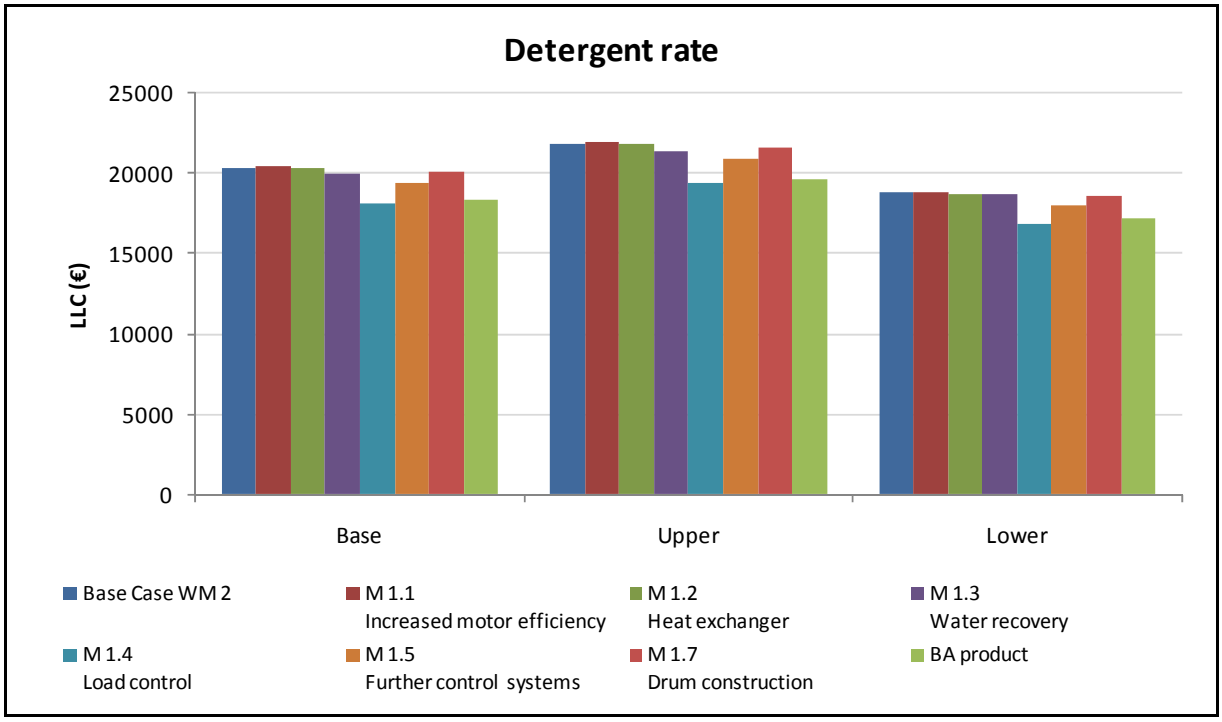


Figure 132 Base case WM 2 and improvement options – impact of detergent rate on LCC by product

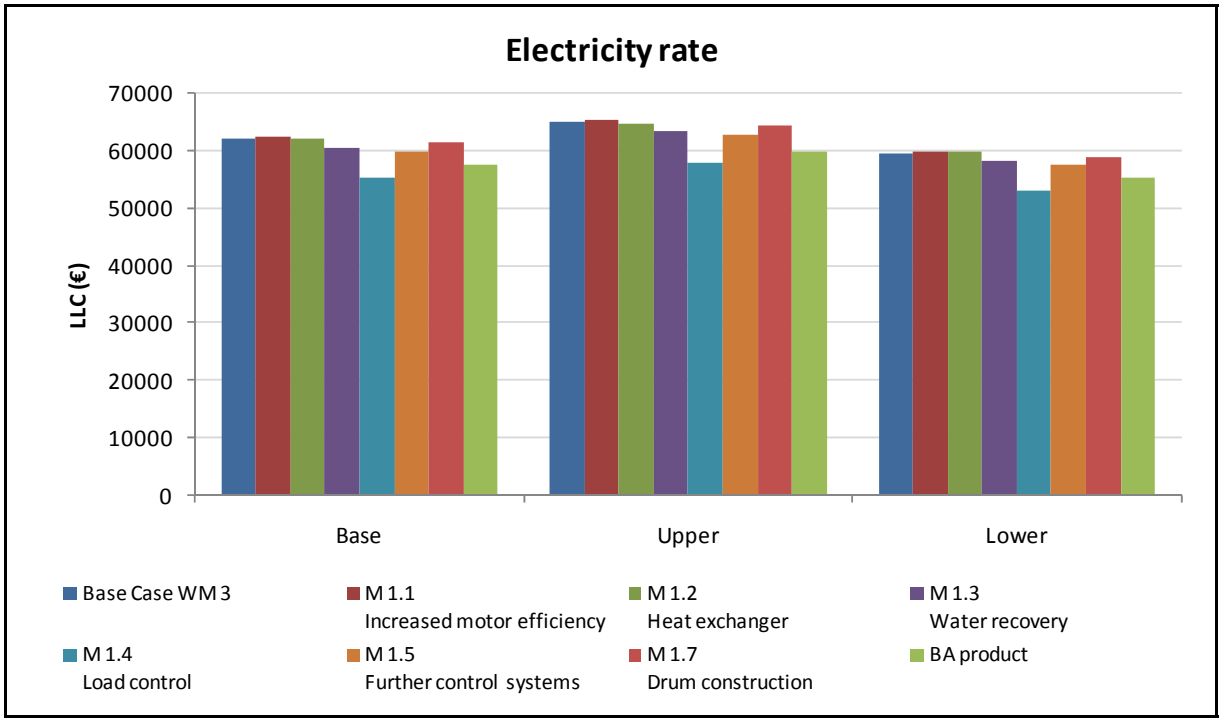


Figure 133 Base case WM 3 and improvement options – impact of electricty rates on LCC by product

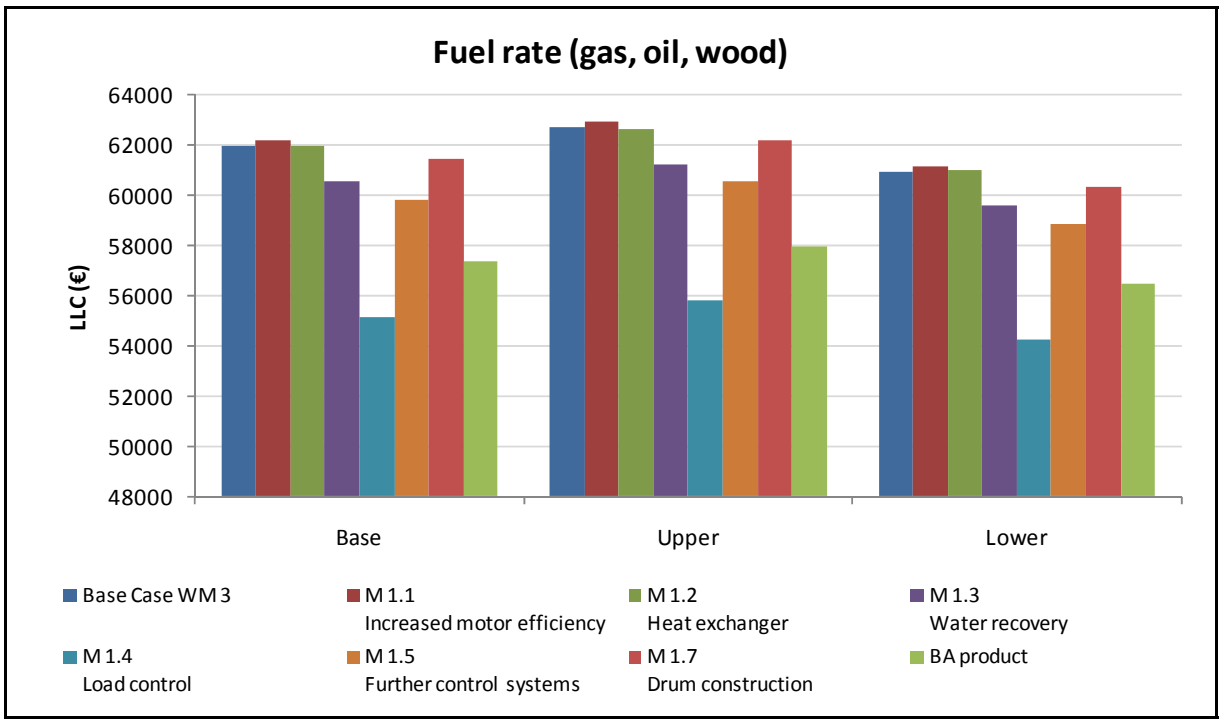


Figure 134 Base case WM 3 and improvement options – impact of gas rates on LCC by product

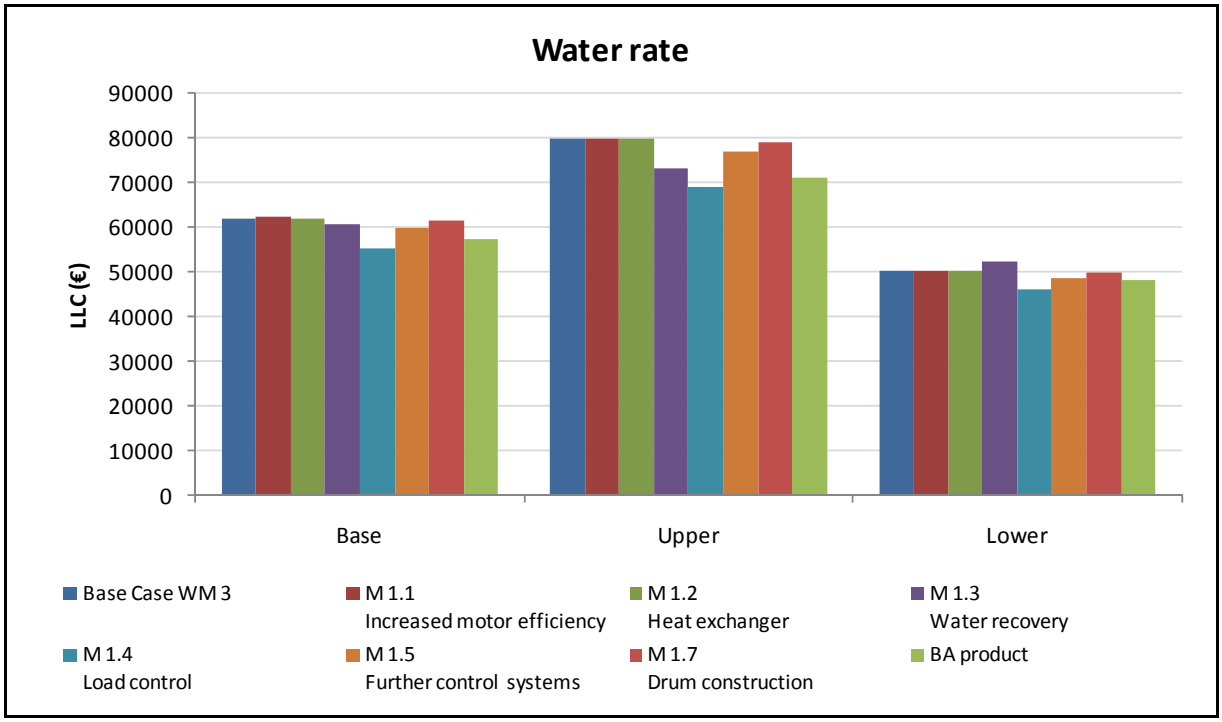


Figure 135 Base case WM 3 and improvement options – impact of water rate on LCC by product

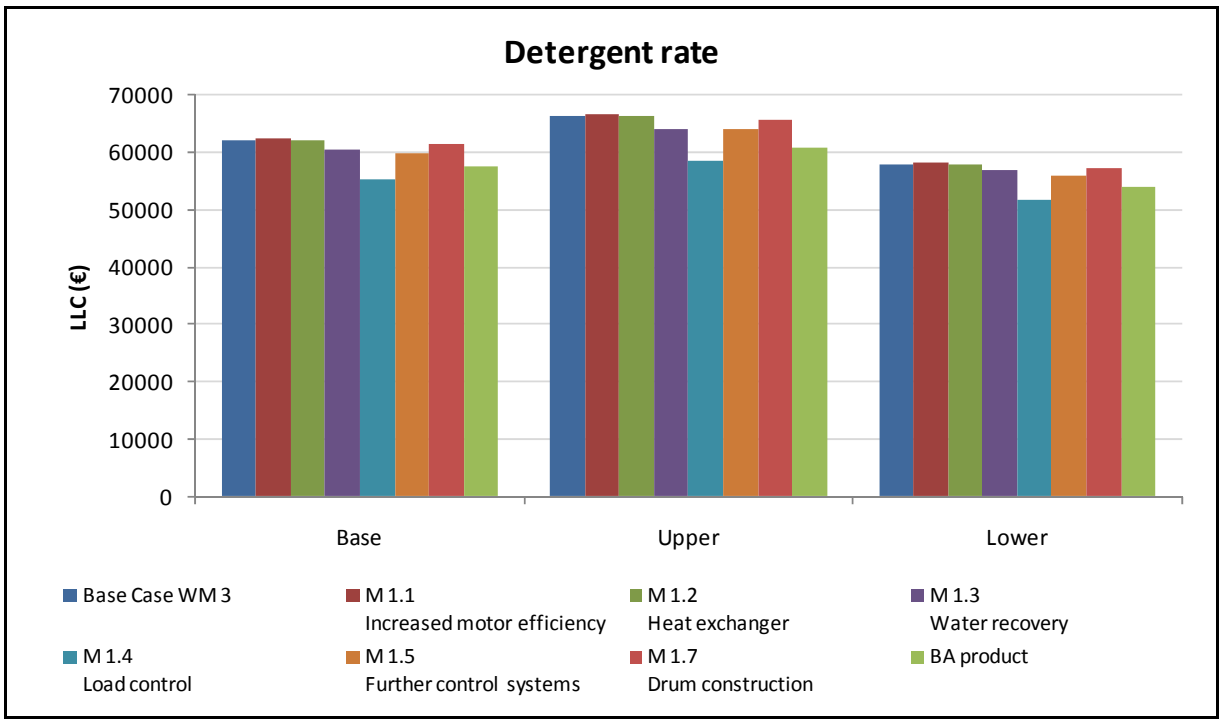


Figure 136 Base case WM 3 and improvement options – impact of detergent rate on LCC by product

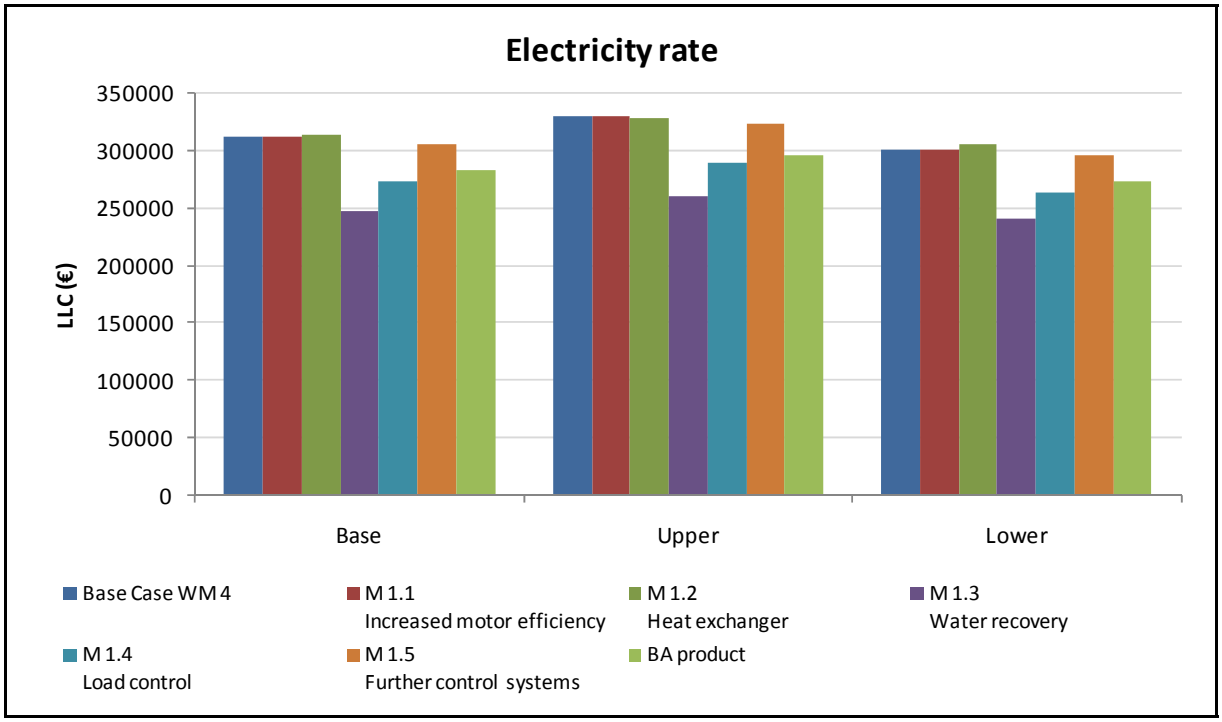


Figure 137 Base case WM 4 and improvement options – impact of electricty rates on LCC by product

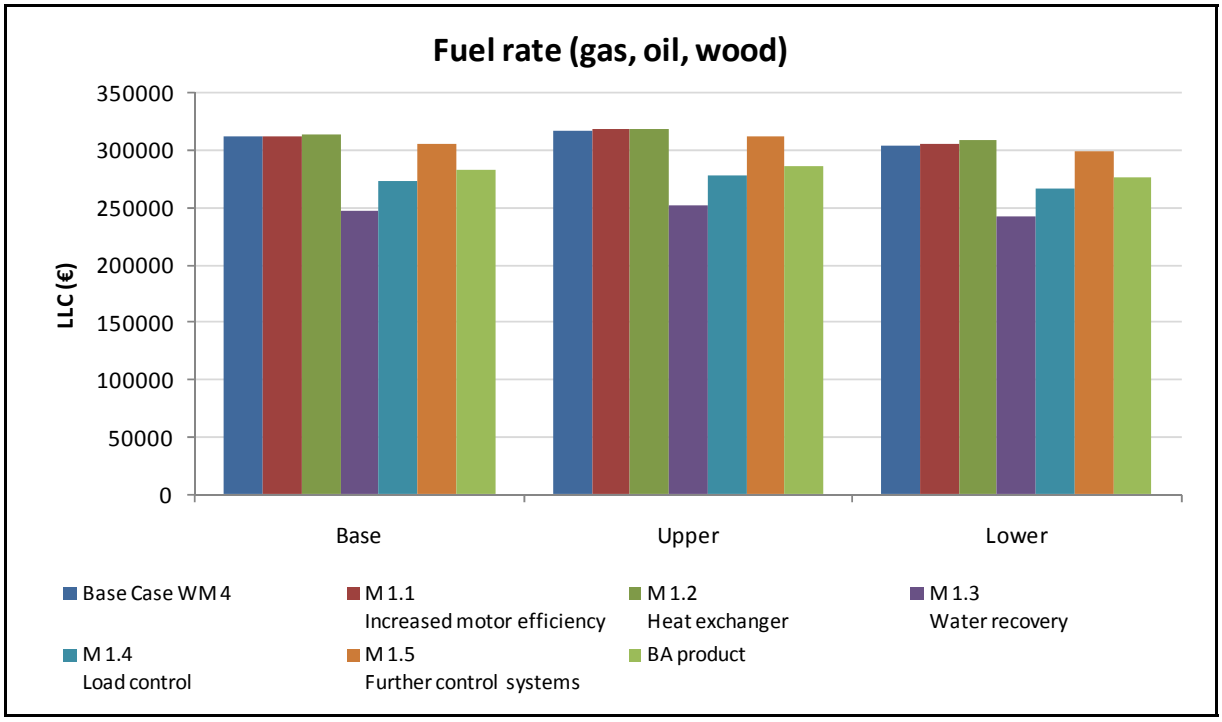


Figure 138 Base case WM 4 and improvement options – impact of gas rates on LCC by product

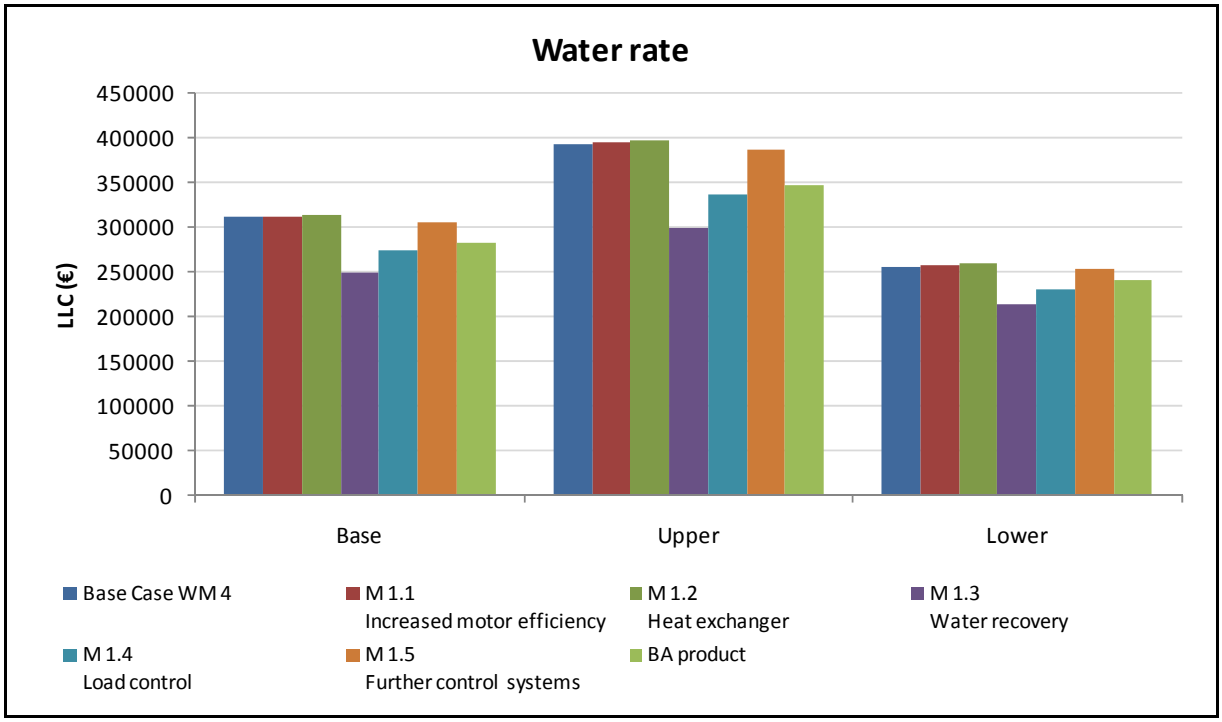


Figure 139 Base case WM 4 and improvement options – impact of water rate on LCC by product

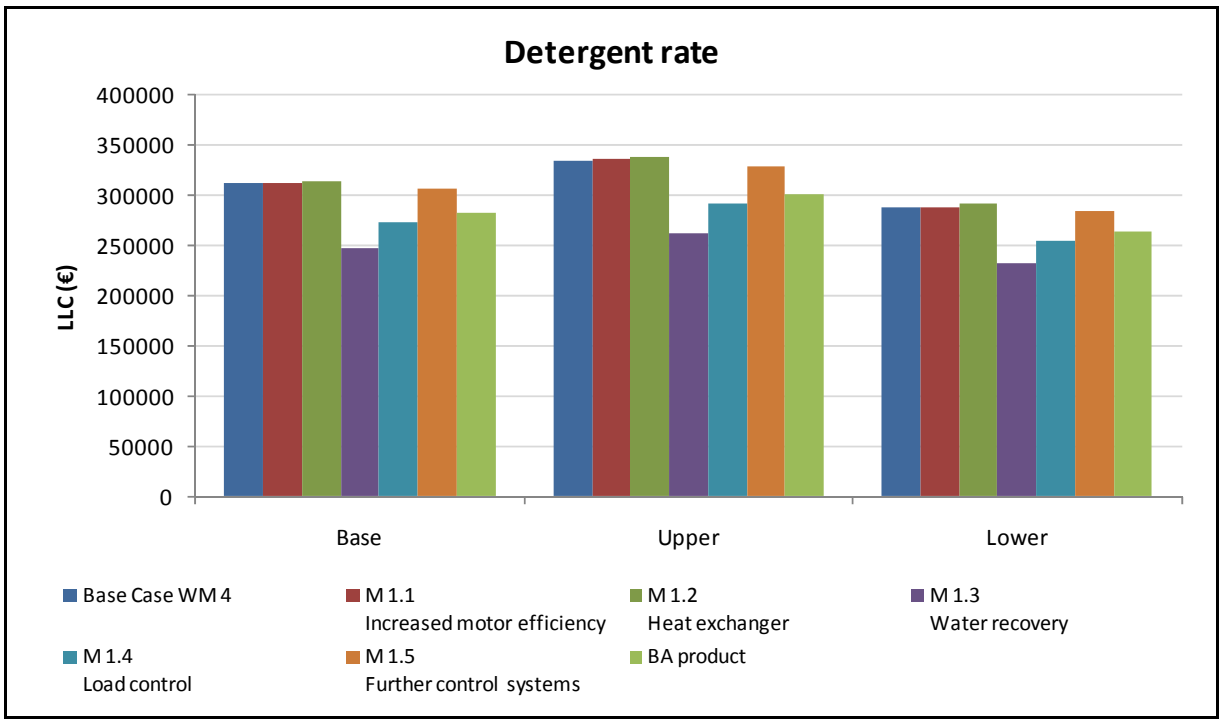


Figure 140 Base case WM 4 and improvement options – impact of detergent rate on LCC by product

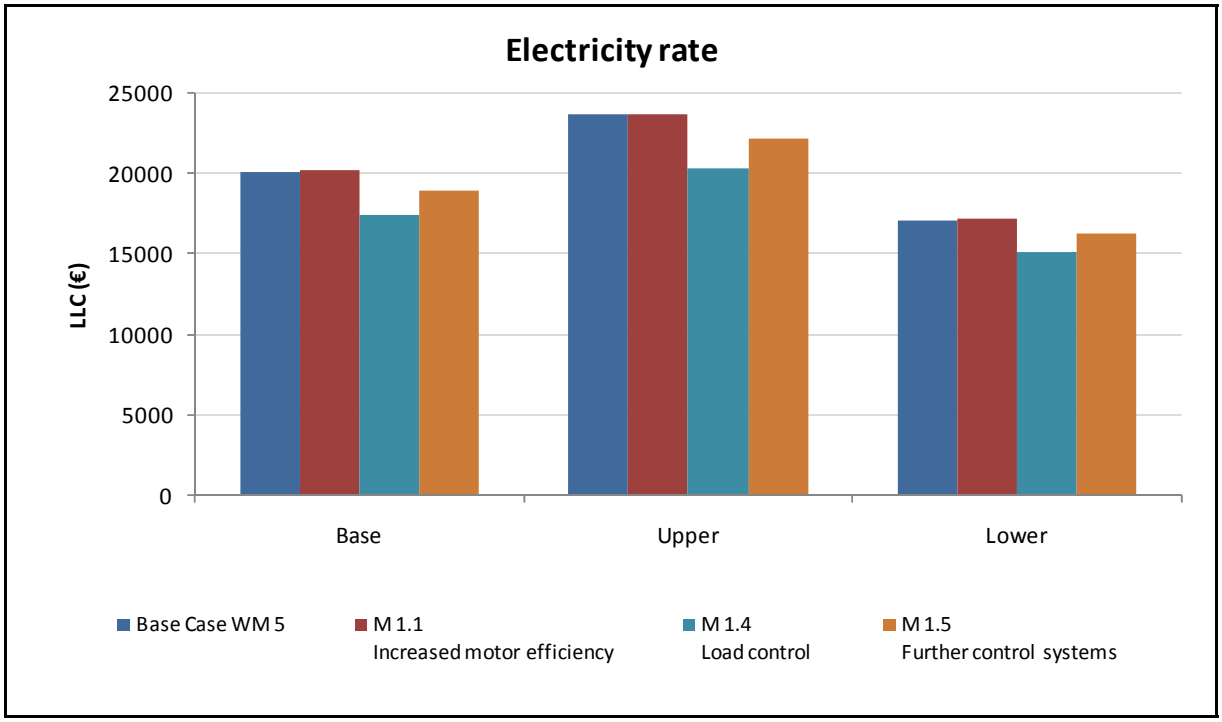


Figure 141 Base case WM 5 and improvement options – impact of electricty rates on LCC by product

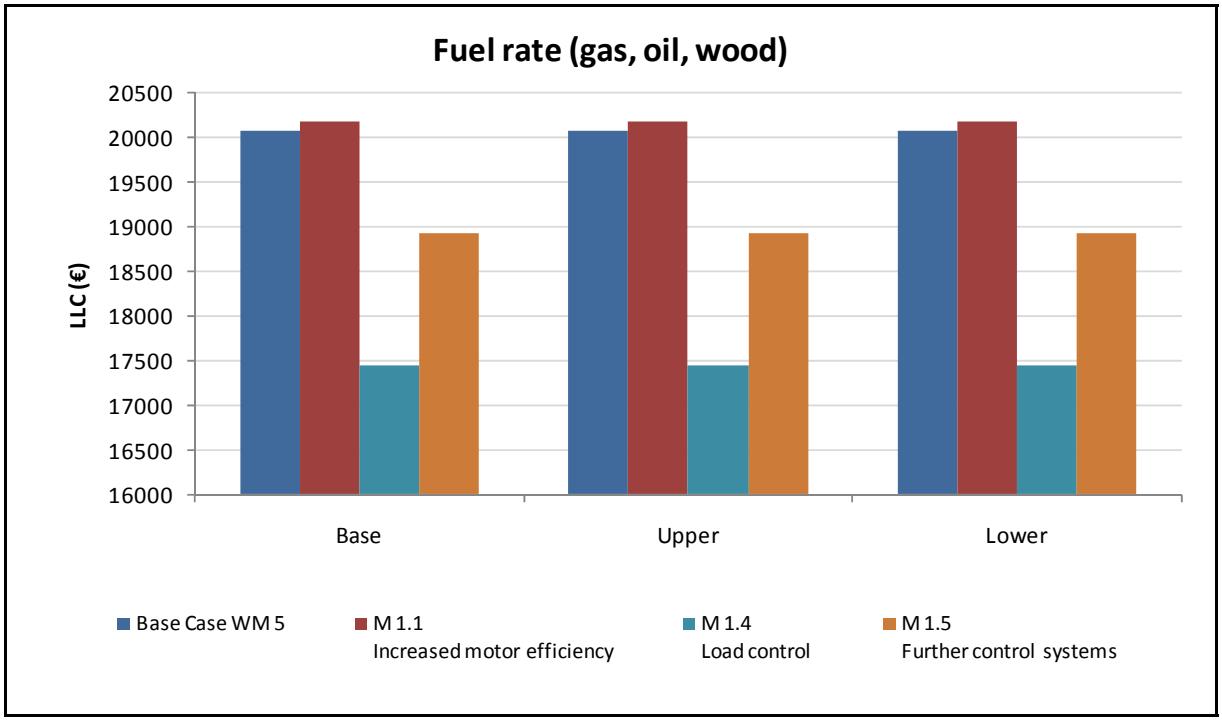


Figure 142 Base case WM 5 and improvement options – impact of gas rates on LCC by product

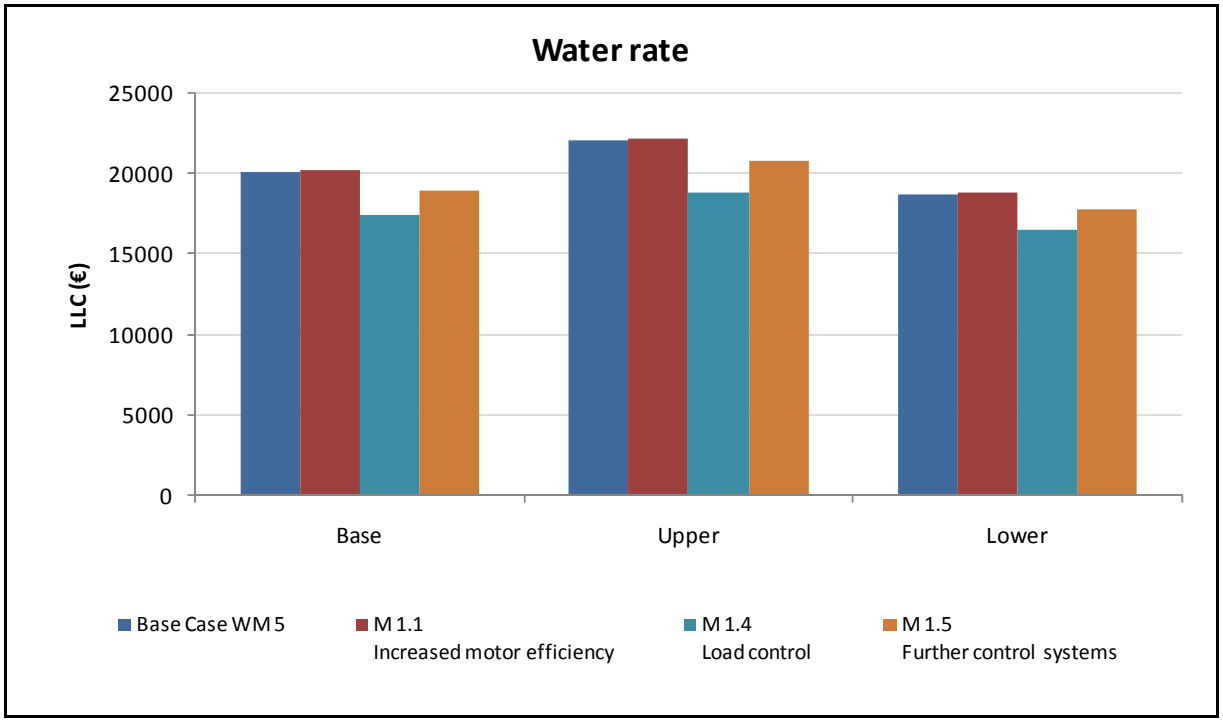


Figure 143 Base case WM 5 and improvement options – impact of water rate on LCC by product

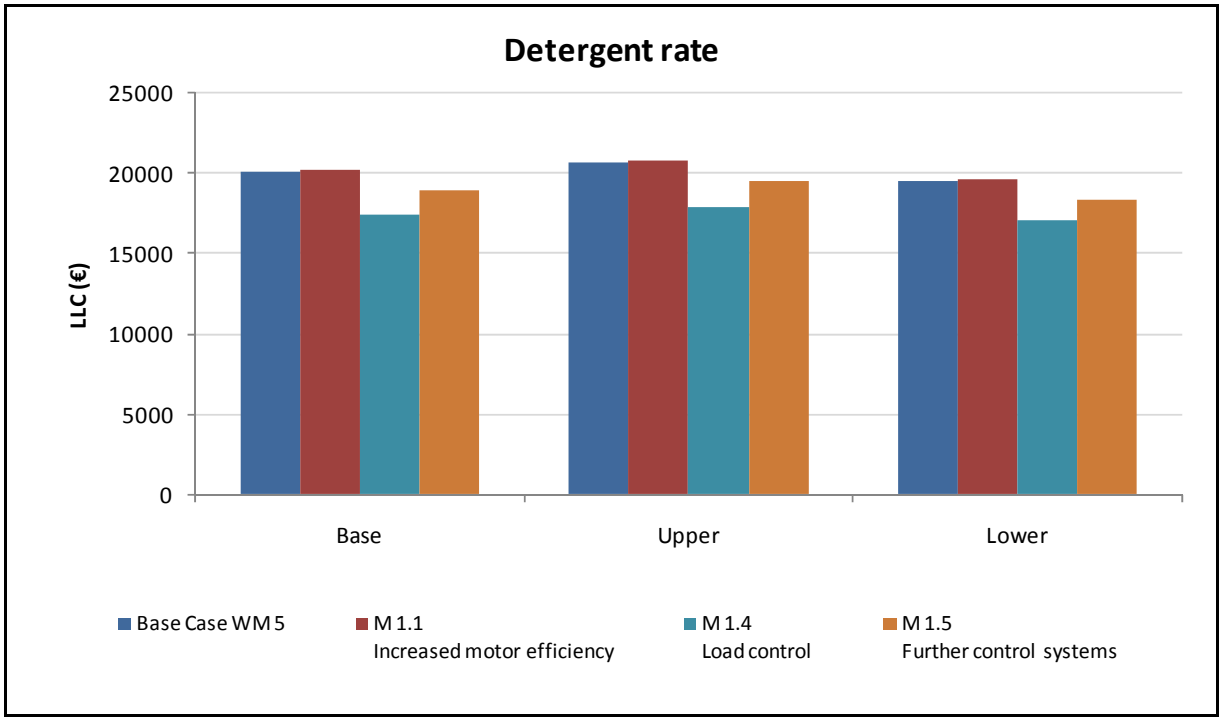


Figure 144 Base case WM 5 and improvement options – impact of detergent rate on LCC by product

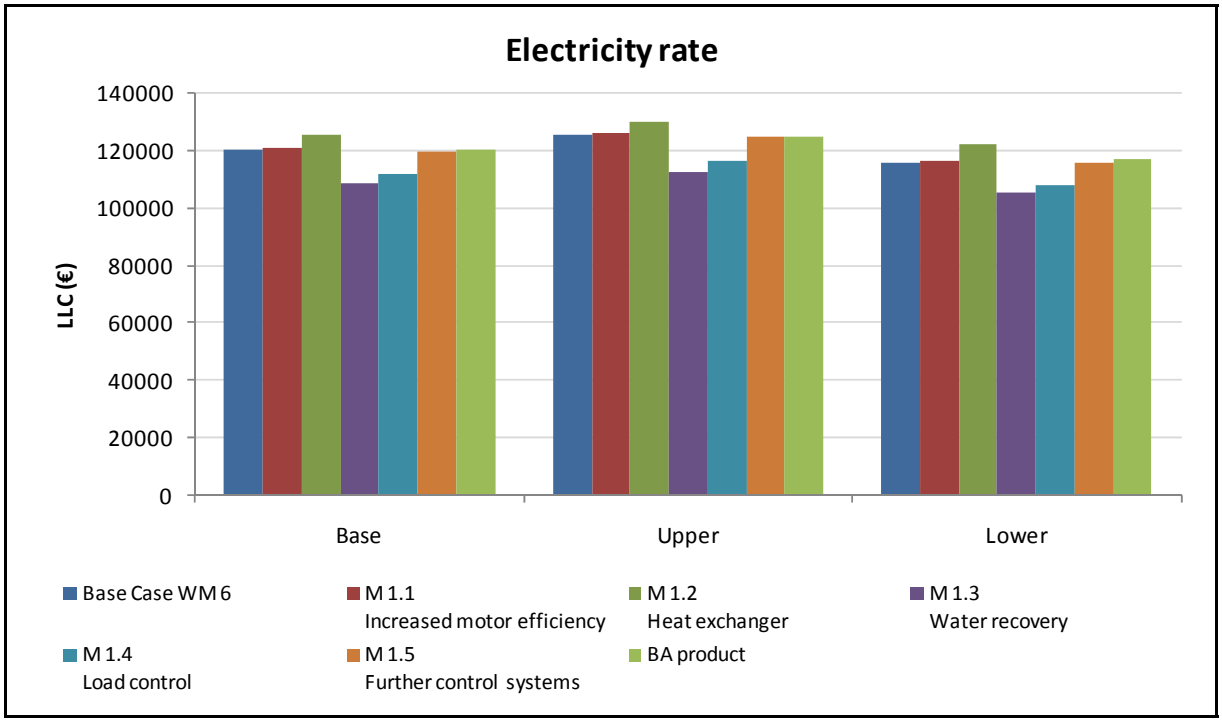


Figure 145 Base case WM 6 and improvement options – impact of electricty rates on LCC by product

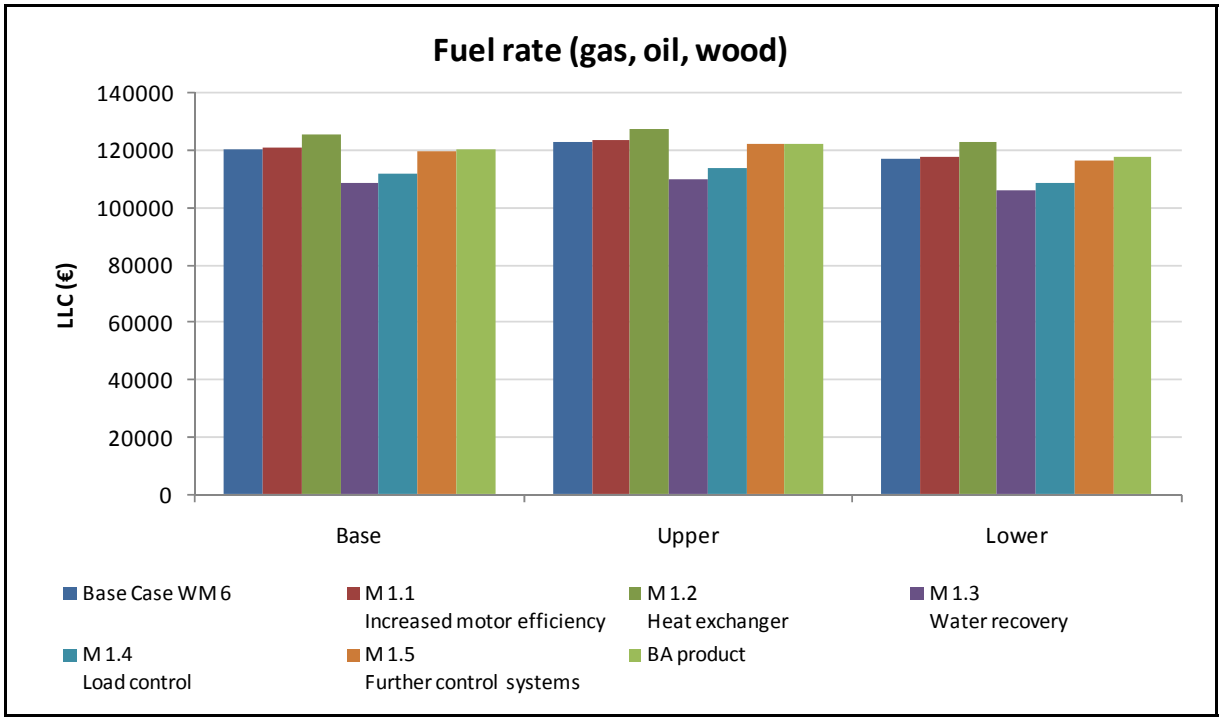


Figure 146 Base case WM 6 and improvement options – impact of gas rates on LCC by product

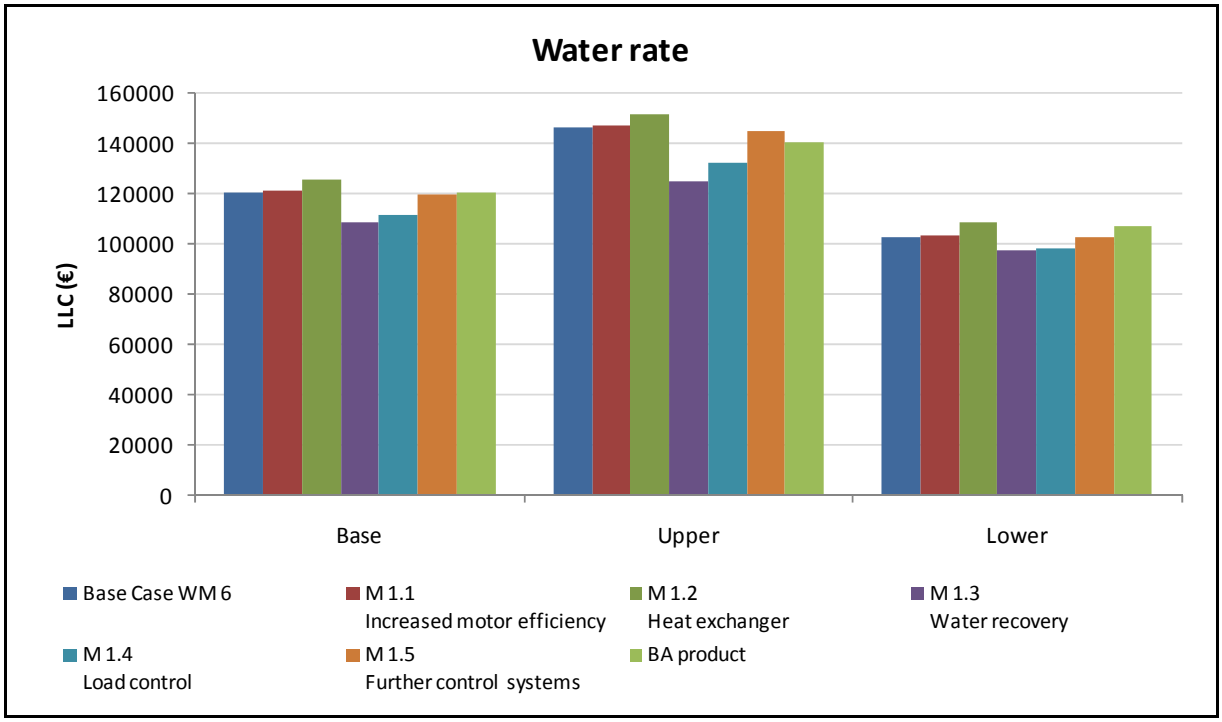


Figure 147 Base case WM 6 and improvement options – impact of water rate on LCC by product

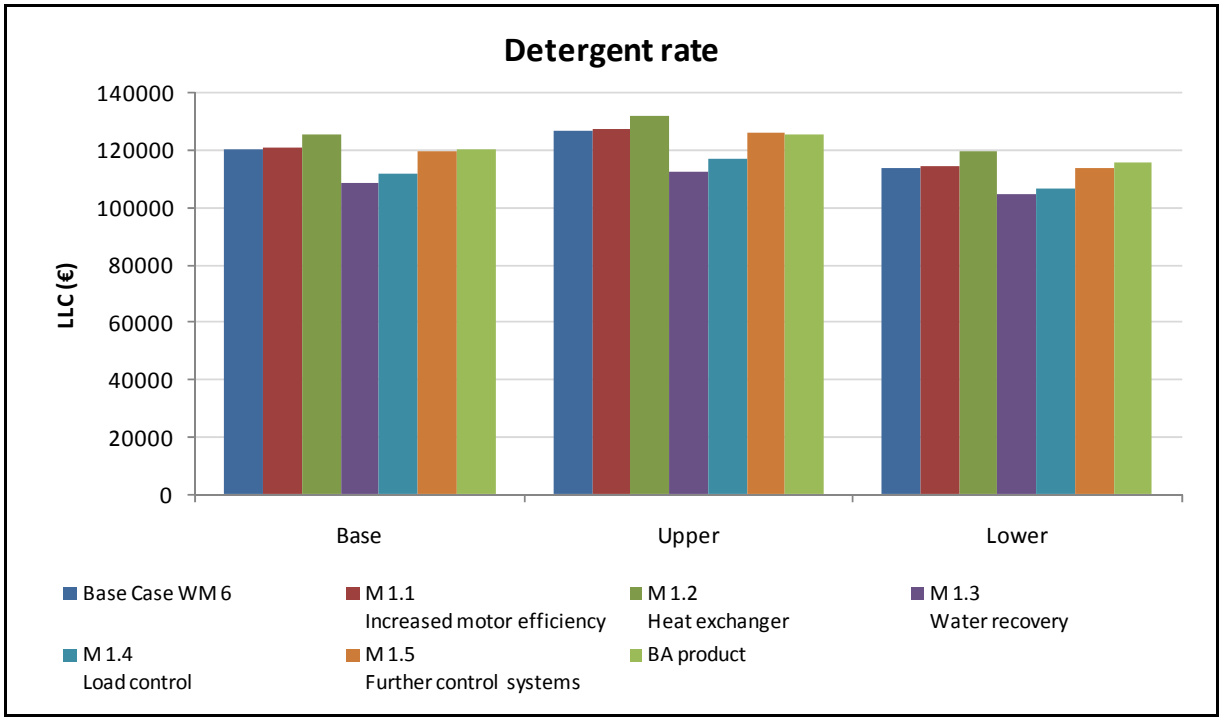


Figure 148 Base case WM 6 and improvement options – impact of detergent rate on LCC by product

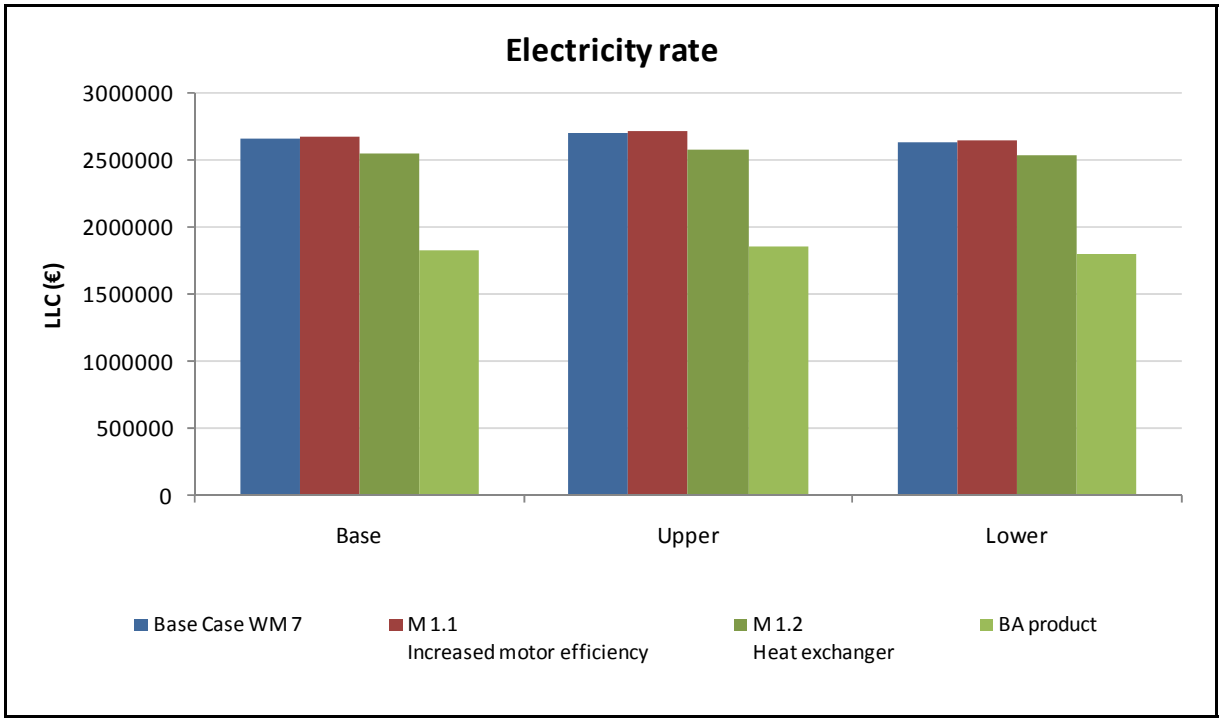


Figure 149 Base case WM 7 and improvement options – impact of electricty rates on LCC by product

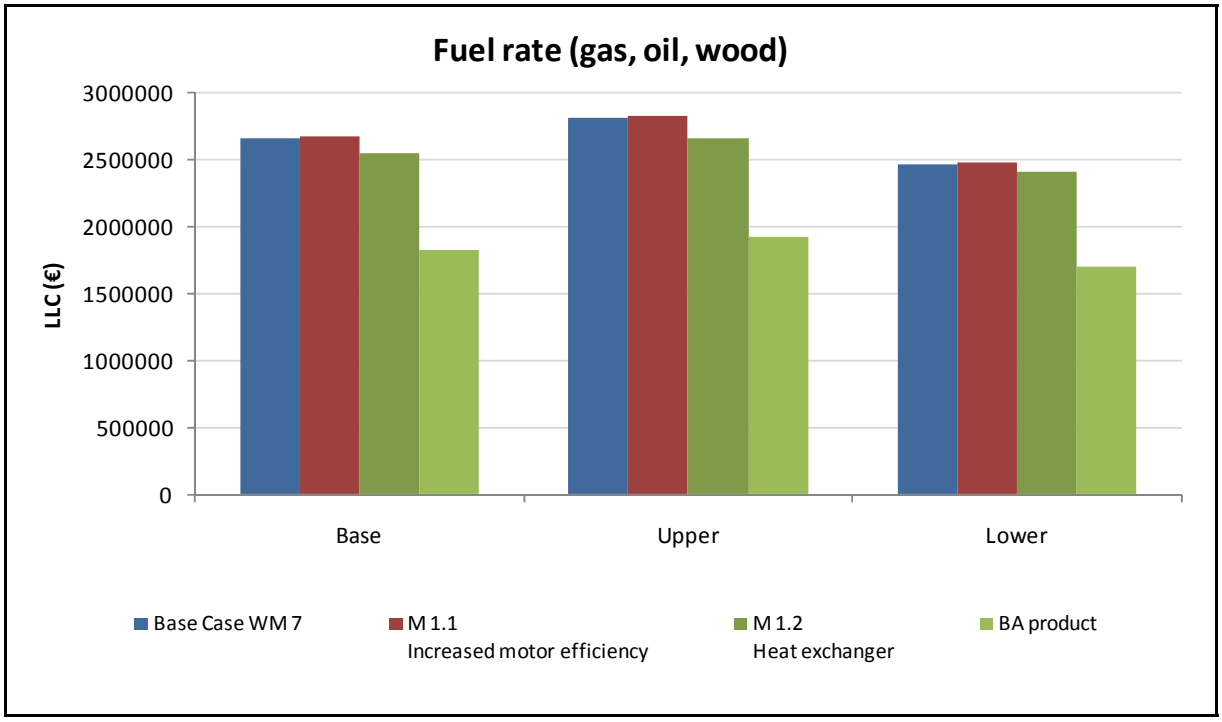


Figure 150 Base case WM 7 and improvement options – impact of gas rates on LCC by product

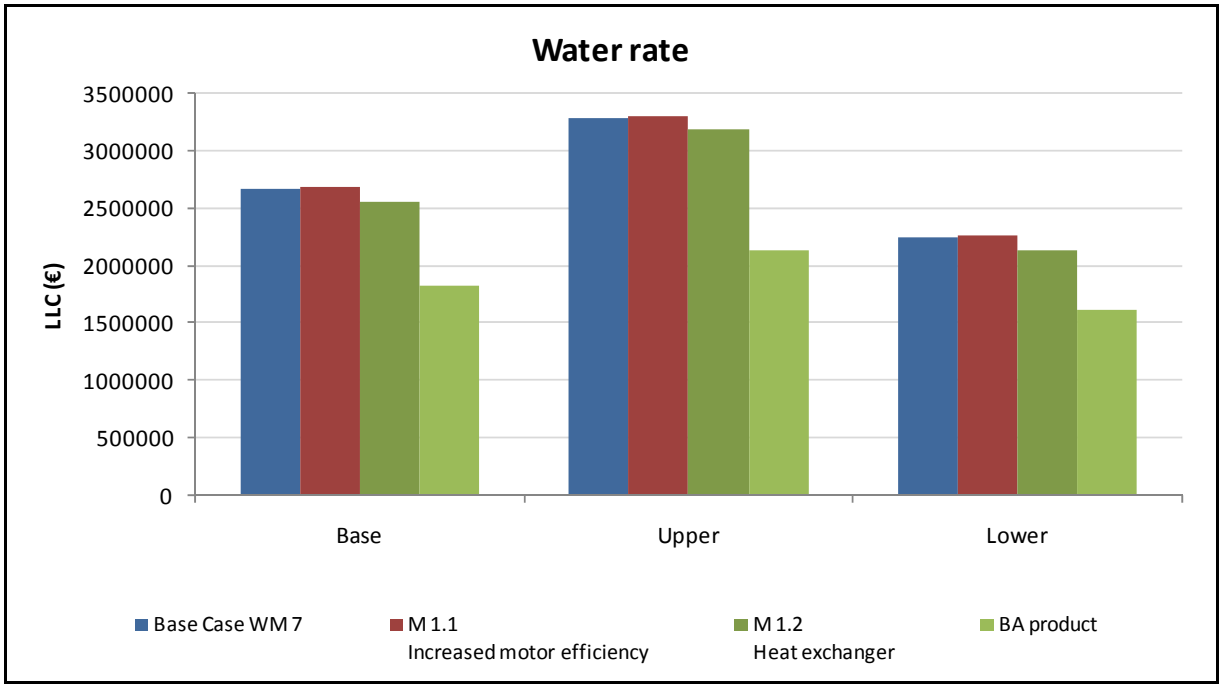


Figure 151 Base case WM 7 and improvement options – impact of water rate on LCC by product

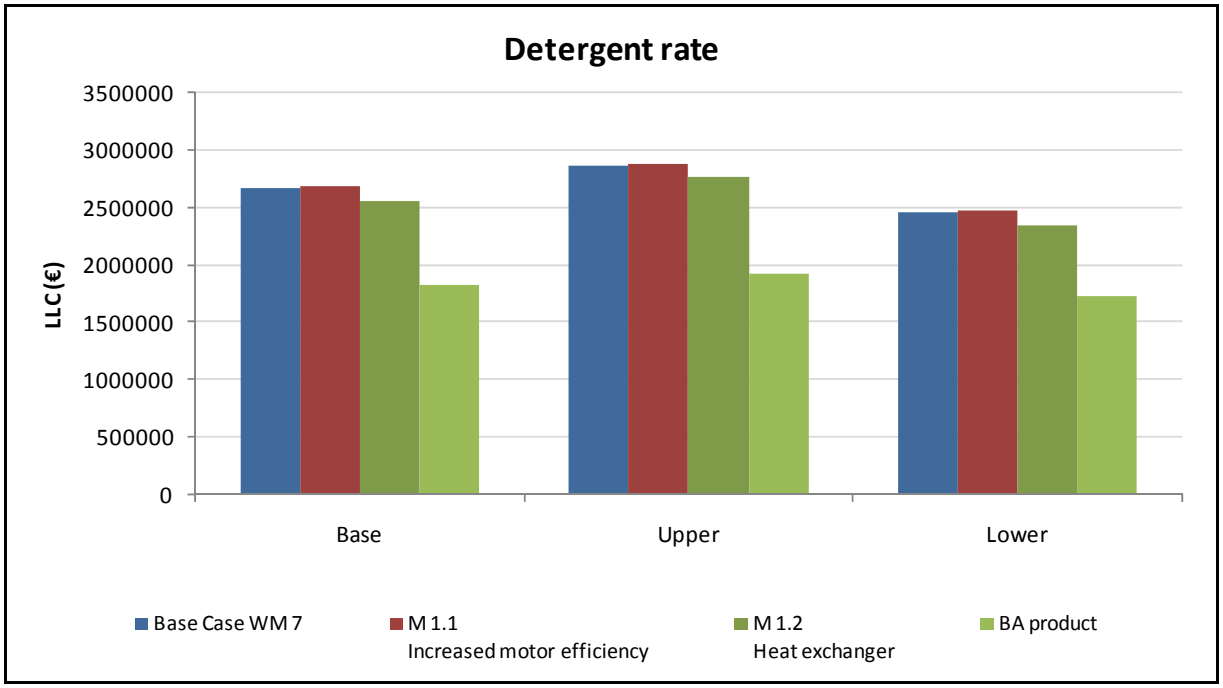


Figure 152 Base case WM 7 and improvement options – impact of detergent rate on LCC by product

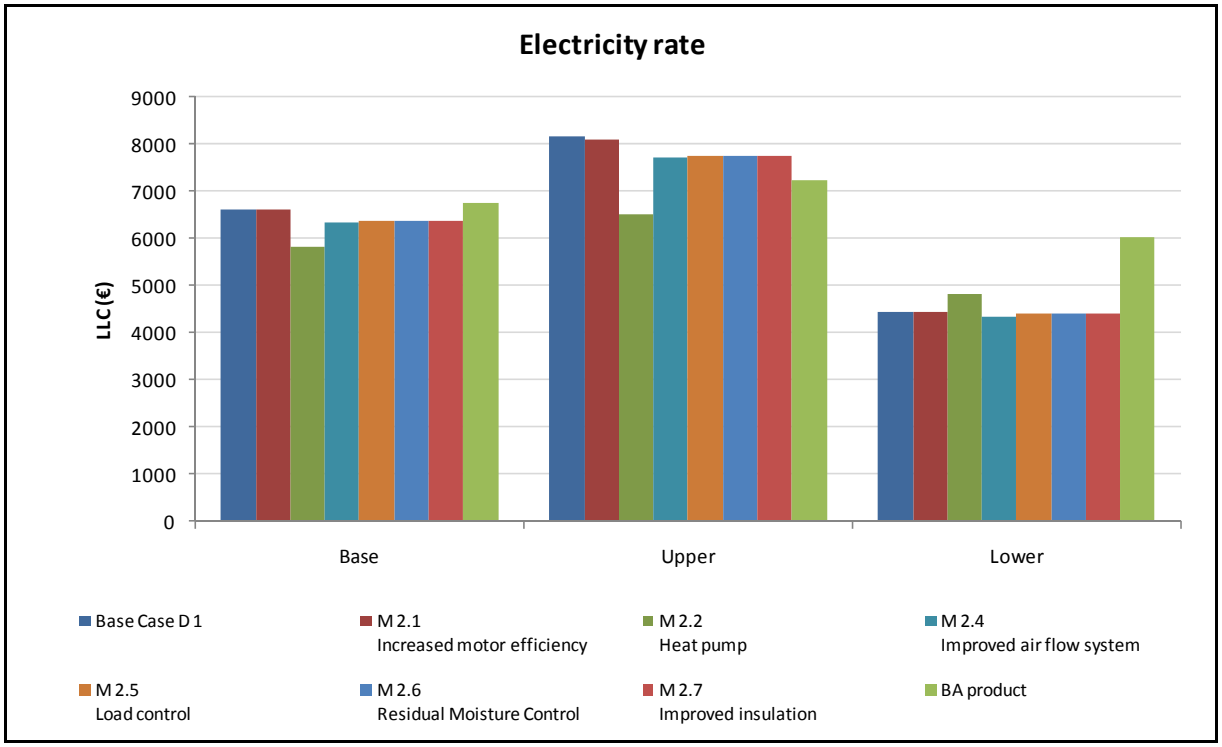


Figure 153 Base case D 1 and improvement options – impact of electricty rates on LCC by product

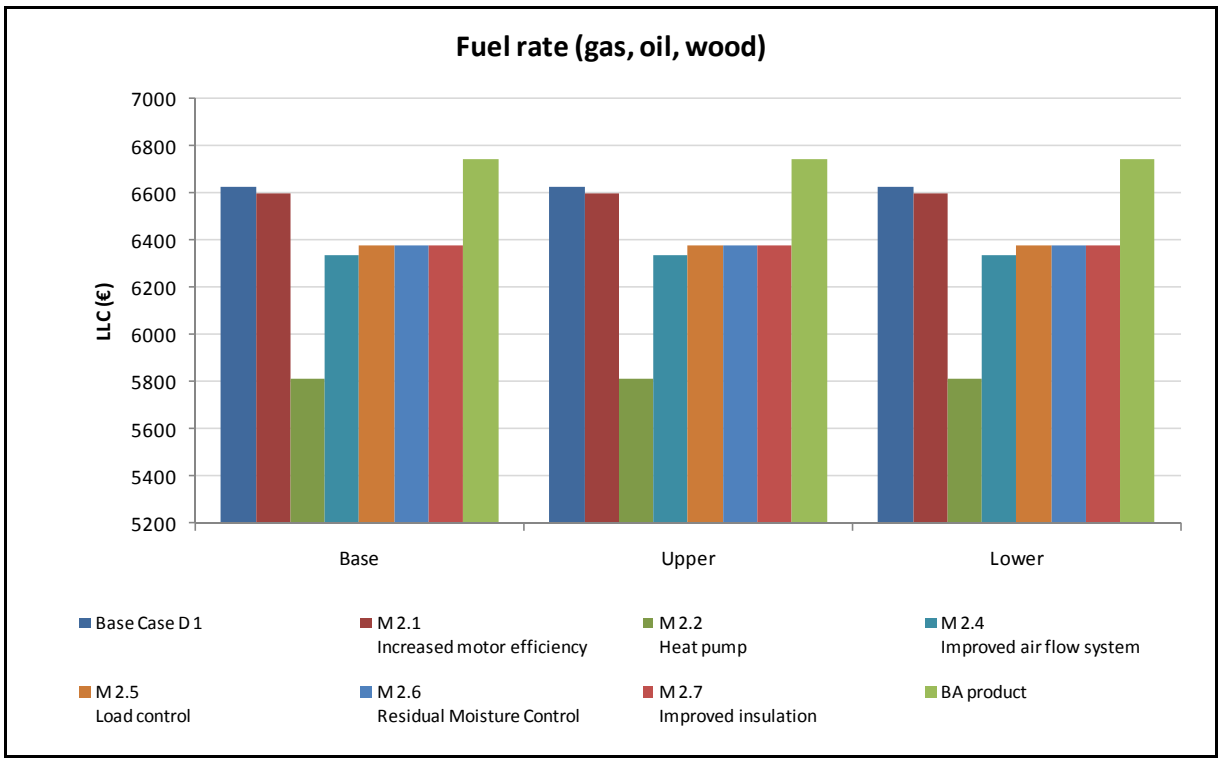


Figure 154 Base case D 1 and improvement options – impact of gas rates on LCC by product

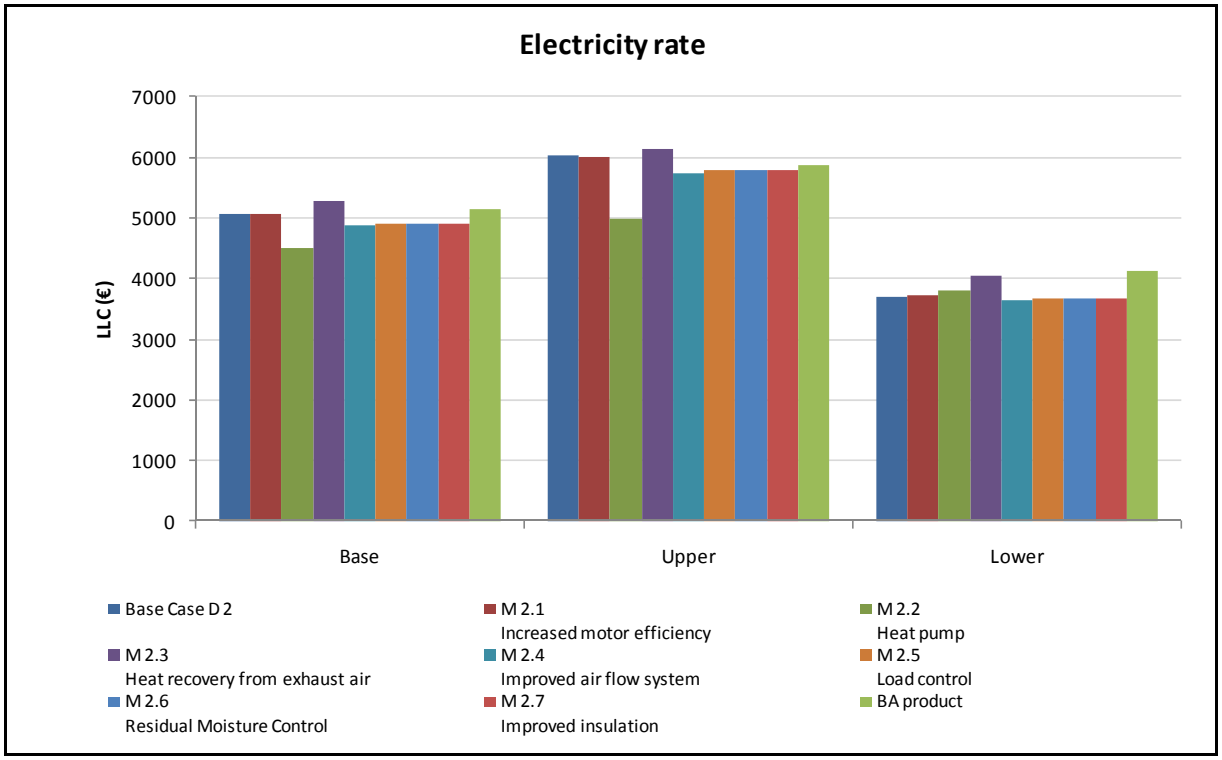


Figure 155 Base case D 2 and improvement options – impact of electricity rates on LCC by product

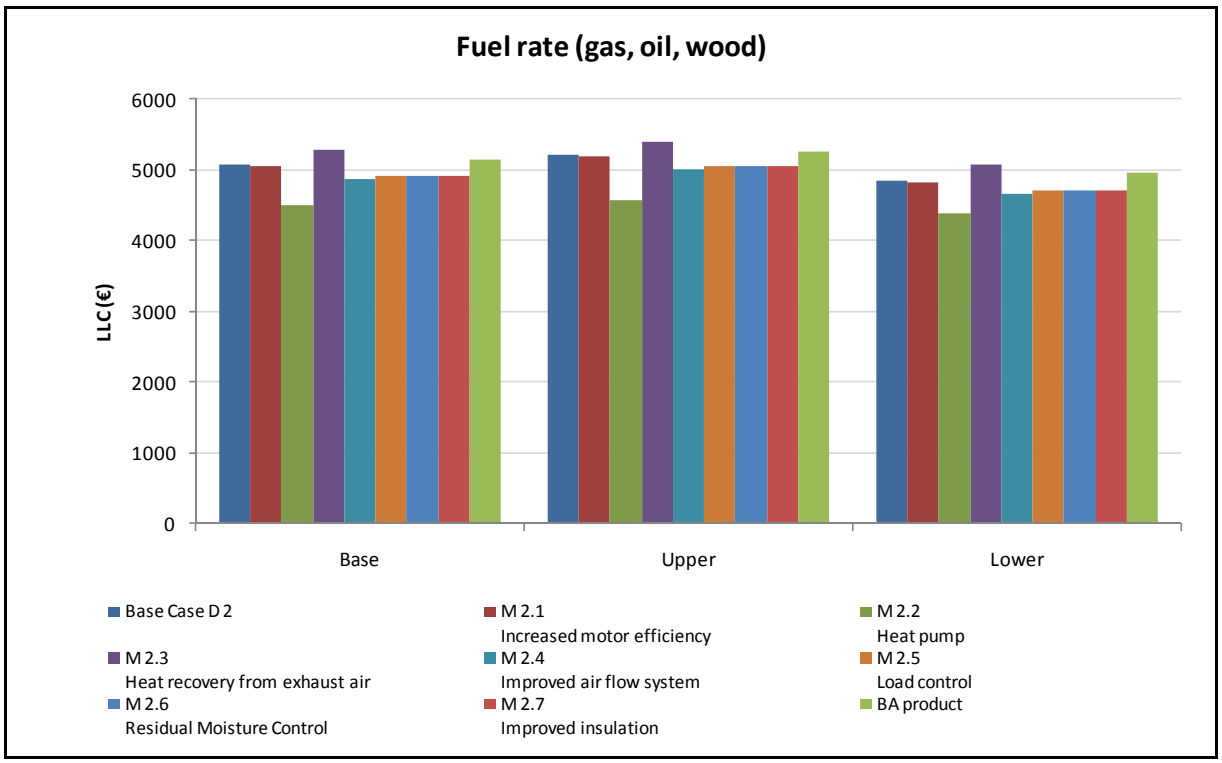


Figure 156 Base case D 2 and improvement options – impact of gas rates on LCC by product

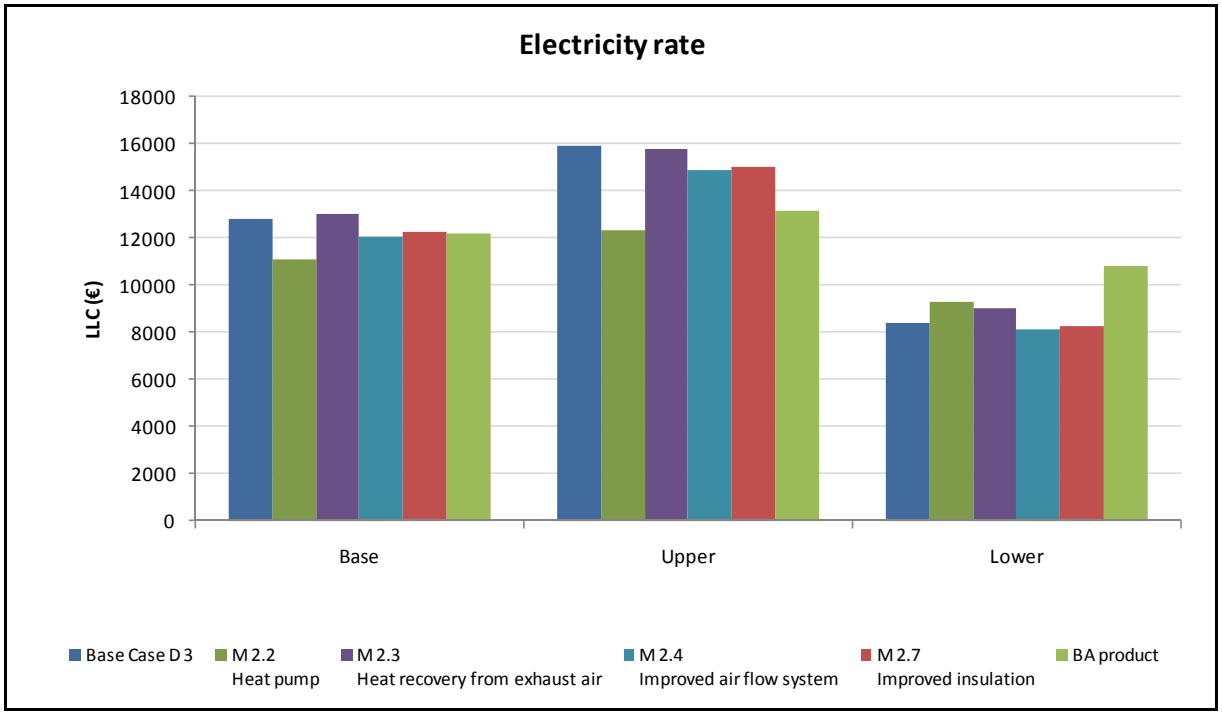


Figure 157 Base case D 3 and improvement options – impact of electricity rates on LCC by product

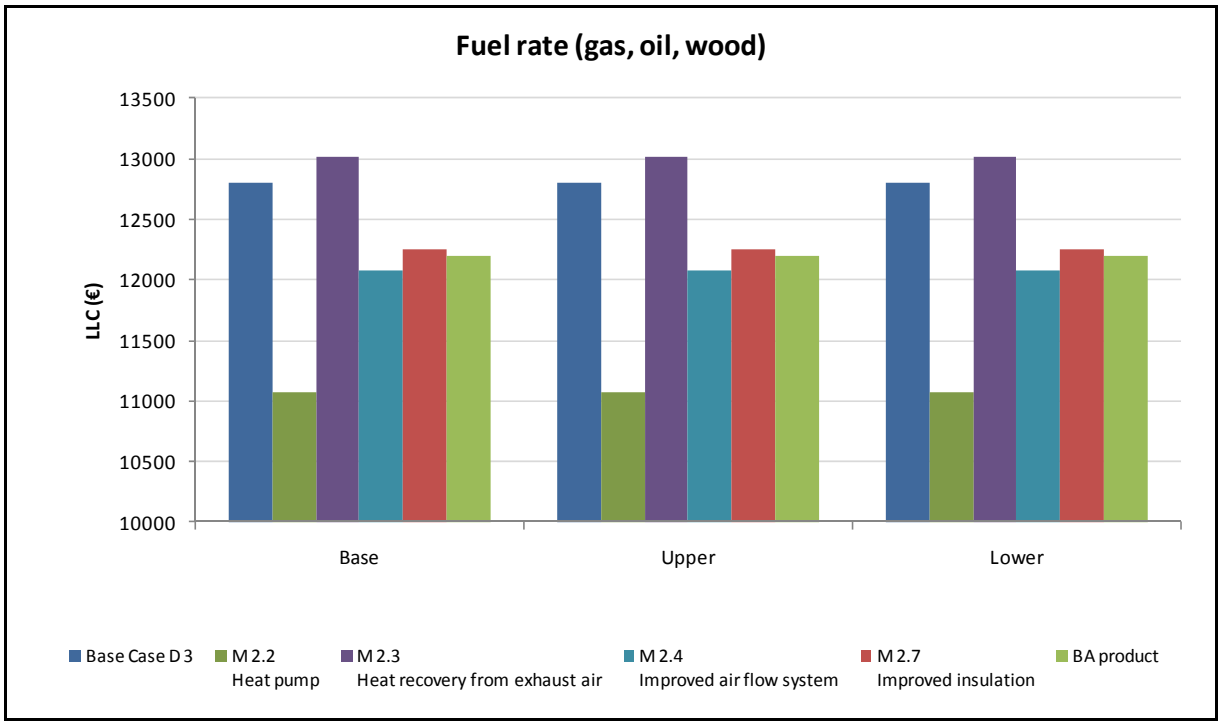


Figure 158 Base case D 3 and improvement options – impact of gas rates on LCC by product

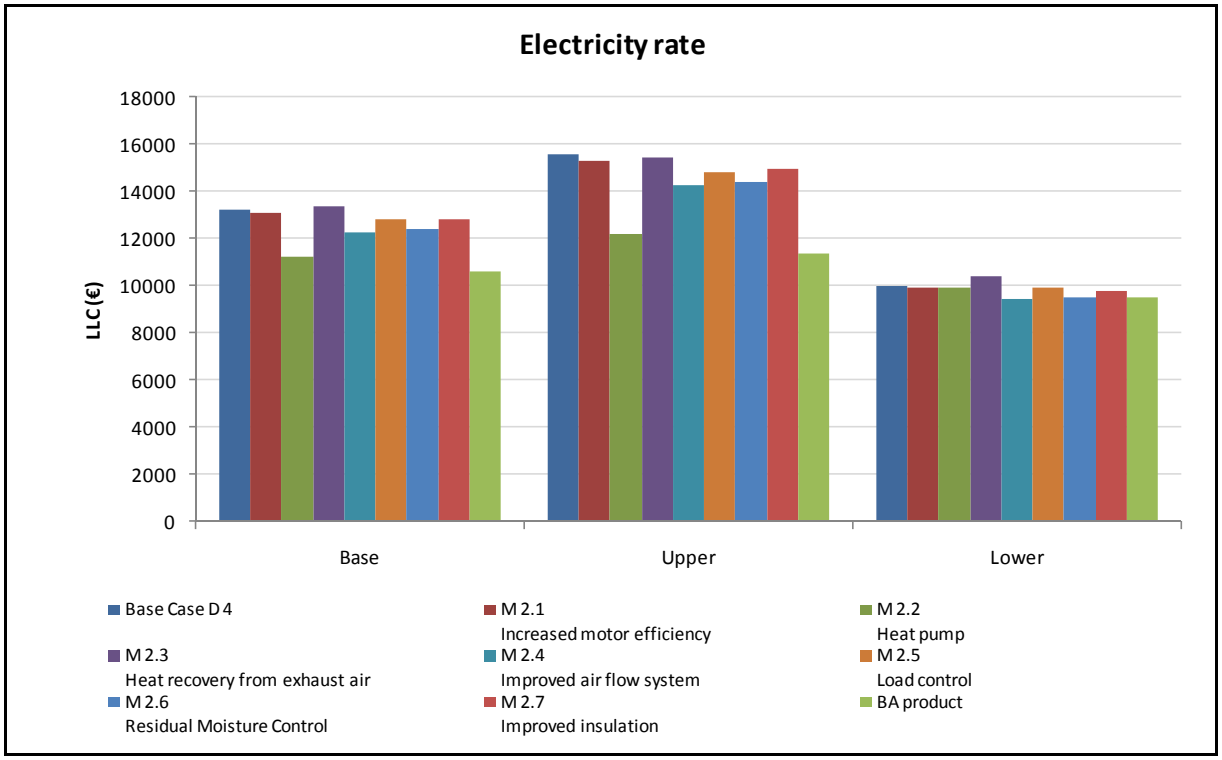


Figure 159 Base case D 4 and improvement options – impact of electricity rates on LCC by product

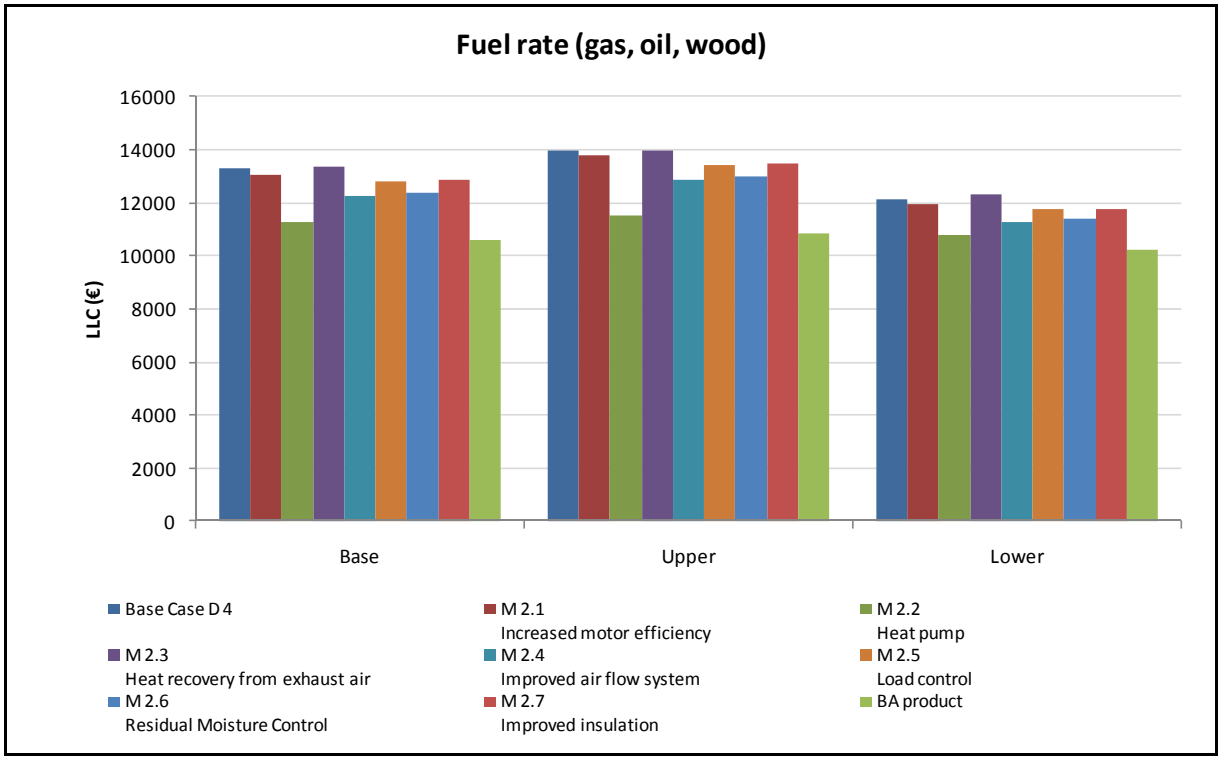


Figure 160 Base case D 4 and improvement options – impact of gas rates on LCC by product

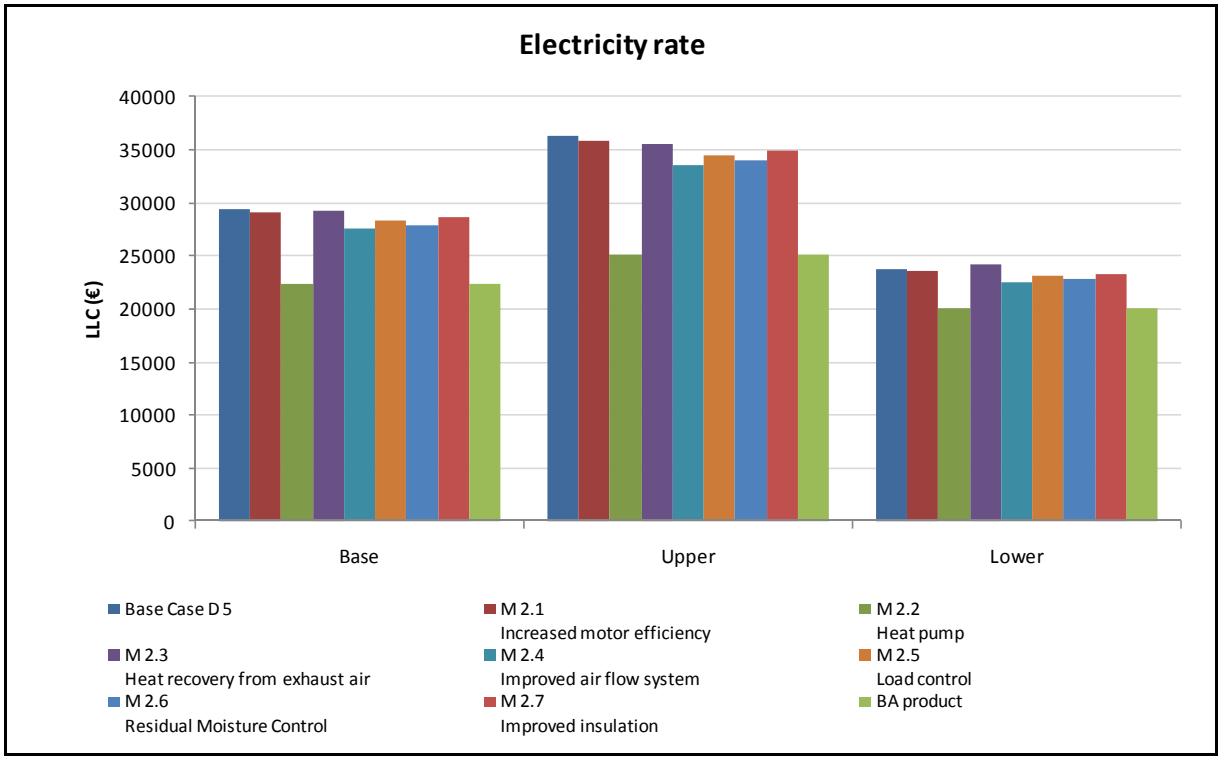


Figure 161 Base case D 5 and improvement options – impact of electricity rates on LCC by product

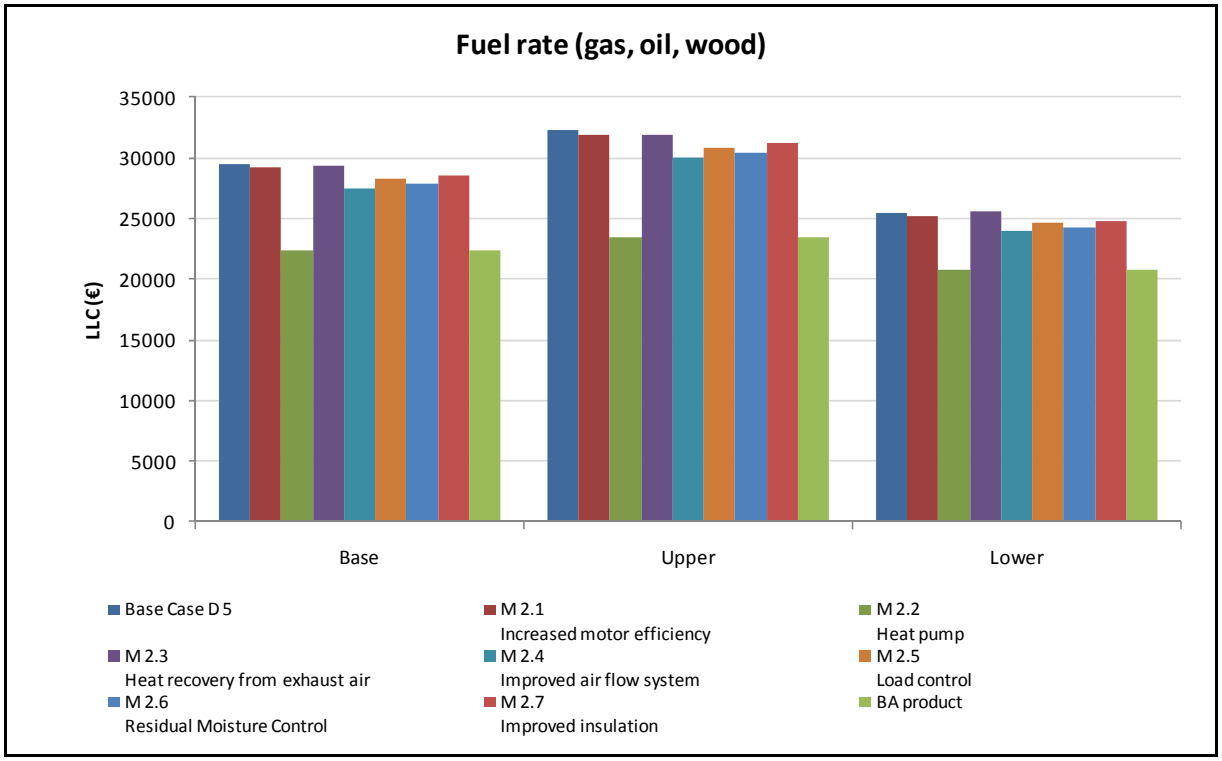


Figure 162 Base case D 5 and improvement options – impact of gas rates on LCC by product

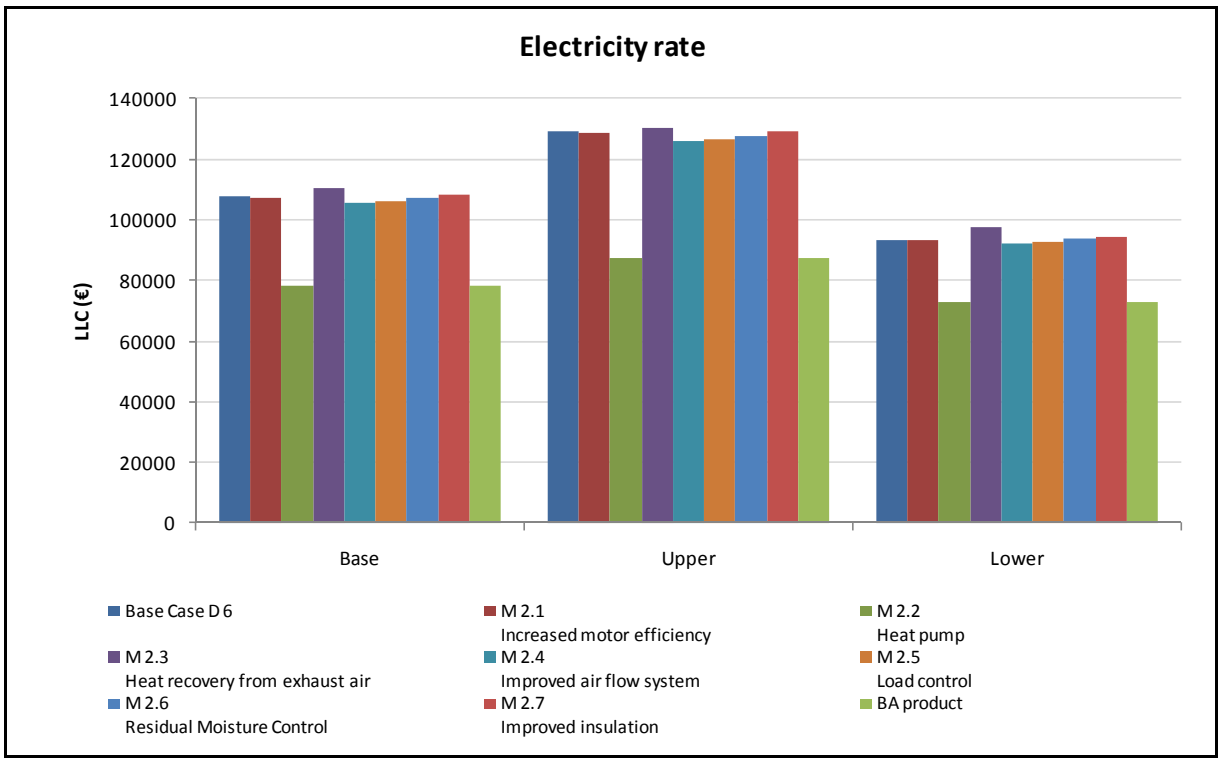


Figure 163 Base case D 6 and improvement options – impact of electricity rates on LCC by product

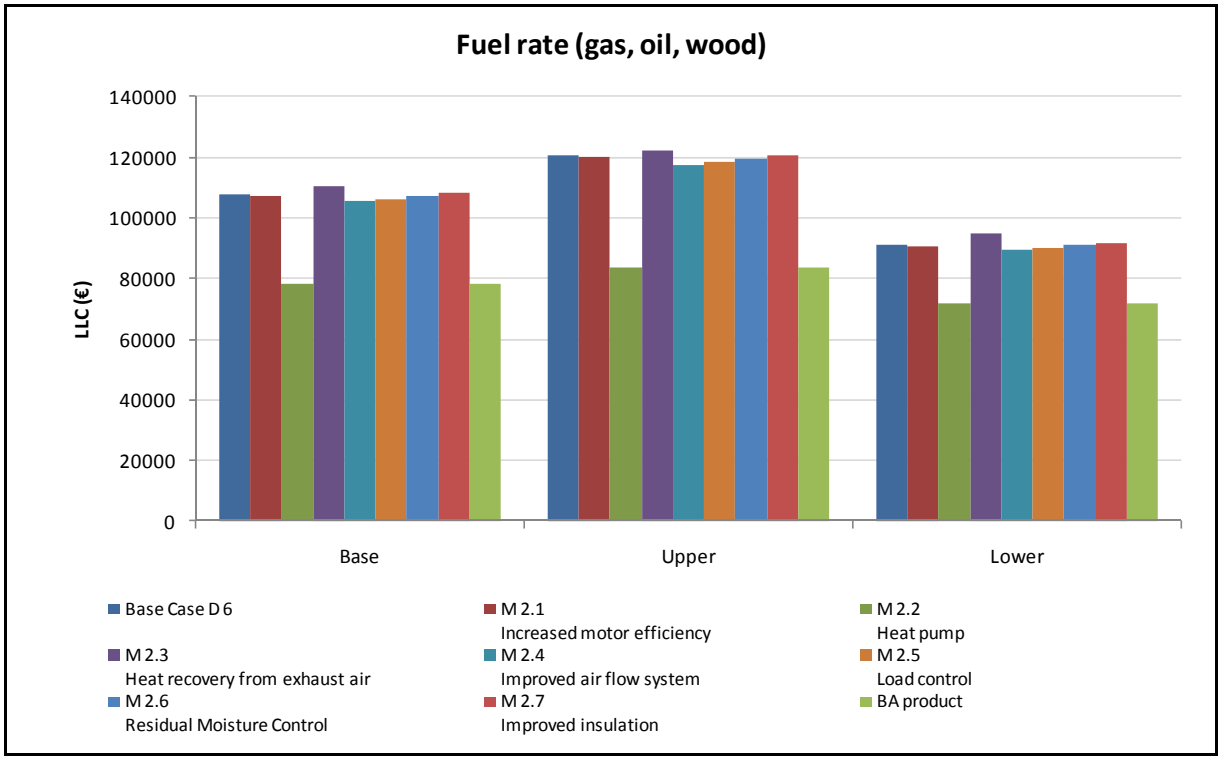


Figure 164 Base case D 6 and improvement options – impact of gas rates on LCC by product

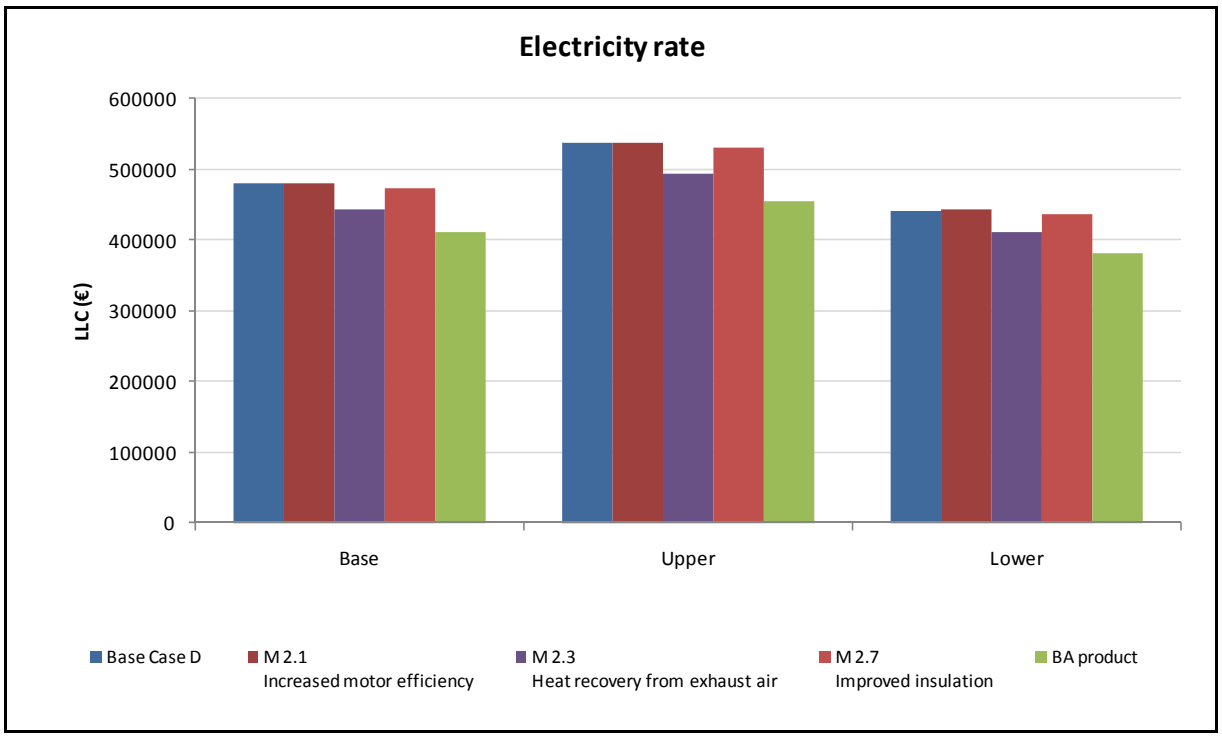


Figure 165 Base case D 7 and improvement options – impact of electricity rates on LCC by product

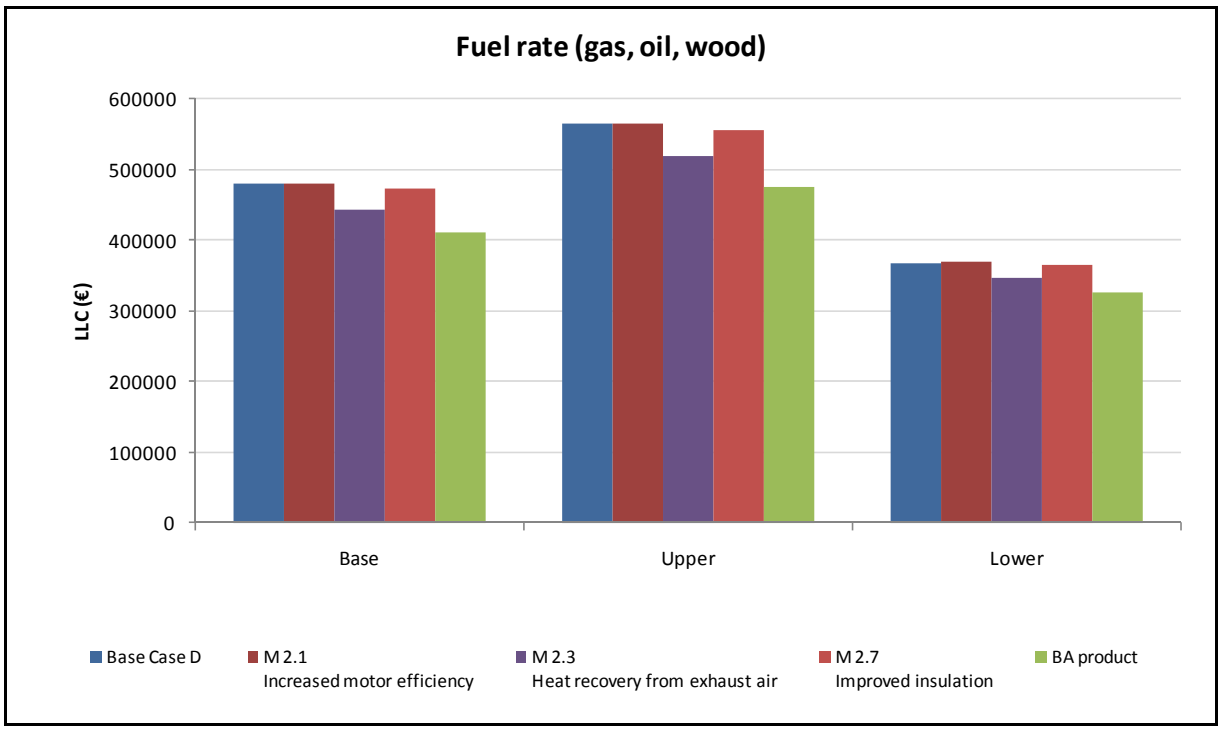


Figure 166 Base case D 7 and improvement options – impact of gas rates on LCC by product

4.5 Product purchase price

4.5.1 Assumptions

The product purchase price is a major parameter for the calculation of the LCC. Table 27 presents the ranges which will be studied for the sensitivity analysis (20% error margin).

As the improved products purchase prices are directly linked to the base case prices, the same error margin is applied to the purchase prices of the improved products.

Table 27 Purchase prices ranges for the sensitivity analysis

Base case	Base purchase price (€)	Min	Max
WM 1 - Semi-professional washer extractor	2 670	2 136	3 204
WM 2 - Professional washing extractor (<15 kg)	5 000	4 000	6 000
WM 3 - Professional washing extractor (15–40 kg)	15 250	12 200	18 300
WM 4 - Professional washing extractor (>40 kg)	58 750	47 000	70 500
WM 5 - Professional washer dryer	8 000	6 400	9 600
WM 6 - Professional barrier washer	38 250	30 600	45 900
WM 7 - Washing tunnel machine	390 000	312 000	468 000
D 1 - Semi-professional dryer, condenser	1 970	1 576	2 364
D 2 - Semi-professional dryer, air vented	1 680	1 344	2 016
D 3 - Professional cabinet dryer	3 500	2 800	4 200
D 4 - Professional air tumble dryer (<15 kg)	4 000	3 200	4 800
D 5 - Professional air tumble dryer (15–40 kg)	7 125	5 700	8 550
D 6 - Professional air tumble dryer (>40 kg)	21 500	17 200	25 800
D 7 - Industrial pass-through (transfer) tumble dryer	62 500	50 000	75 000

4.5.2 Results

Figure 167 to Figure 180 show the influence of the variation of the purchase prices on the life cycle costs of the different base cases and associated improvement options.

The option leading to the lowest life cycle costs always remain the same for a given base case, whatever the purchase price values considered (base, lower or upper). However, a few relative changes in the rankings of options happen, for instance:

- For base case D 1, D 2 and D 3, the LCC of the BA product becomes lower than the LCC of the base case with the lower values.

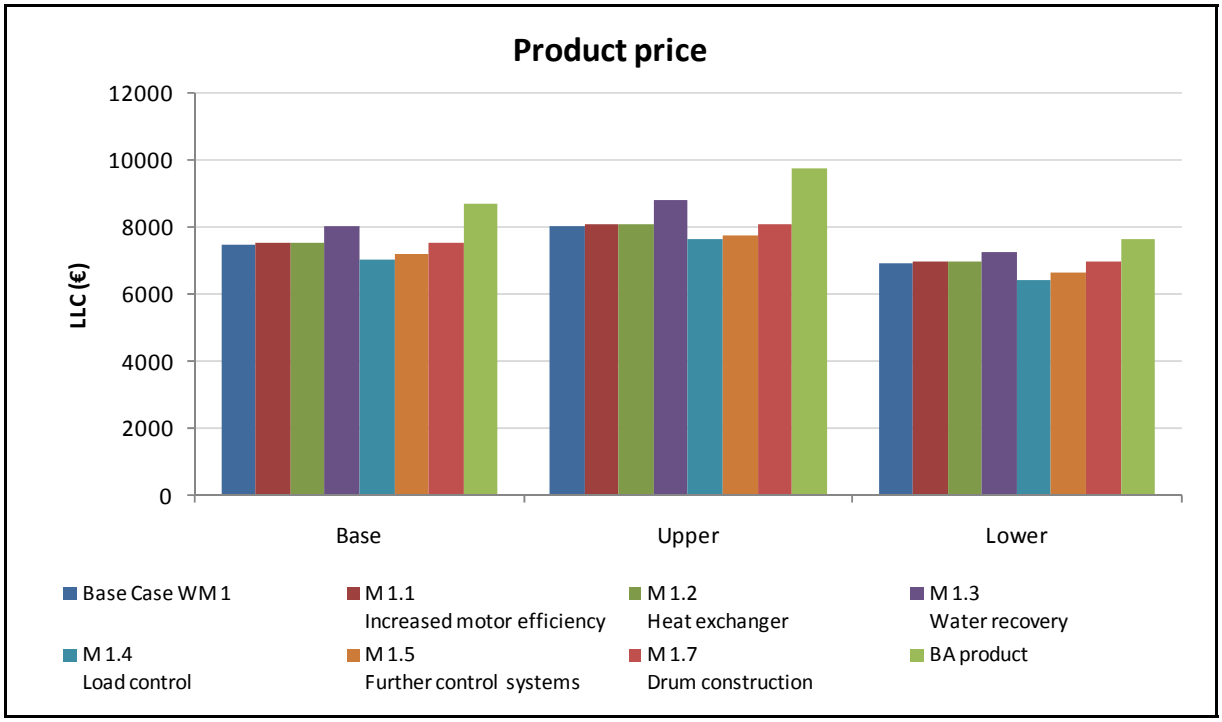


Figure 167 Base case WM 1 and improvement options – impact of purchase price on LCC by product

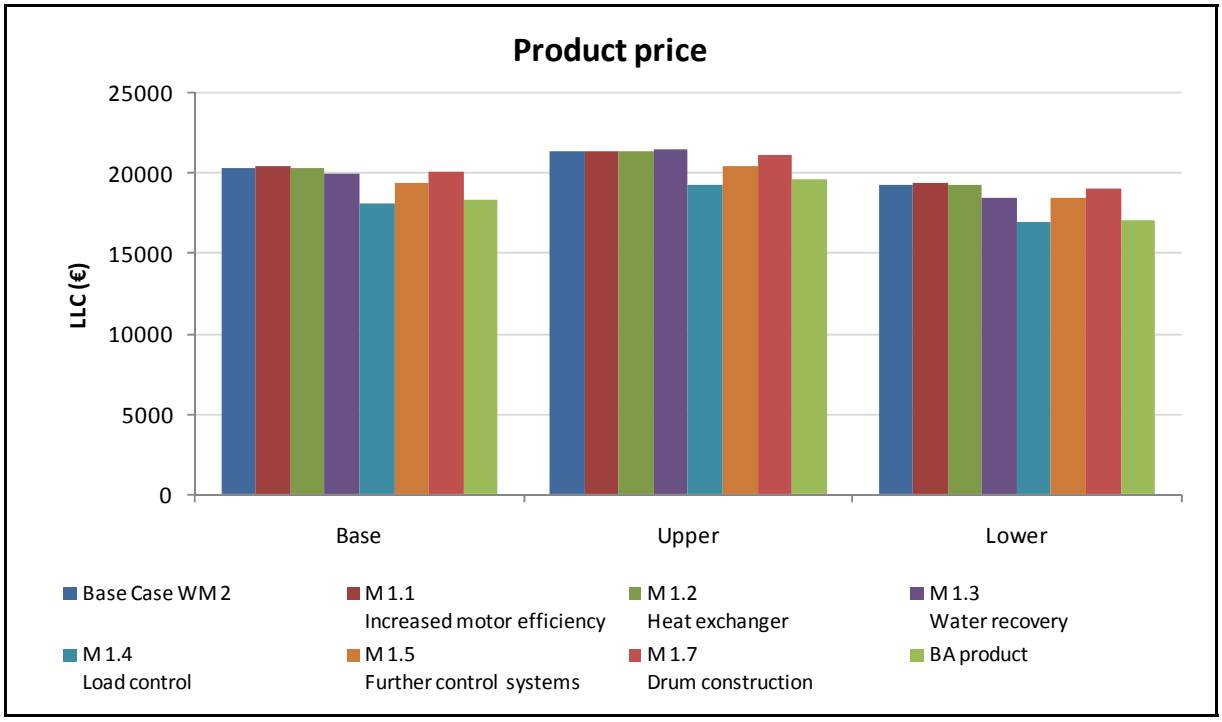


Figure 168 Base case WM 2 and improvement options – impact of purchase price on LCC by product

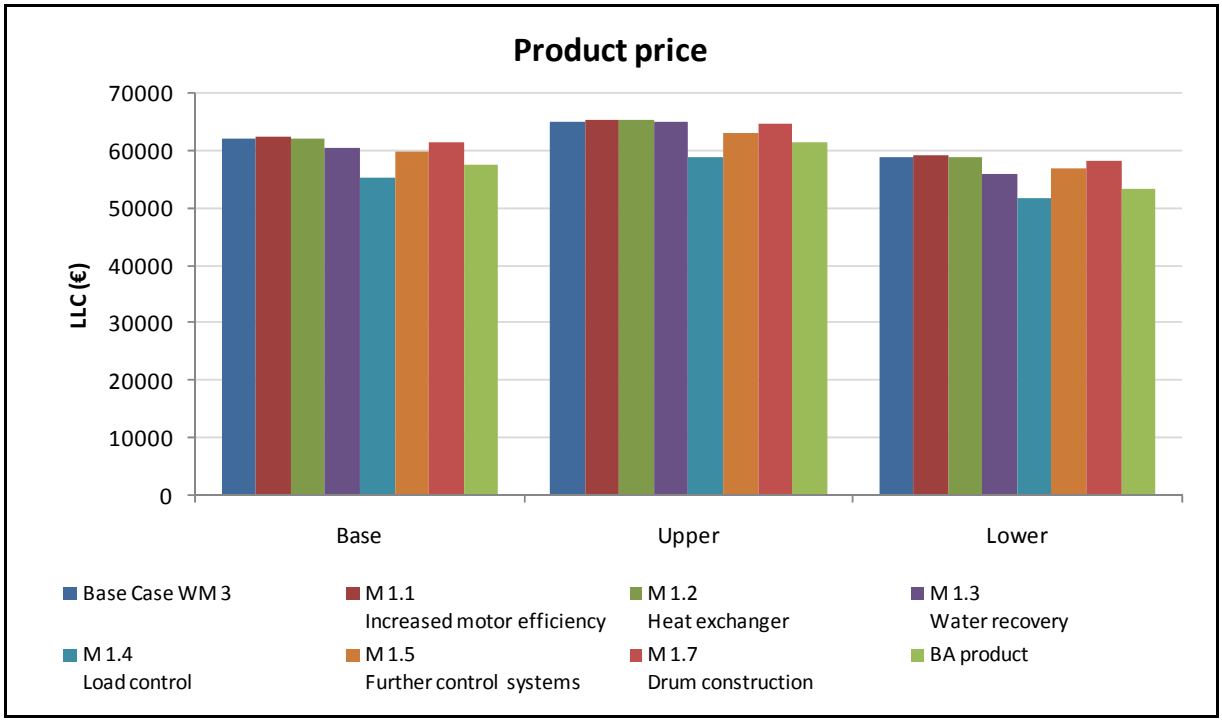


Figure 169 Base case WM 3 and improvement options – impact of purchase price on LCC by product

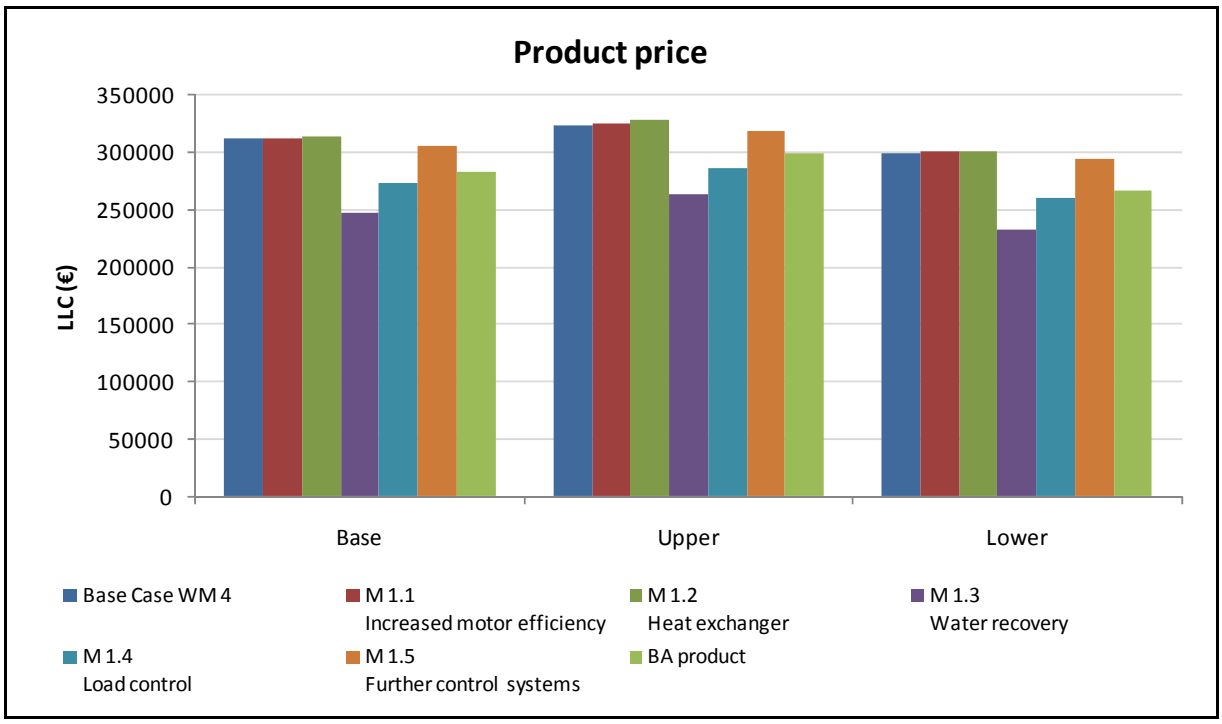


Figure 170 Base case WM 4 and improvement options – impact of purchase price on LCC by product

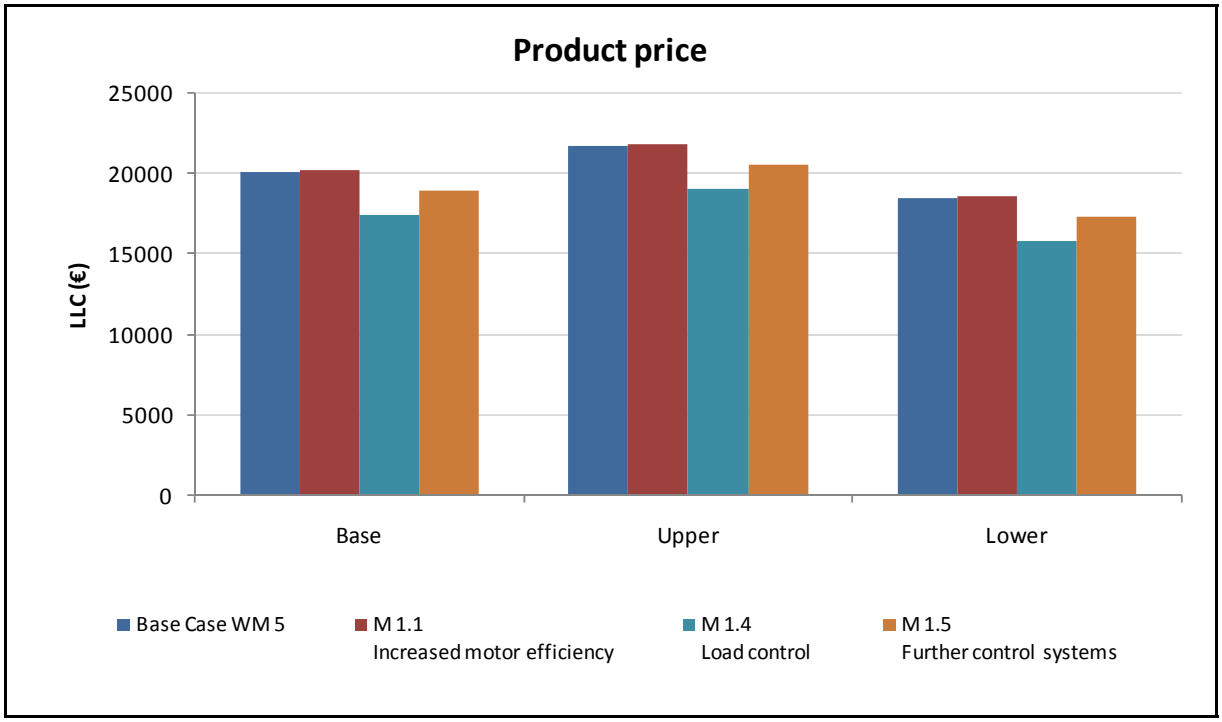


Figure 171 Base case WM 5 and improvement options – impact of purchase price on LCC by product

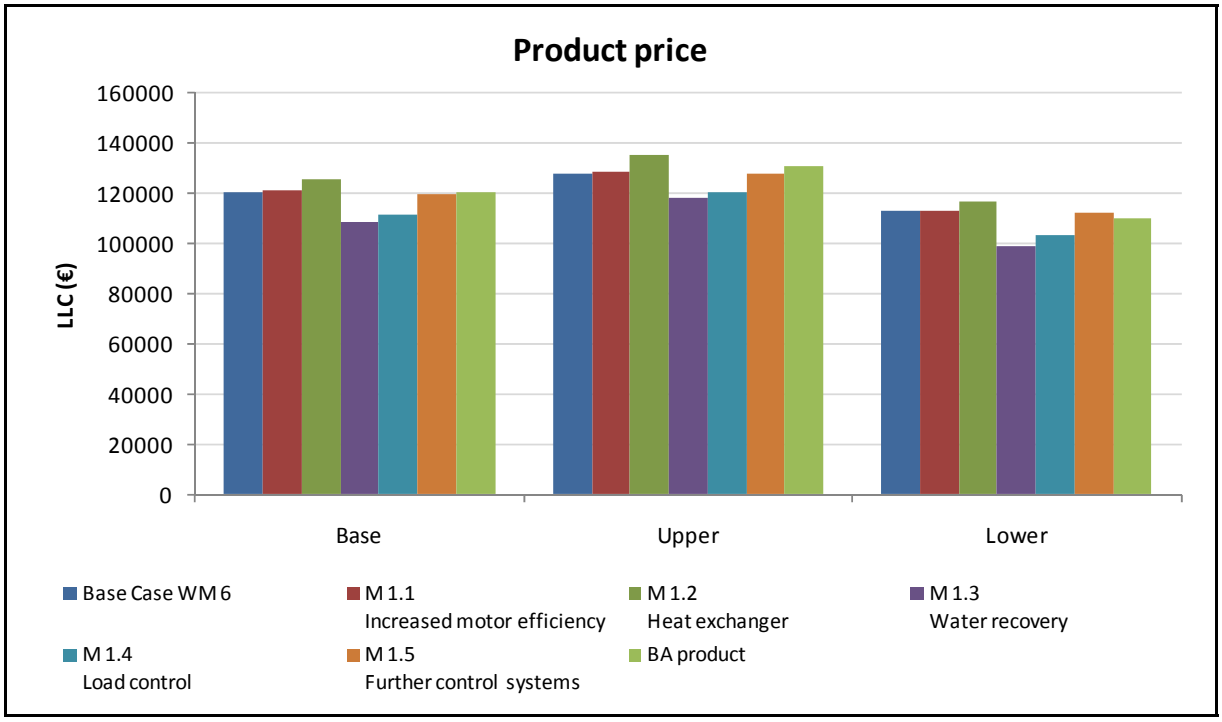


Figure 172 Base case WM 6 and improvement options – impact of purchase price on LCC by product

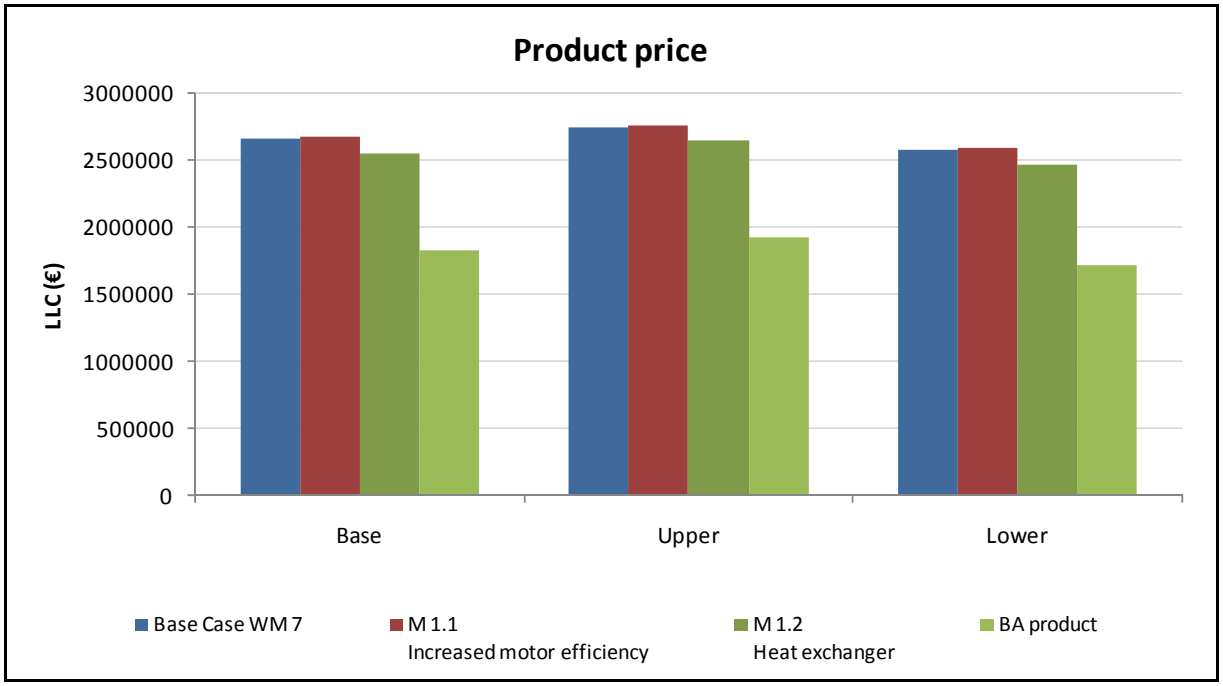


Figure 173 Base case WM 7 and improvement options – impact of purchase price on LCC by product

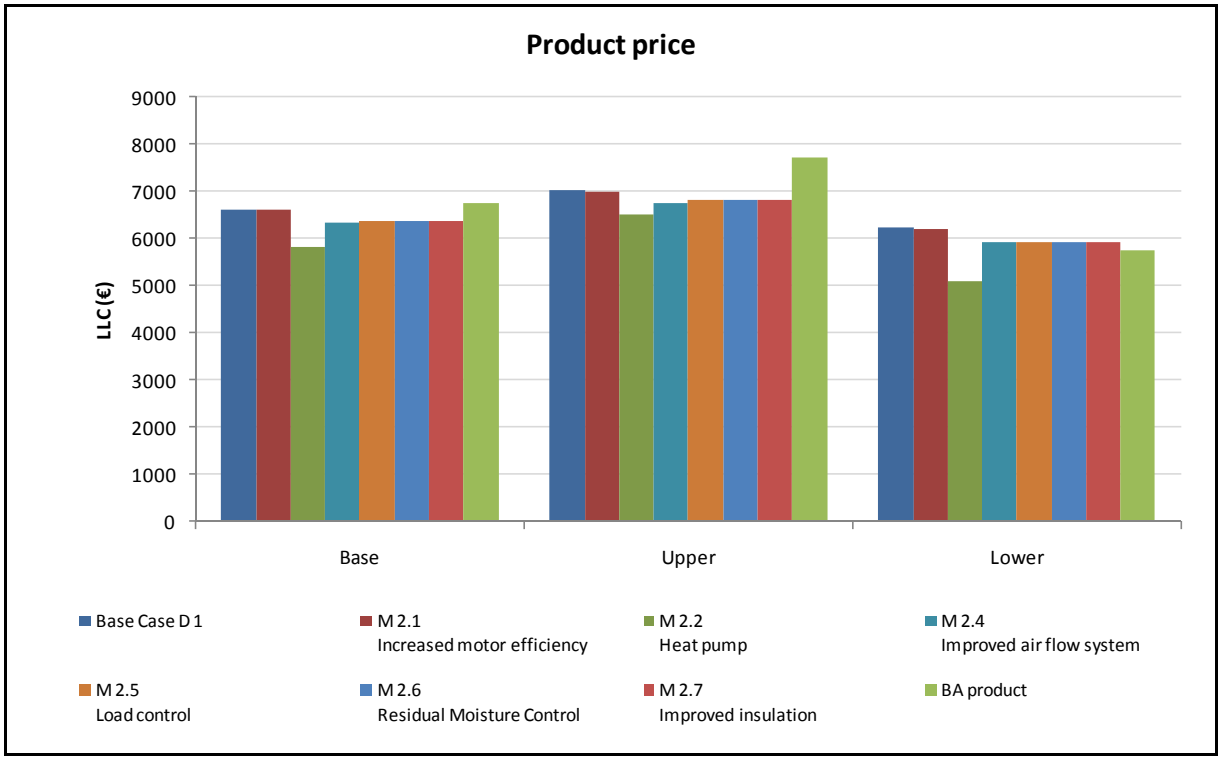


Figure 174 Base case D 1 and improvement options – impact of purchase price on LCC by product

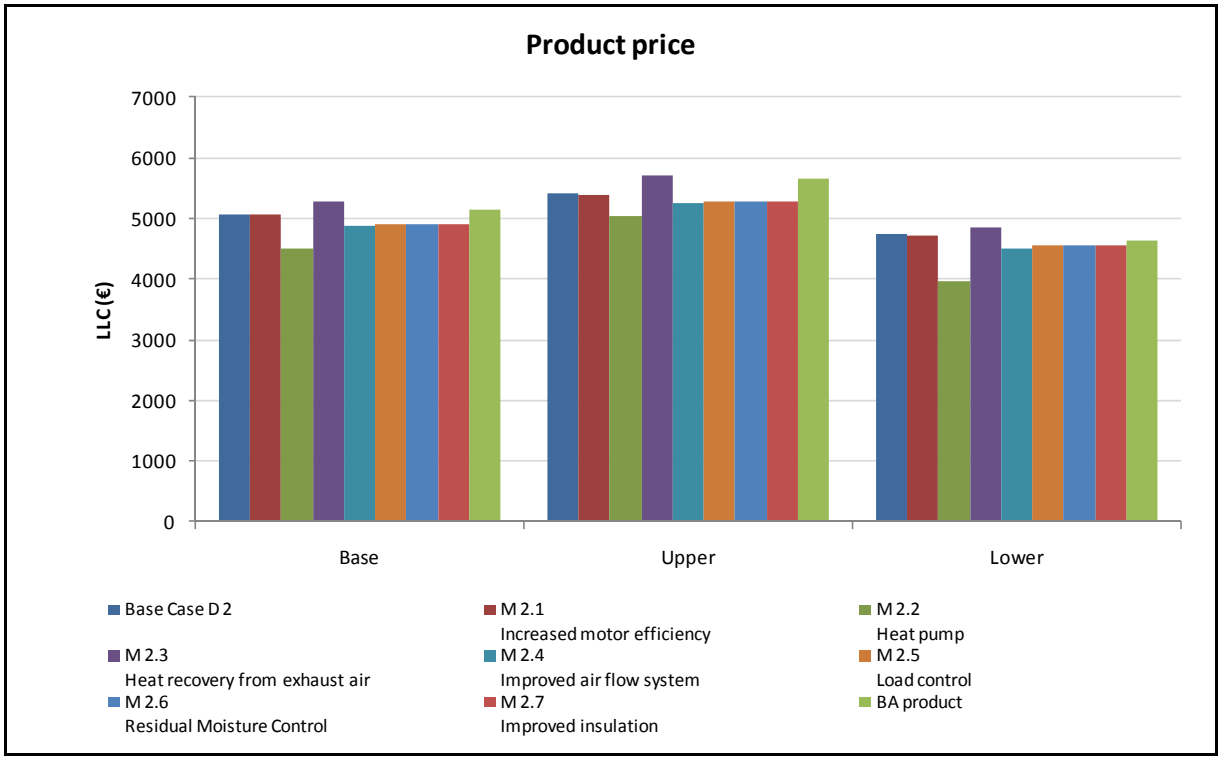


Figure 175 Base case D 2 and improvement options – impact of purchase price on LCC by product

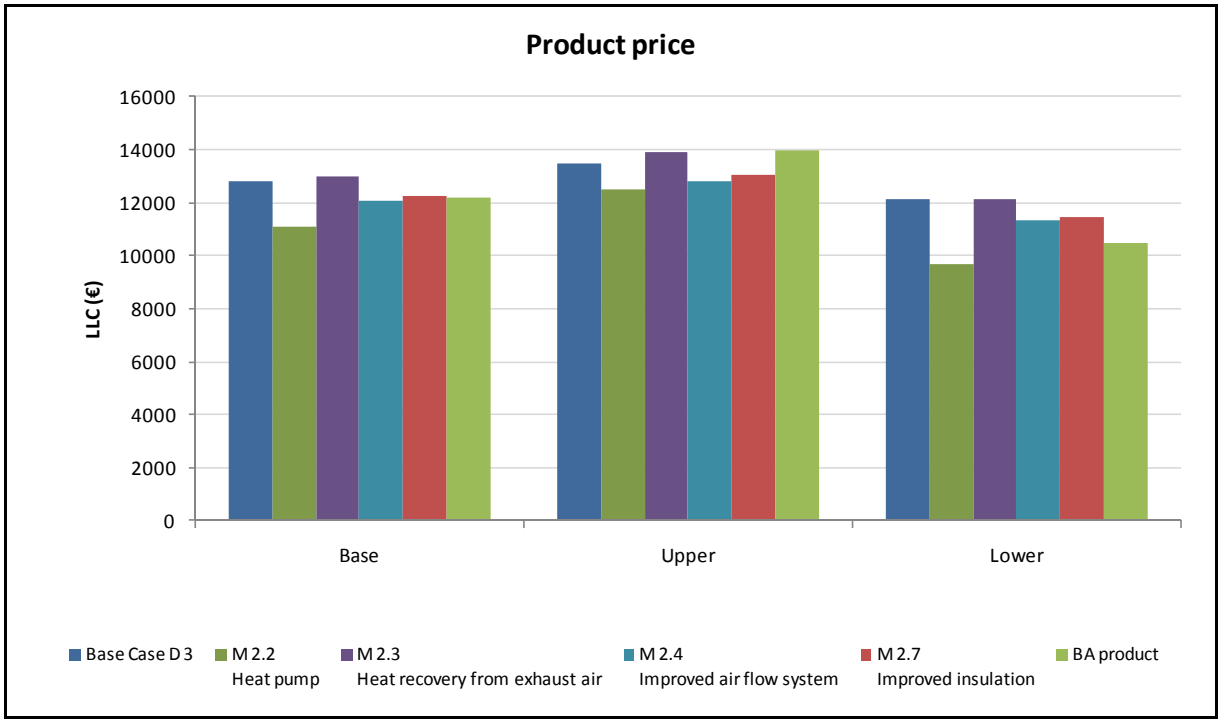


Figure 176 Base case D 3 and improvement options – impact of purchase price on LCC by product

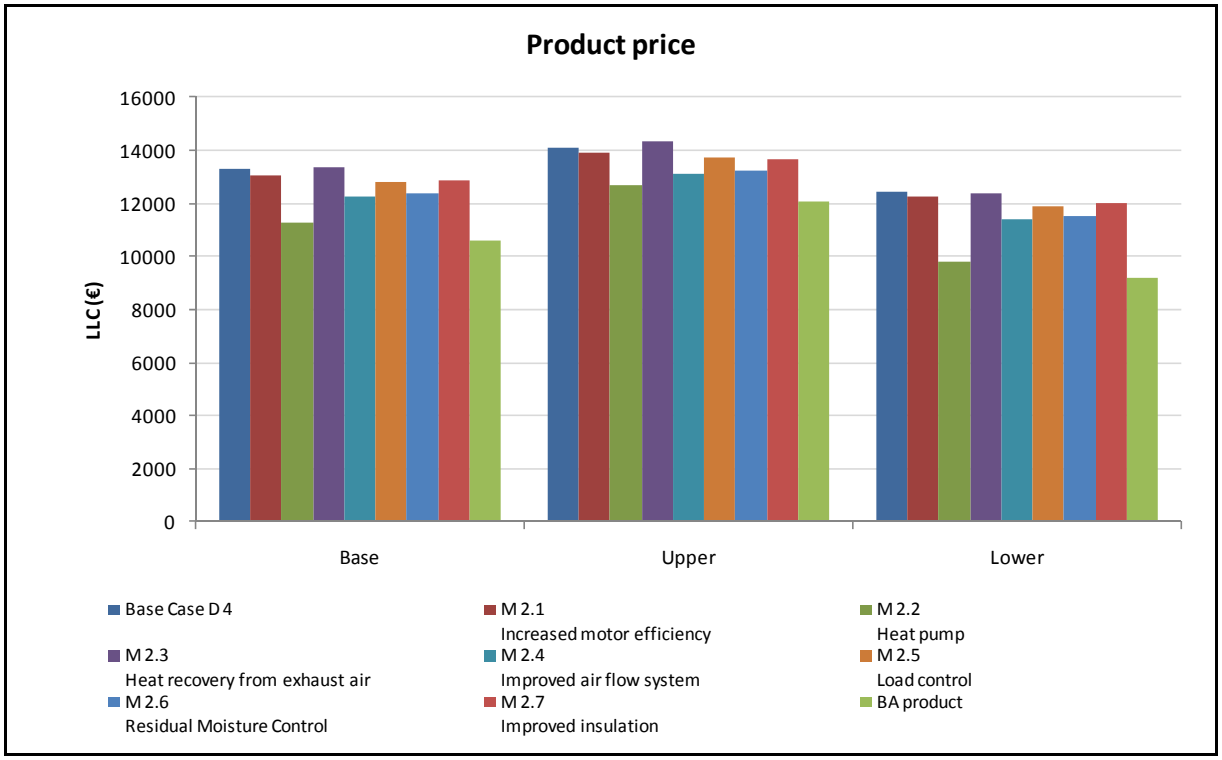


Figure 177 Base case D 4 and improvement options – impact of purchase price on LCC by product

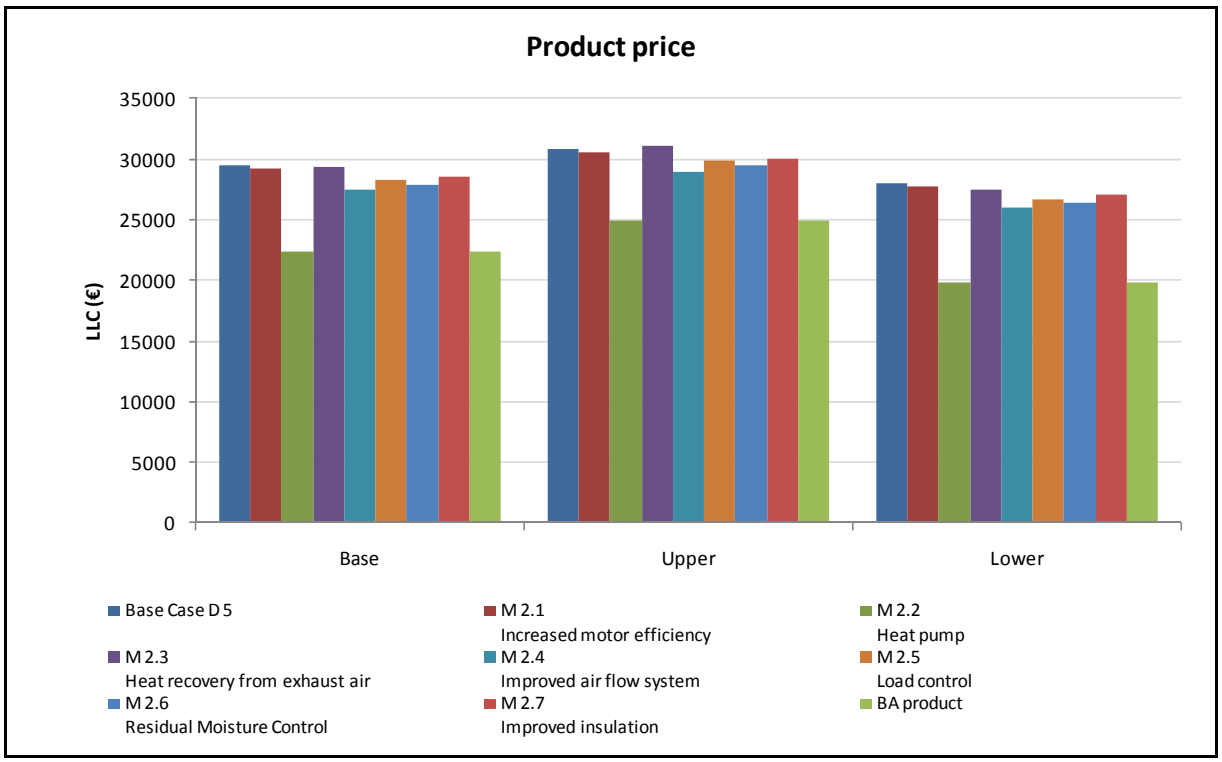


Figure 178 Base case D 5 and improvement options – impact of purchase price on LCC by product

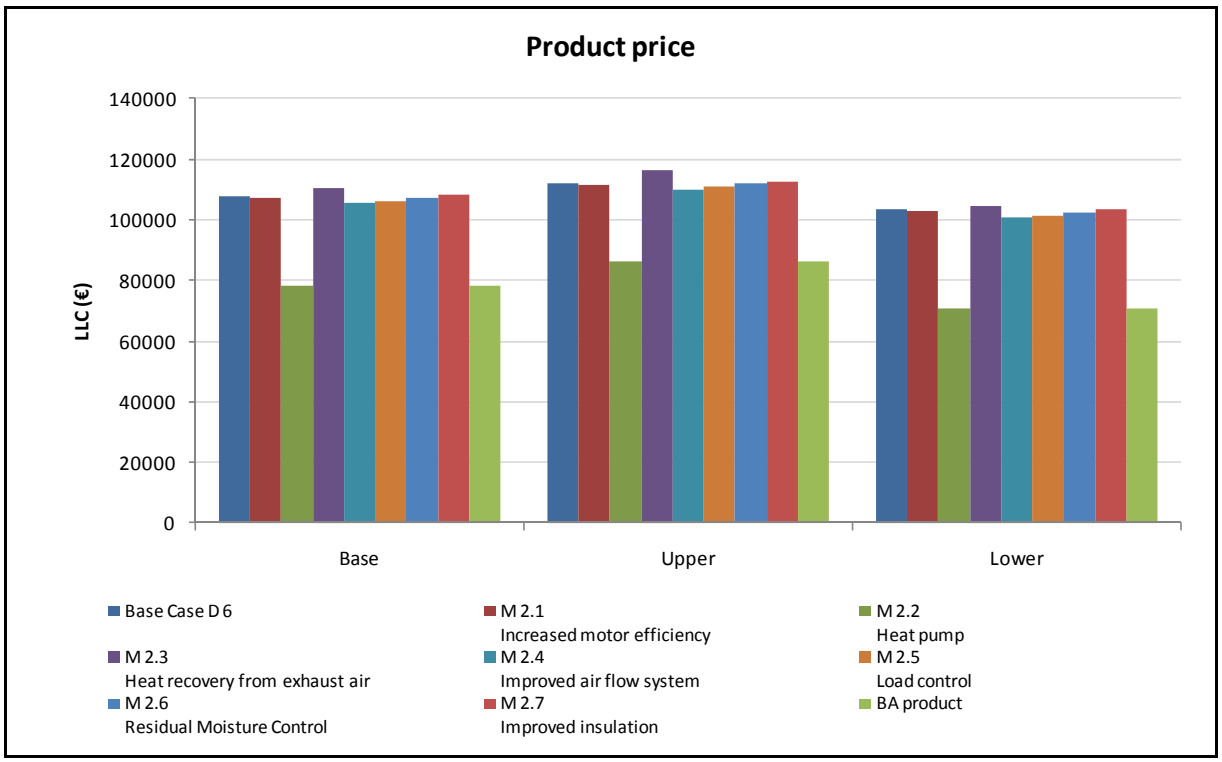


Figure 179 Base case D 6 and improvement options – impact of purchase price on LCC by product

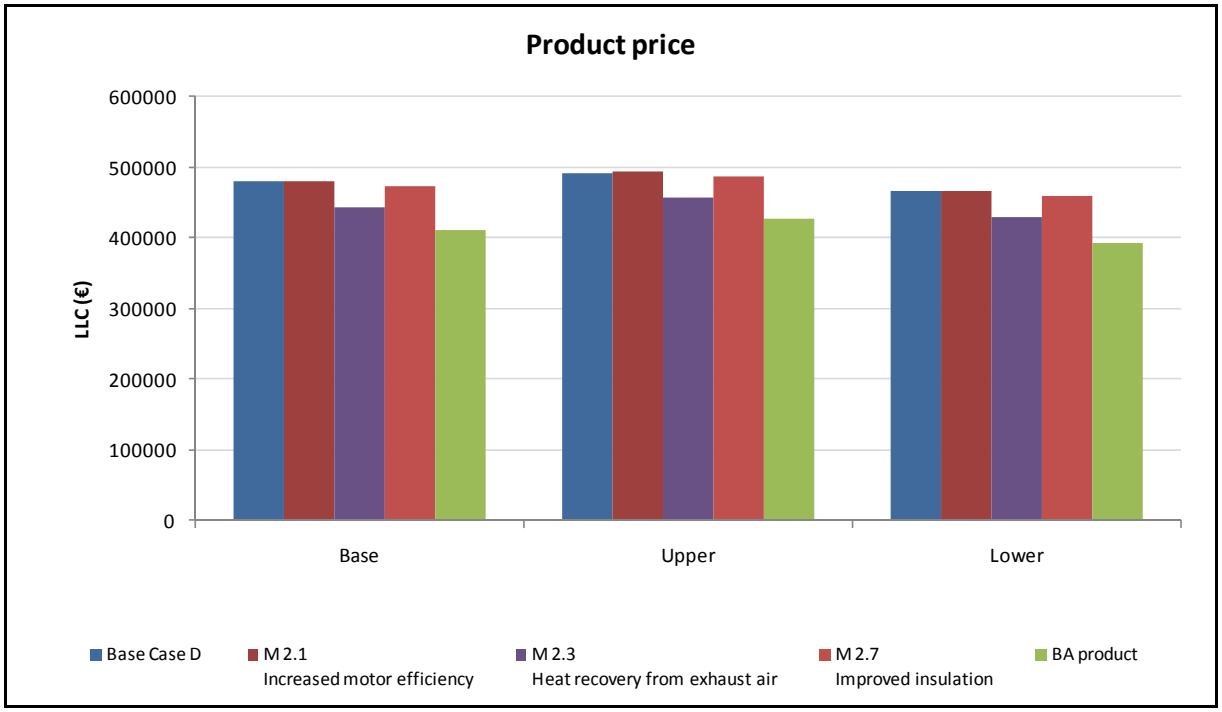


Figure 180 Base case D 7 and improvement options – impact of purchase price on LCC by product

4.6 Discount rate

4.6.1 Assumptions

The discount rate value was provided by the European Commission and the range 2-6% will be studied in the sensitivity analysis.

Table 28 Discount rate range for the sensitivity analysis

Base case	Base discount rate	Min	Max
All base cases	4%	2%	6%

4.6.2 Results

Figure 181 to Figure 194 show the influence of the variation of the discount rate on the life cycle costs of the different base cases and associated improvement options.

The option leading to the lowest life cycle costs always remain the same for a given base case, whatever the discounte rate values considered (base, lower or upper). However, a few relative changes in the rankings of options happen, for instance:

- For base case WM 6 and D 1, the LCC of the BA product becomes lower than the LCC of the base case with the lower values.

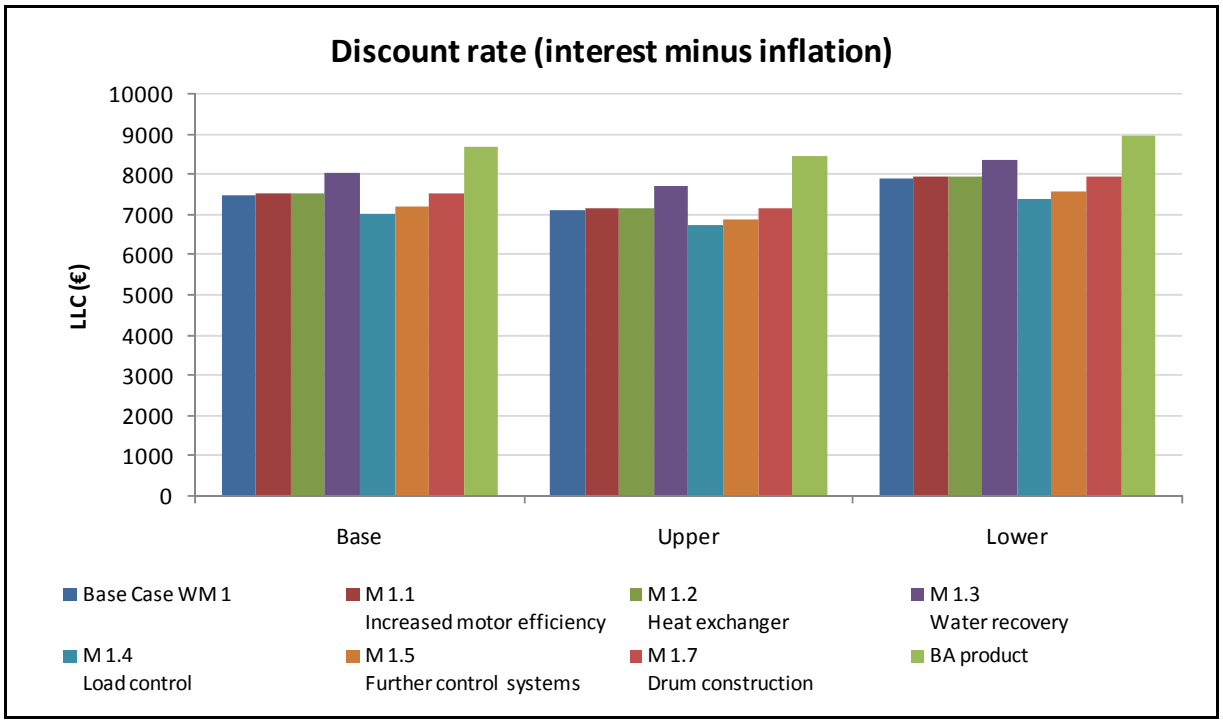


Figure 181 Base case WM 1 and improvement options – impact of discount rate on LCC by product

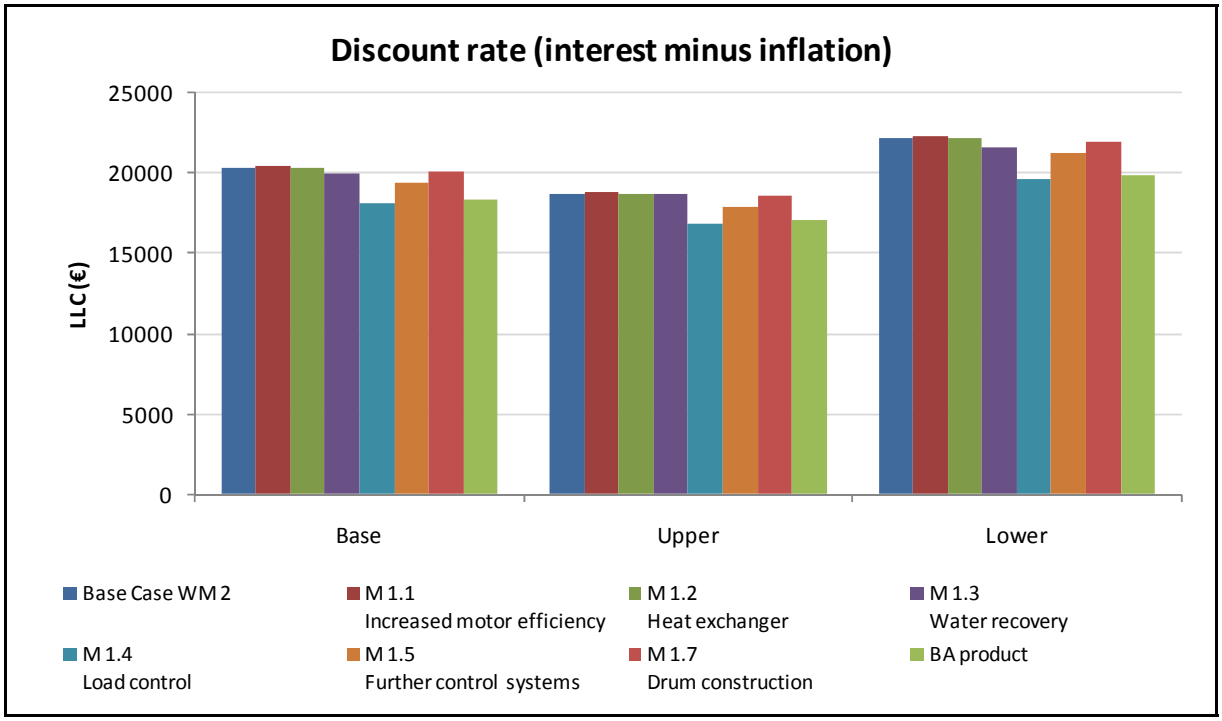


Figure 182 Base case WM 2 and improvement options – impact of discount rate on LCC by product

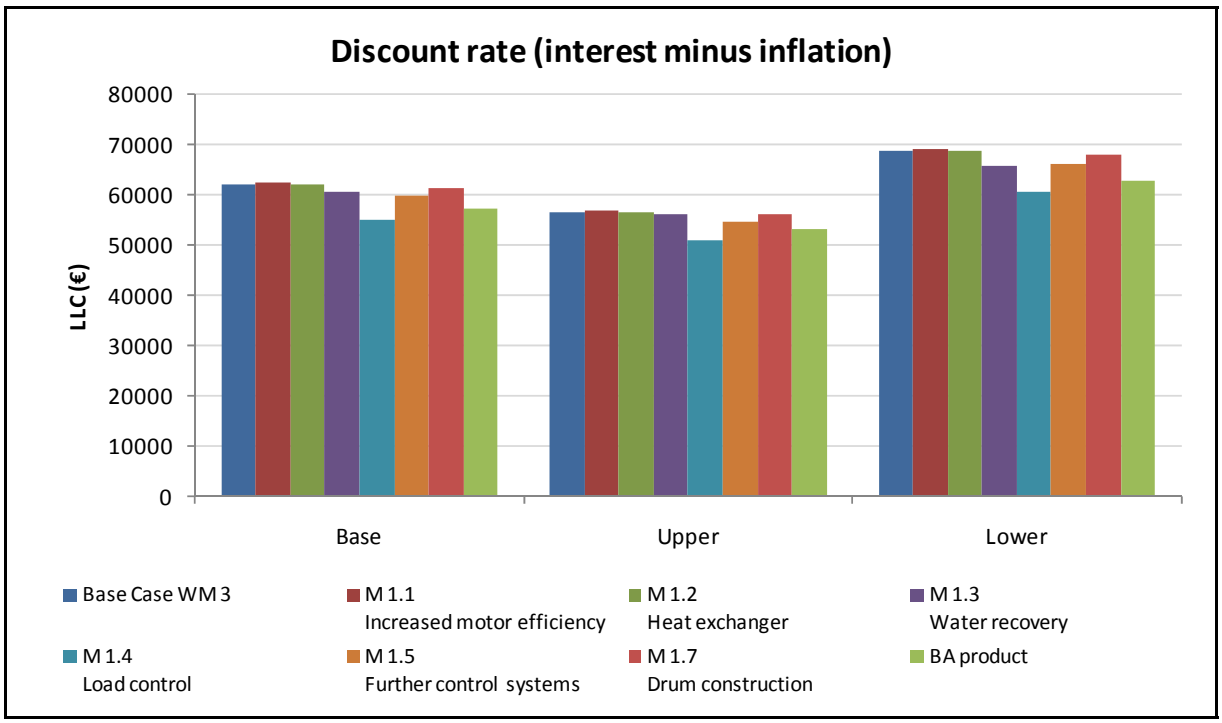


Figure 183 Base case WM 3 and improvement options – impact of discount rate on LCC by product

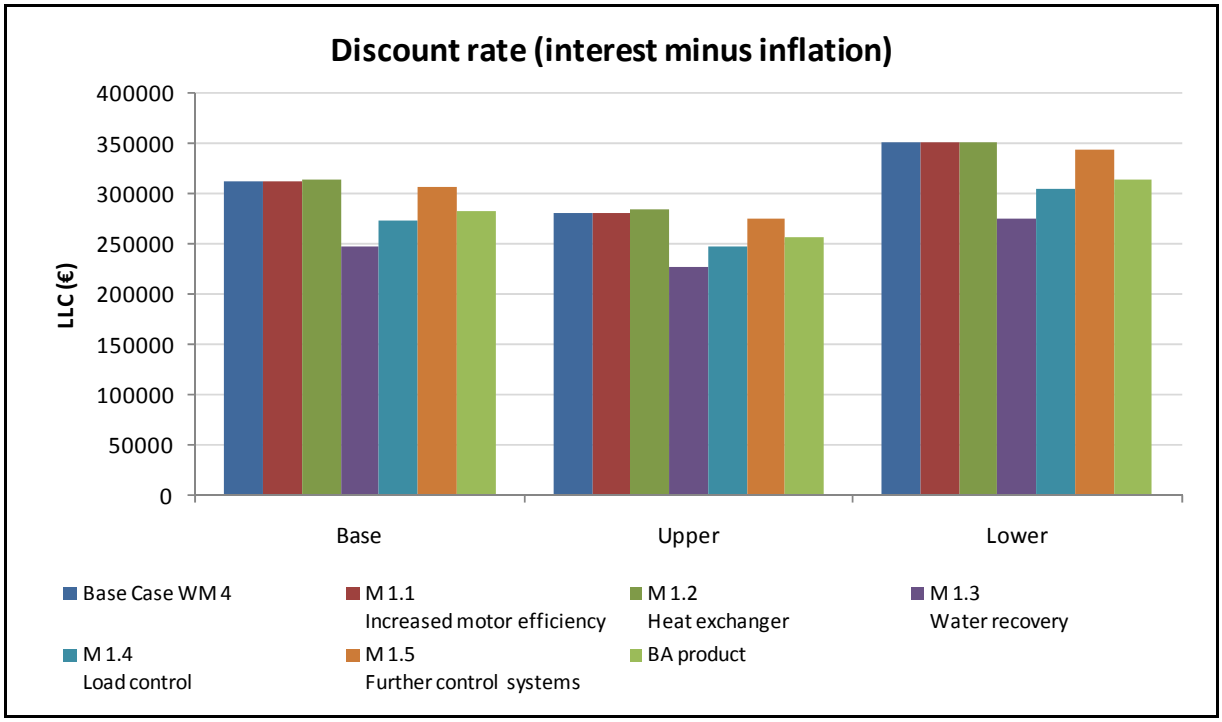


Figure 184 Base case WM 4 and improvement options – impact of discount rate on LCC by product

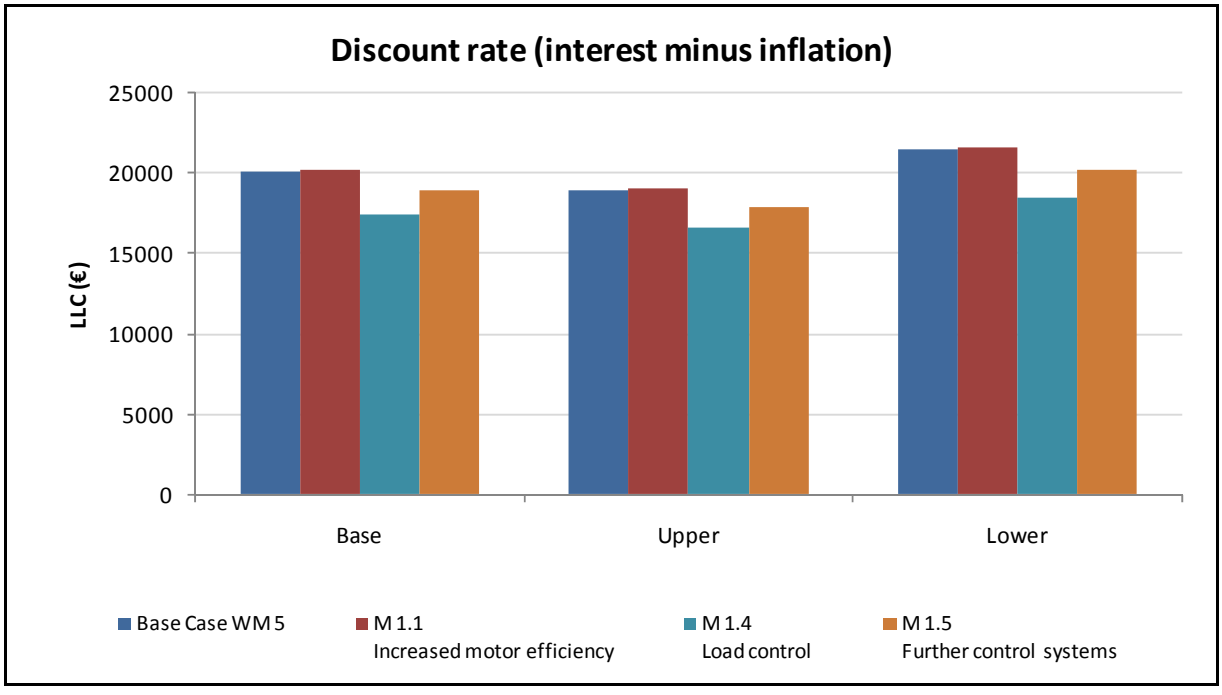


Figure 185 Base case WM 5 and improvement options – impact of discount rate on LCC by product

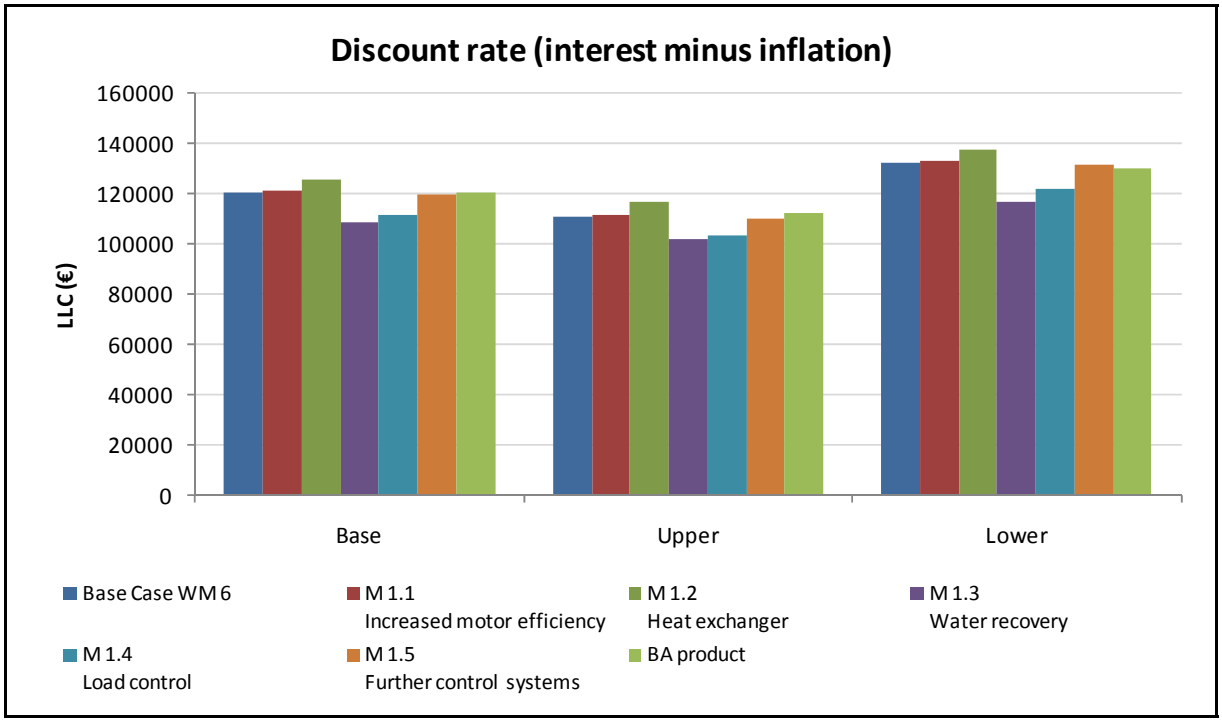


Figure 186 Base case WM 6 and improvement options – impact of discount rate on LCC by product

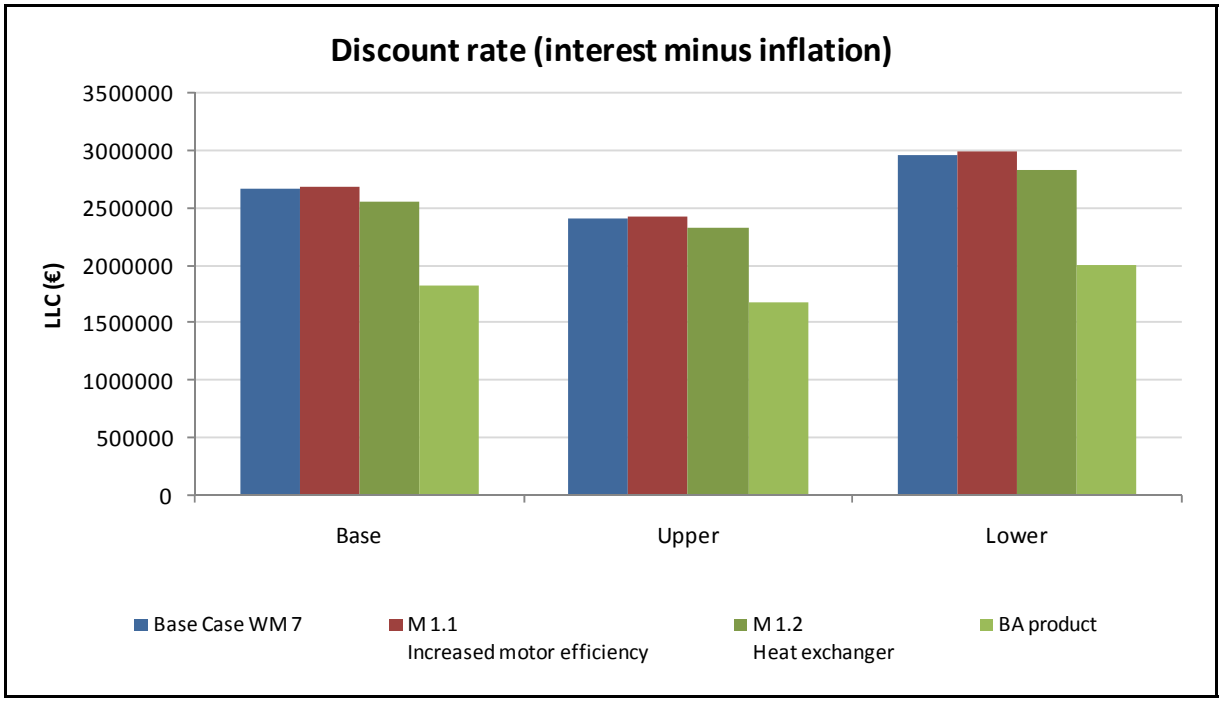


Figure 187 Base case WM 7 and improvement options – impact of discount rate on LCC by product

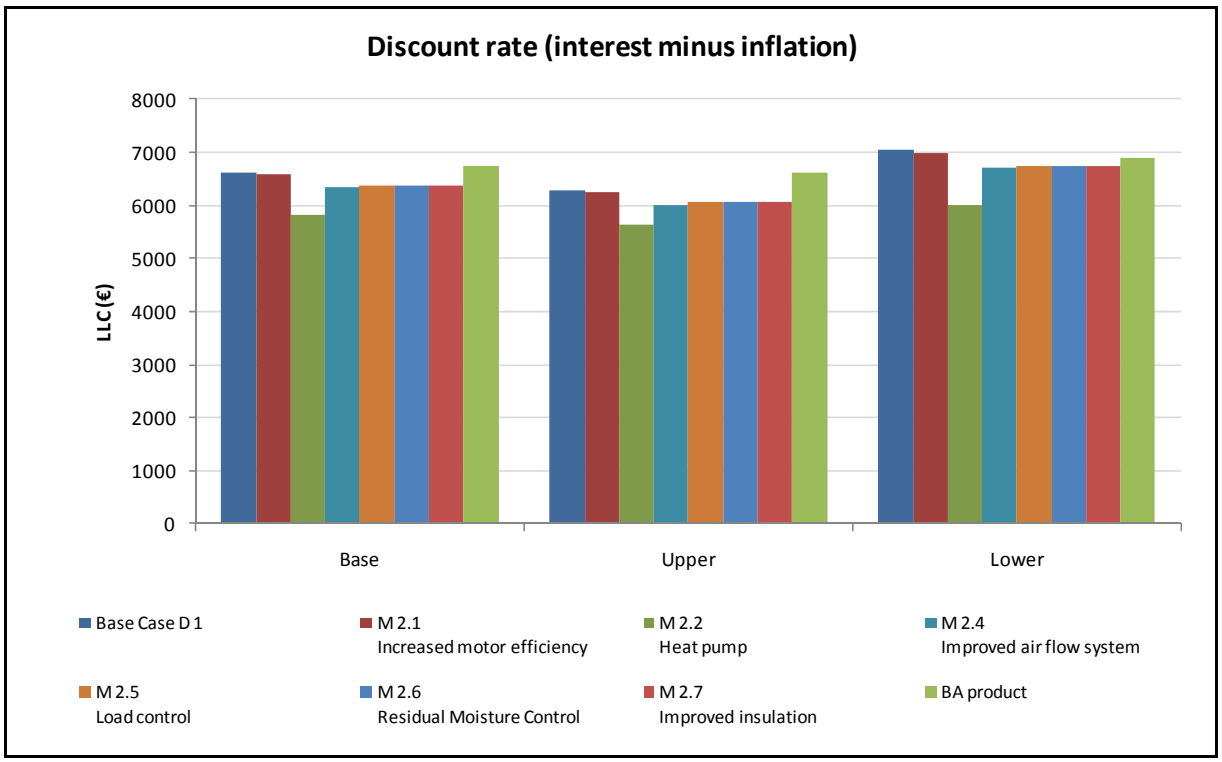


Figure 188 Base case D 1 and improvement options – impact of discount rate on LCC by product

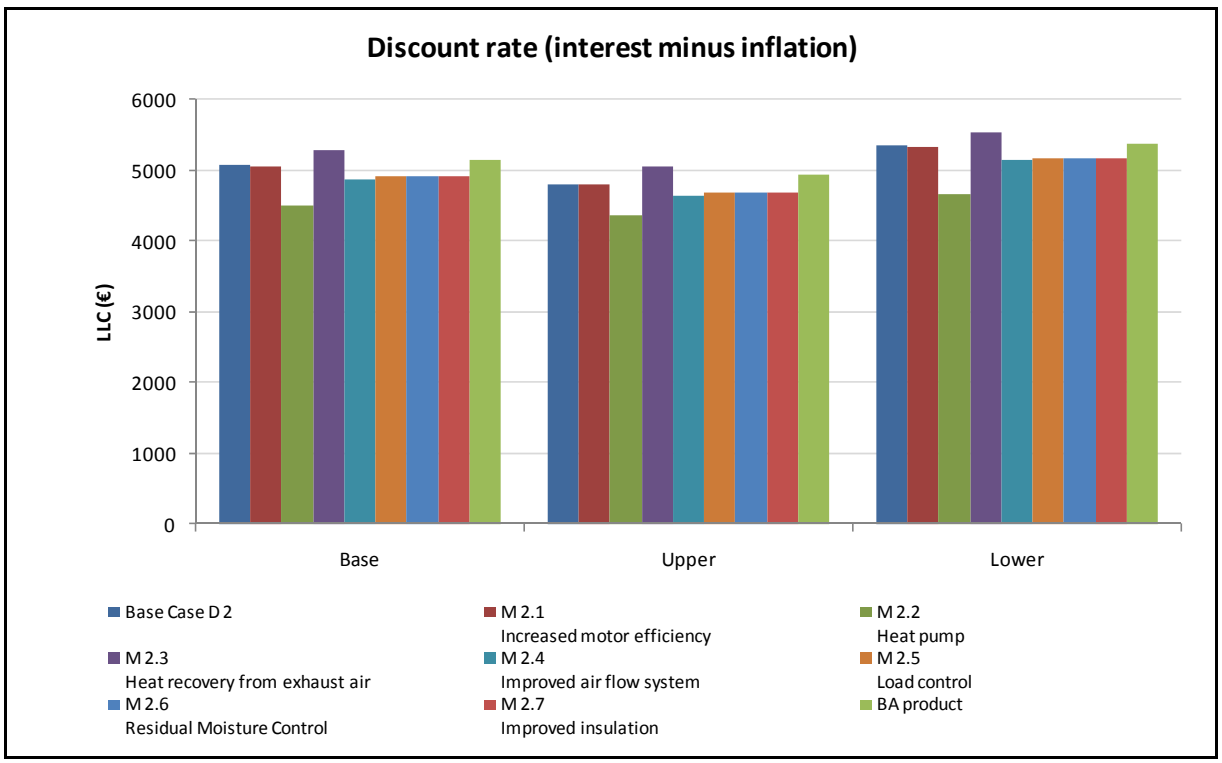


Figure 189 Base case D 2 and improvement options – impact of discount rate on LCC by product

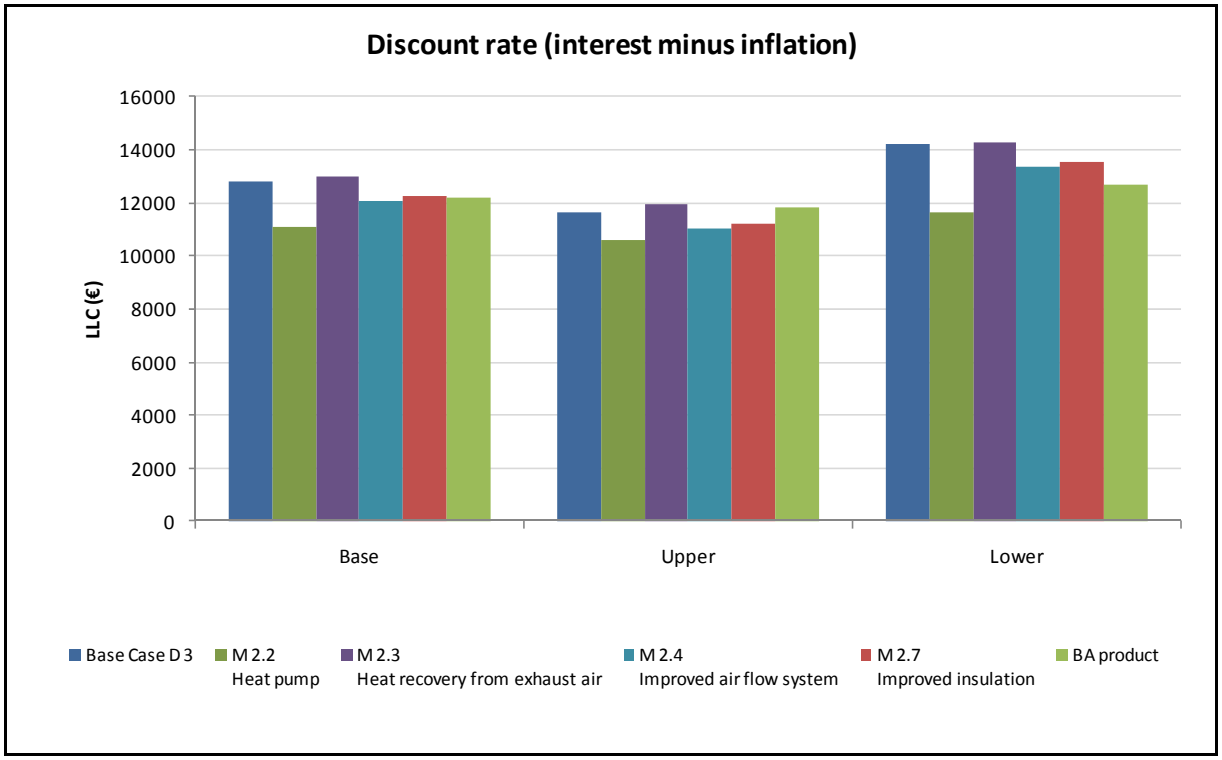


Figure 190 Base case D 3 and improvement options – impact of discount rate on LCC by product

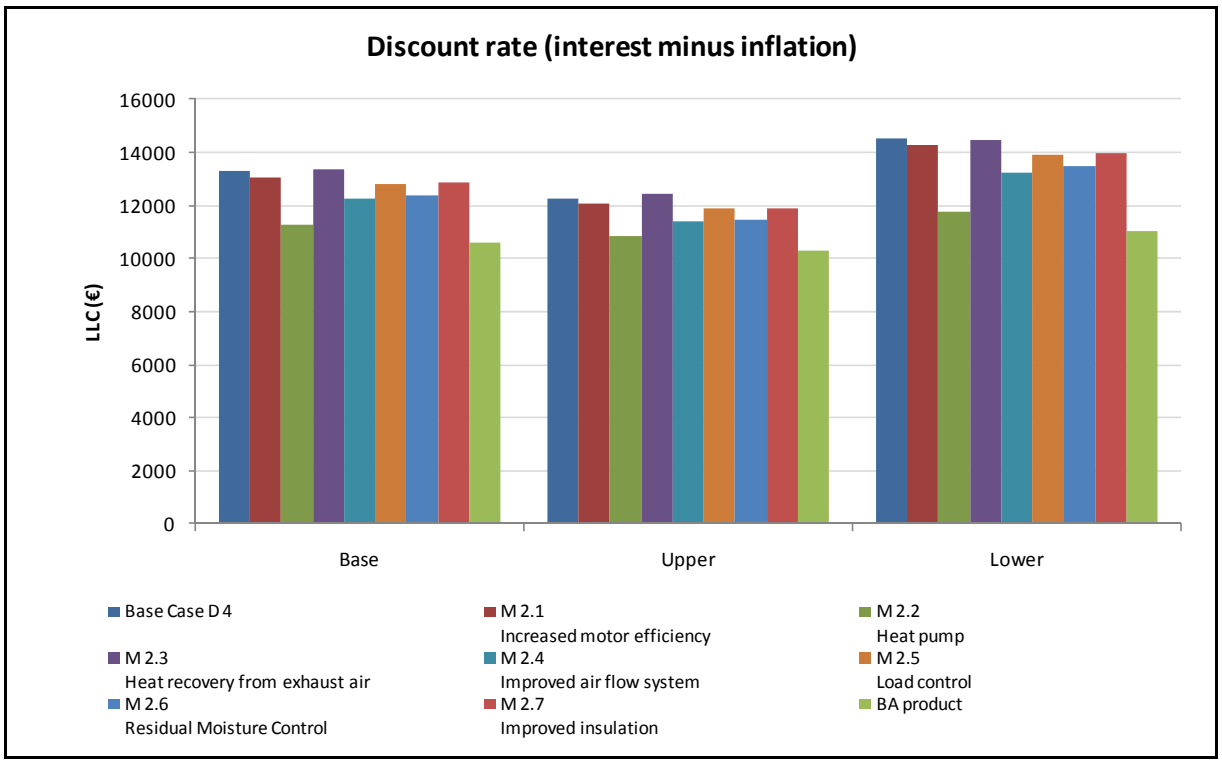


Figure 191 Base case D 4 and improvement options – impact of discount rate on LCC by product

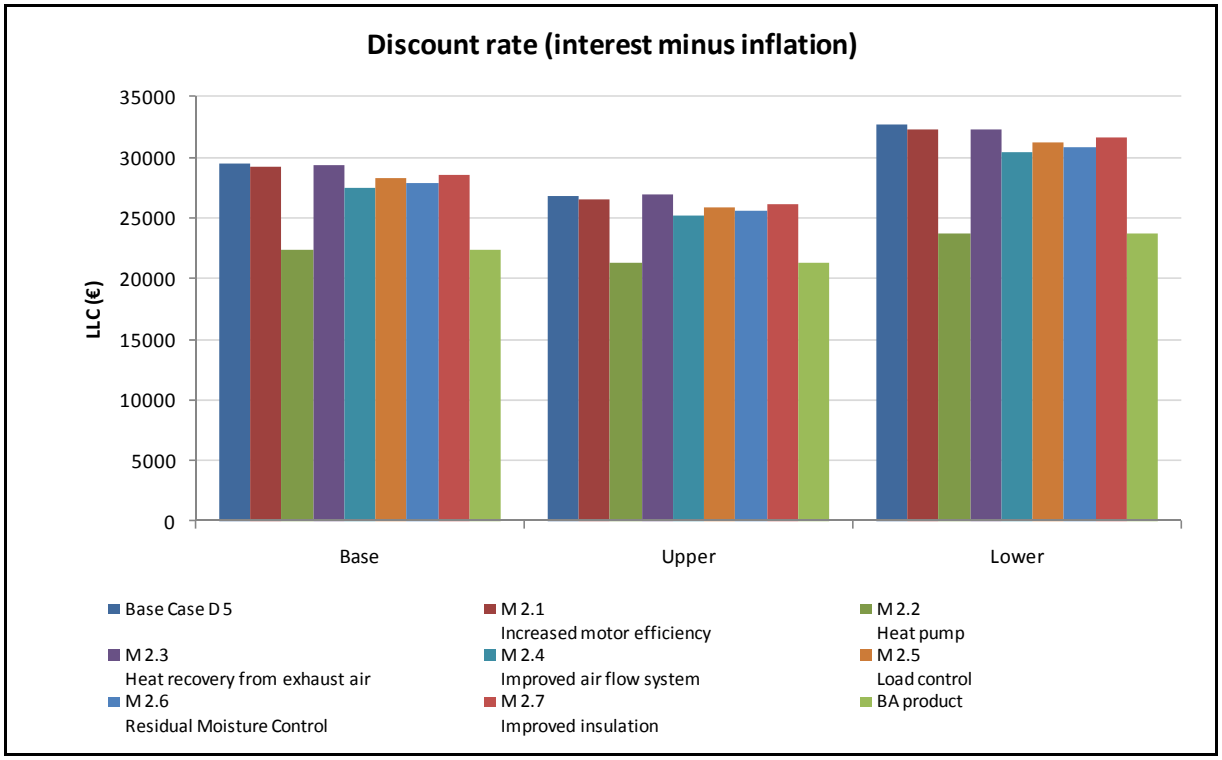


Figure 192 Base case D 5 and improvement options – impact of discount rate on LCC by product

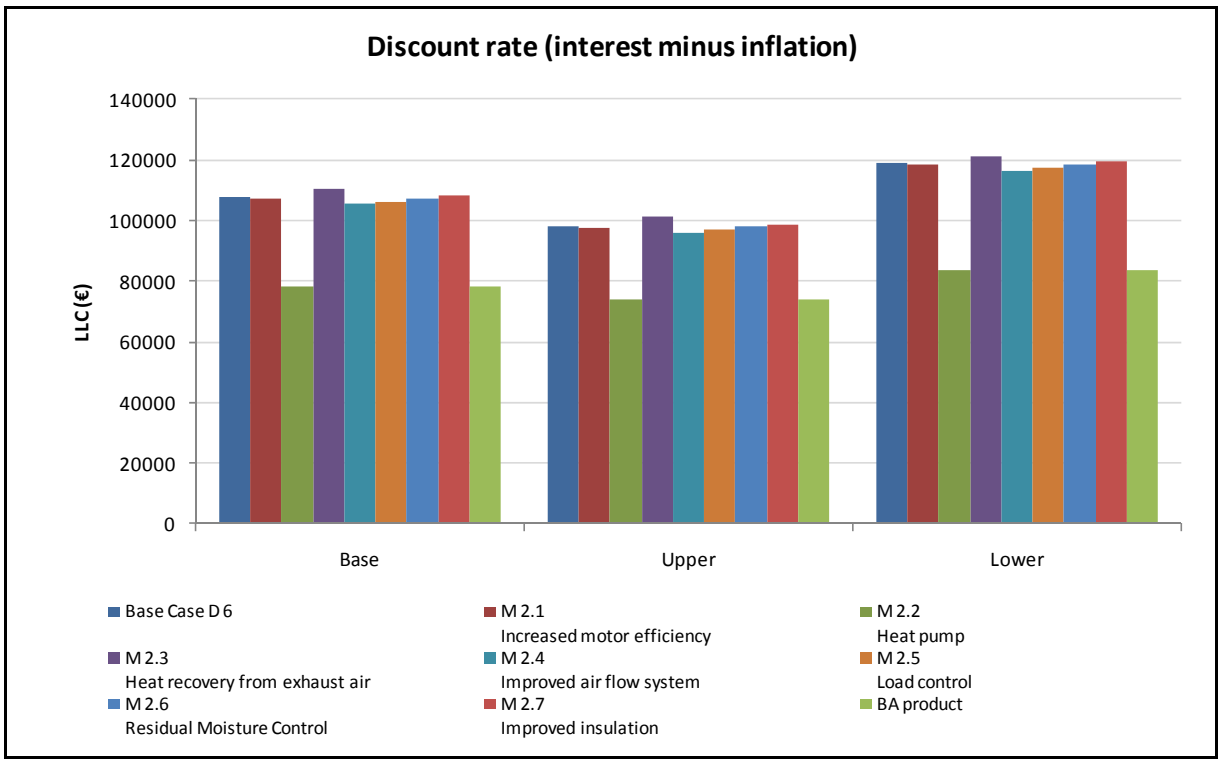


Figure 193 Base case D 6 and improvement options – impact of discount rate on LCC by product

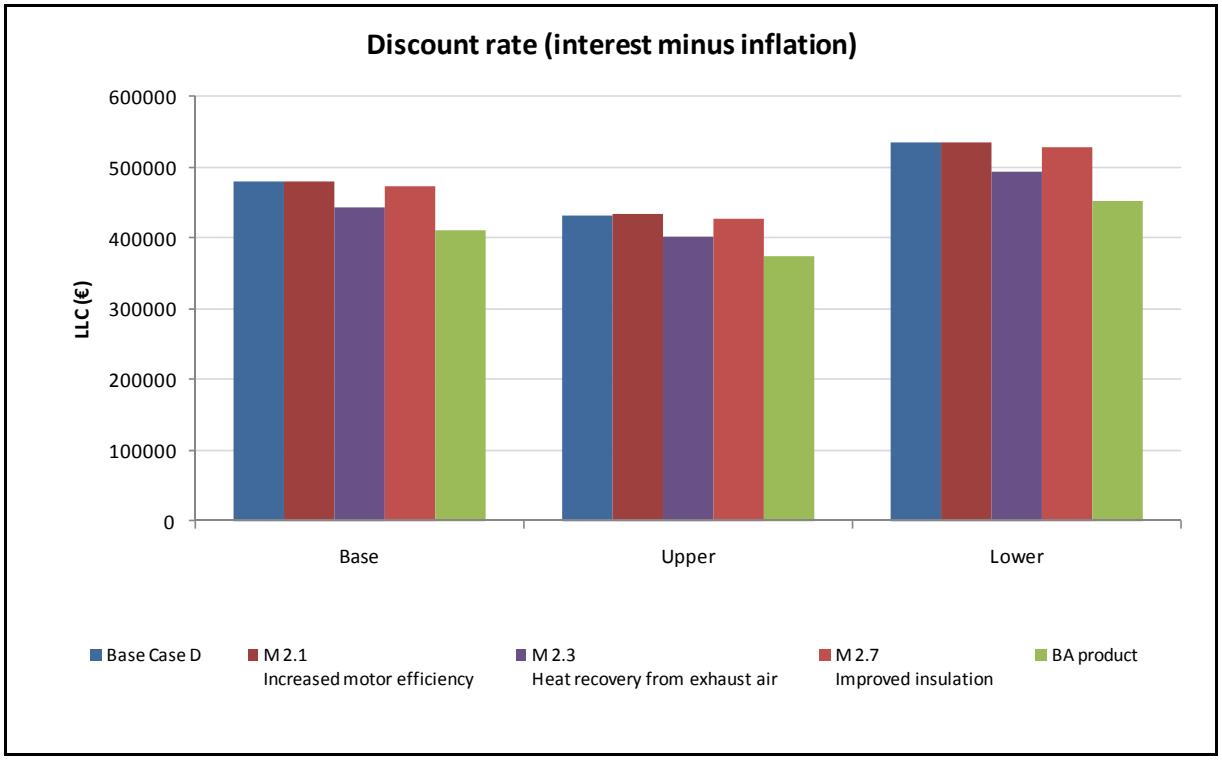


Figure 194 Base case D 7 and improvement options – impact of discount rate on LCC by product

4.7 Combined parameters

4.7.1 Assumptions

In this subsection, all previous parameters will vary simultaneously in a common direction in order to build two extreme sets of parameters:

- the “Minimum” set minimises the importance of the use phase in the life time results: lowest intensity of use, lowest life time, lowest consumables and resources rates, highest purchase price and highest discount rate.
- The “Maximum” set maximises the importance of the use phase in the life time results: highest intensity of use, highest life time, highest consumables and resources rates, lowest purchase price and lowest discount rate.

Table 29 to Table 35 repeat the parameters that will be used for the “minimum” and “maximum” sets. The error margins considered are the same that the ones presented for the sensitivity analysis of separate parameters.

Table 29 Use intensity range for the combined sensitivity analysis

Base Case	Base typical use intensity (kg of laundry per year)	Minimum set	Maximum set
WM 1 - Semi-professional washer extractor	7 000	5 600	8 400
WM 2 - Professional washing extractor (<15 kg)	14 400	11 520	17 280
WM 3 - Professional washing extractor (15–40 kg)	42 200	33 760	50 640
WM 4 - Professional washing extractor (>40 kg)	194 400	155 520	233 280
WM 5 - Professional washer dryer	7 400	5 920	8 880
WM 6 - Professional barrier washer	56 300	45 040	67 560
WM 7 - Washing tunnel machine	3 825 000	3 060 000	4 590 000
D 1 - Semi-professional dryer, condenser	6 500	5 200	7 800
D 2 - Semi-professional dryer, air vented	6 500	5 200	7 800
D 3 - Professional cabinet dryer	6 300	5 040	7 560
D 4 - Professional air tumble dryer (<15 kg)	14 400	11 520	17 280
D 5 - Professional air tumble dryer (15–40 kg)	40 500	32 400	48 600
D 6 - Professional air tumble dryer (>40 kg)	168 000	134 400	201 600
D 7 - Industrial pass-through (transfer) tumble dryer	1 020 000	816 000	1 224 000

Table 30 Product life time ranges for the combined sensitivity analysis

Base Case	Base product life time (years)	Minimum set	Maximum set
WM 1 - Semi-professional washer extractor	8	6	10
WM 2 - Professional washing extractor (<15 kg)	12	10	14
WM 3 - Professional washing extractor (15–40 kg)	14	12	16
WM 4 - Professional washing extractor (>40 kg)	15	13	17
WM 5 - Professional washer dryer	11	9	13
WM 6 - Professional barrier washer	14	12	16
WM 7 - Washing tunnel machine	13	11	15
D 1 - Semi-professional dryer, condenser	8	6	10
D 2 - Semi-professional dryer, air vented	8	6	10
D 3 - Professional cabinet dryer	15	13	17
D 4 - Professional air tumble dryer (<15 kg)	13	11	15
D 5 - Professional air tumble dryer (15–40 kg)	14	12	16
D 6 - Professional air tumble dryer (>40 kg)	13	11	15
D 7 - Industrial pass-through (transfer) tumble dryer	13	11	15

Table 31 Electricity rate ranges for the combined sensitivity analysis

Base Case	Base electricity rate (€/kWh)	Minimum set	Maximum set
WM 1 - Semi-professional washer extractor	0.138	0.071 (Estonia)	0.185 (Slovakia)
WM 2 - Professional washing extractor (<15 kg)			
WM 3 - Professional washing extractor (15–40 kg)	0.105	0.059 (Estonia)	0.160 (Cyprus)
WM 4 - Professional washing extractor (>40 kg)	0.090	0.055 (Estonia)	0.144 (Cyprus)
WM 5 - Professional washer dryer	0.105	0.059 (Estonia)	0.160 (Cyprus)
WM 6 - Professional barrier washer			
WM 7 - Washing tunnel machine	0.090	0.055 (Estonia)	0.144 (Cyprus)
D 1 - Semi-professional dryer, condenser	0.138	0.071 (Estonia)	0.185 (Slovakia)
D 2 - Semi-professional dryer, air vented			
D 3 - Professional cabinet dryer			
D 4 - Professional air tumble dryer (<15 kg)			
D 5 - Professional air tumble dryer (15–40 kg)	0.105	0.059 (Estonia)	0.160 (Cyprus)
D 6 - Professional air tumble dryer (>40 kg)	0.090	0.055 (Estonia)	0.144 (Cyprus)
D 7 - Industrial pass-through (transfer) tumble dryer			

Table 32 Gas rate ranges for the combined sensitivity analysis

Base Case	Base gas rate (€/GJ)	Minimum set	Maximum set
WM 1 - Semi-professional washer extractor	11.2115	5.5257 (Romania)	14.7633 (Sweden)
WM 2 - Professional washing extractor (<15 kg)			
WM 3 - Professional washing extractor (15–40 kg)	10.0097	5.5080 (Romania)	13.1448 (Sweden)
WM 4 - Professional washing extractor (>40 kg)	8.7921	5.6072 (Romania)	11.2499 (Sweden)
WM 5 - Professional washer dryer	10.0097	5.5080 (Romania)	13.1448 (Sweden)
WM 6 - Professional barrier washer			
WM 7 - Washing tunnel machine	8.7921	5.6072 (Romania)	11.2499 (Sweden)
D 1 - Semi-professional dryer, condenser	11.2115	5.5257 (Romania)	14.7633 (Sweden)
D 2 - Semi-professional dryer, air vented			
D 3 - Professional cabinet dryer			
D 4 - Professional air tumble dryer (<15 kg)			
D 5 - Professional air tumble dryer (15–40 kg)	10.0097	5.5080 (Romania)	13.1448 (Sweden)
D 6 - Professional air tumble dryer (>40 kg)	8.7921	5.6072 (Romania)	11.2499 (Sweden)
D 7 - Industrial pass-through (transfer) tumble dryer			

Table 33 Water and detergent rates ranges for the combined sensitivity analysis

Item	Base price (for all case-cases)	Minimum set	Maximum set
Water	2.64 €/m^3	1.11 €/m^3 (Rome)	4.91 €/m^3 (Berlin)
Detergent	2.0 €/kg	1.5 €/kg	2.5 €/kg

Table 34 Purchase price ranges for the combined sensitivity analysis

Base case	Base purchase price (in €)	Minimum set	Maximum set
WM 1 - Semi-professional washer extractor	2 670	3 204	2 136
WM 2 - Professional washing extractor (<15 kg)	5 000	6 000	4 000
WM 3 - Professional washing extractor (15–40 kg)	15 250	18 300	12 200
WM 4 - Professional washing extractor (>40 kg)	58 750	70 500	47 000
WM 5 - Professional washer dryer	8 000	9 600	6 400
WM 6 - Professional barrier washer	38 250	45 900	30 600
WM 7 - Washing tunnel machine	390 000	468 000	312 000
D 1 - Semi-professional dryer, condenser	1 970	2 364	1 576
D 2 - Semi-professional dryer, air vented	1 680	2 016	1 344
D 3 - Professional cabinet dryer	3 500	4 200	2 800
D 4 - Professional air tumble dryer (<15 kg)	4 000	4 800	3 200
D 5 - Professional air tumble dryer (15–40 kg)	7 125	8 550	5 700
D 6 - Professional air tumble dryer (>40 kg)	21 500	25 800	17 200
D 7 - Industrial pass-through (transfer) tumble dryer	62 500	75 000	50 000

Table 35 Discount rate range for the combined sensitivity analysis

Base Case	Base discount rate	Minimum set	Maximum set
All base cases	4%	6%	2%

4.7.2 Results

Figure 195 to Figure 222 show the influence of the variations of several combined parameters on the total energy consumption and the life cycle costs of the different base cases and associated improvement options.

This is clearly the analysis resulting in the most important changes in rankings, especially in the economic analysis:

- Base case WM 1: the base case becomes the LLCC with the minimum set, instead of option M 1.4;
- Base case WM 2: option M 1.5 becomes the LLCC with the minimum set, instead of option M 1.4, while the BA product becomes the LLCC with the maximum set;
- Base case WM 3: option M 1.5 becomes the LLCC with the minimum set, instead of option M 1.4;
- Base case WM 4: option M 1.4 becomes the LLCC with the minimum set, instead of option M 1.3;
- Base case WM 6: the base case becomes the LLCC with the minimum set, instead of option M 1.3;
- Base case D 1: the base case becomes the LLCC with the minimum set, instead of option M 2.2;
- Base case D 2: the base case becomes the LLCC with the minimum set, instead of option M 2.2;
- Base case D 3: option M 2.4 becomes the LLCC with the minimum set, instead of option M 2.2, while the BA product becomes the LLCC with the maximum set;
- Base case D 4: option M 2.6 becomes the LLCC with the minimum set, instead of the BA product.
- Base case D 5: option M 2.4 becomes the LLCC with the minimum set, instead of the BA product.
- Base case D 6: the base case becomes the LLCC with the minimum set, instead of the BA product.
- Base case D 7: option M 2.3 becomes the LLCC with the minimum set, instead of the BA product.

Besides, many changes also occur in the relative rankings between the different options, which demonstrate the high dependency of the economic results toward the parameters assessed.

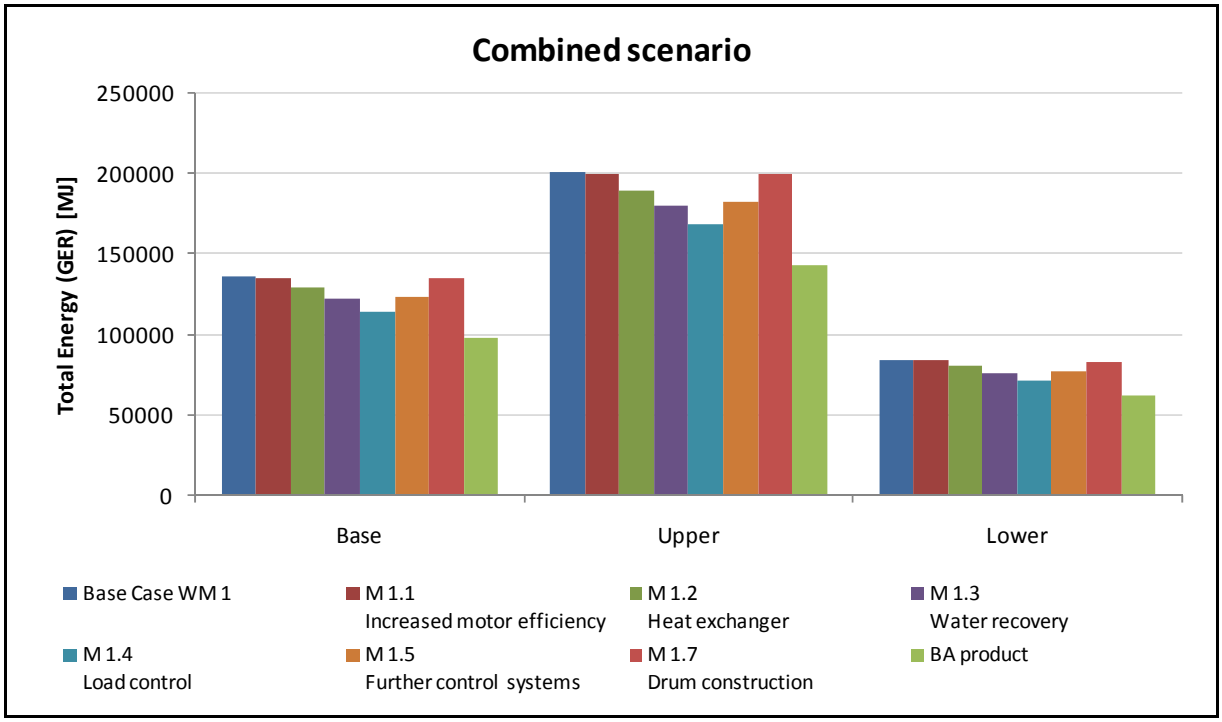


Figure 195 Base case WM 1 and improvement options – impact of combined scenario on total energy over life time by product

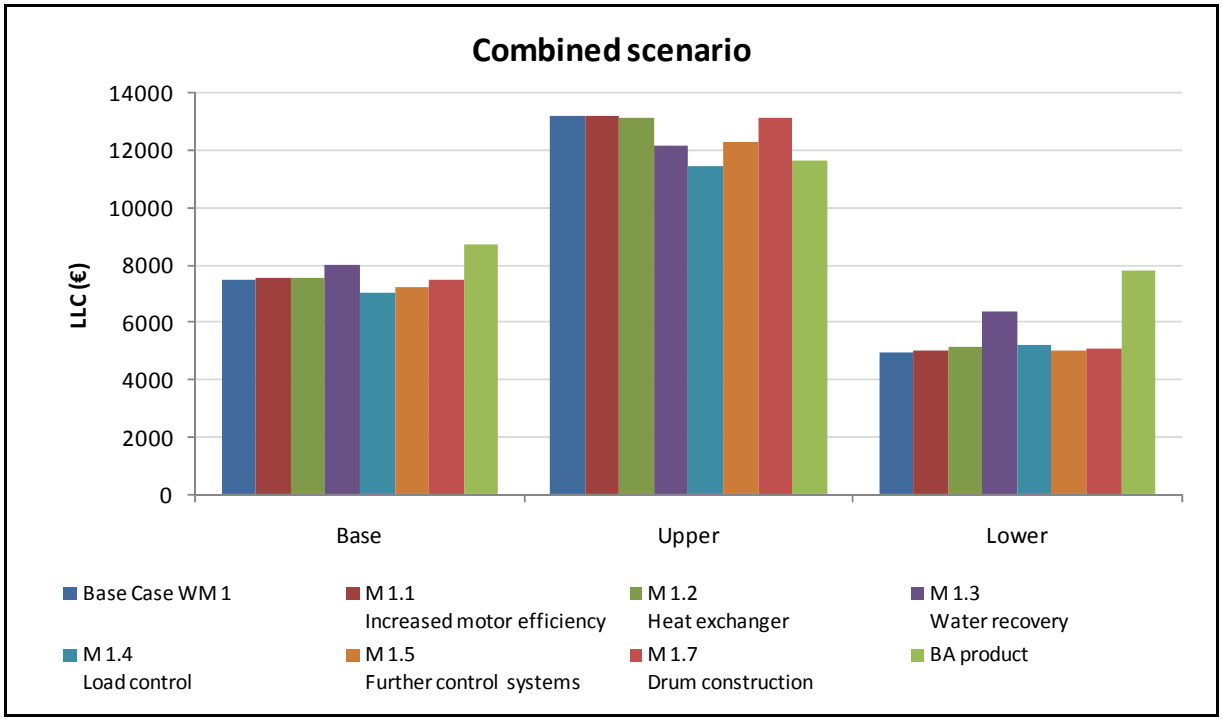


Figure 196 Base case WM 1 and improvement options – impact of combined scenario on LCC by product

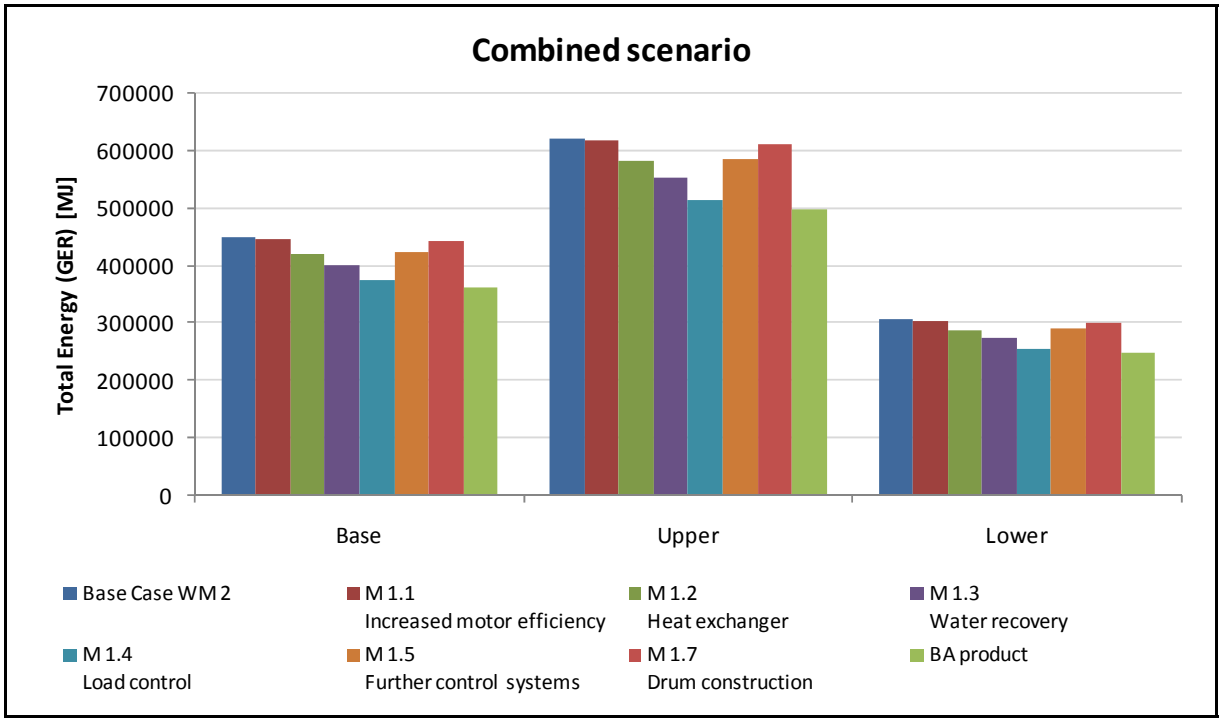


Figure 197 Base case WM 2 and improvement options – impact of combined scenario on total energy over life time by product

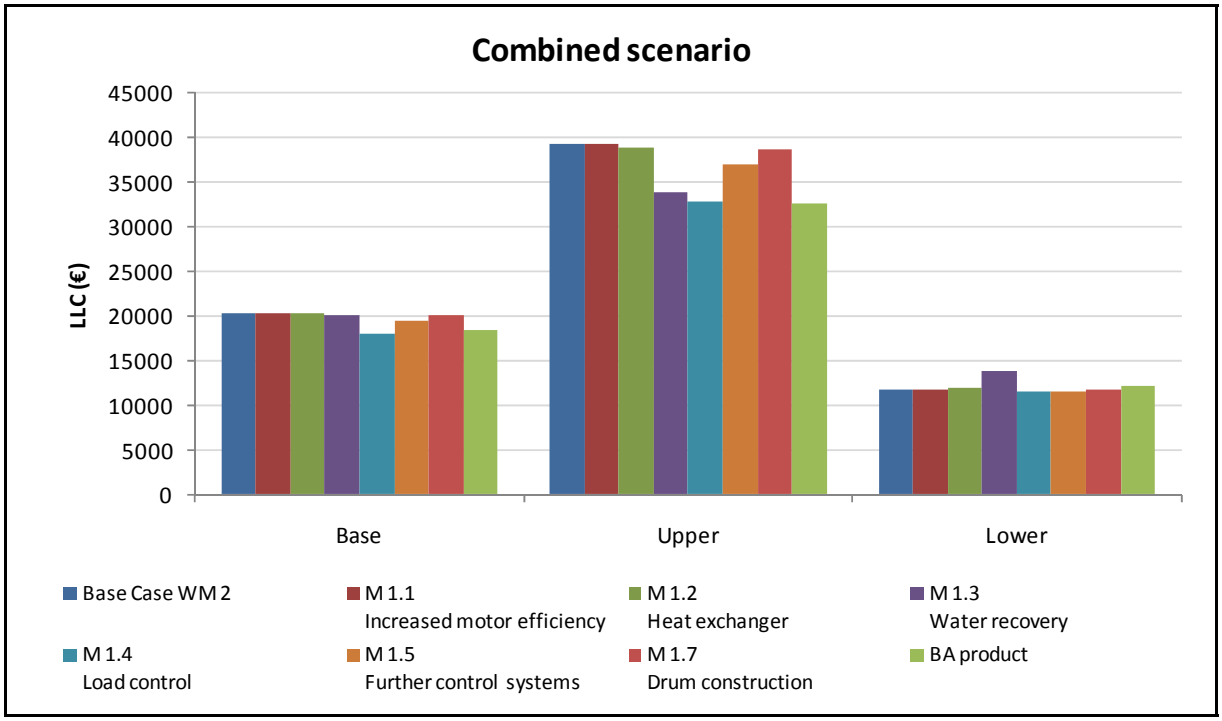


Figure 198 Base case WM 2 and improvement options – impact of combined scenario on LCC by product

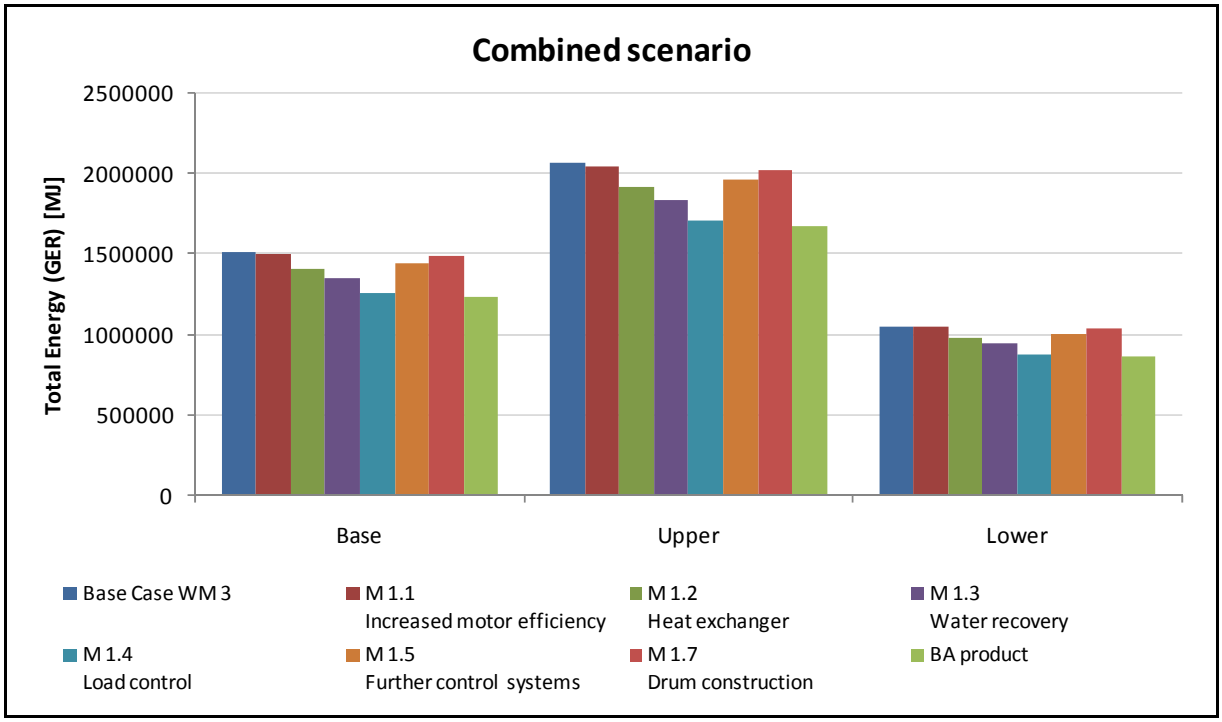


Figure 199 Base case WM 3 and improvement options – impact of combined scenario on total energy over life time by product

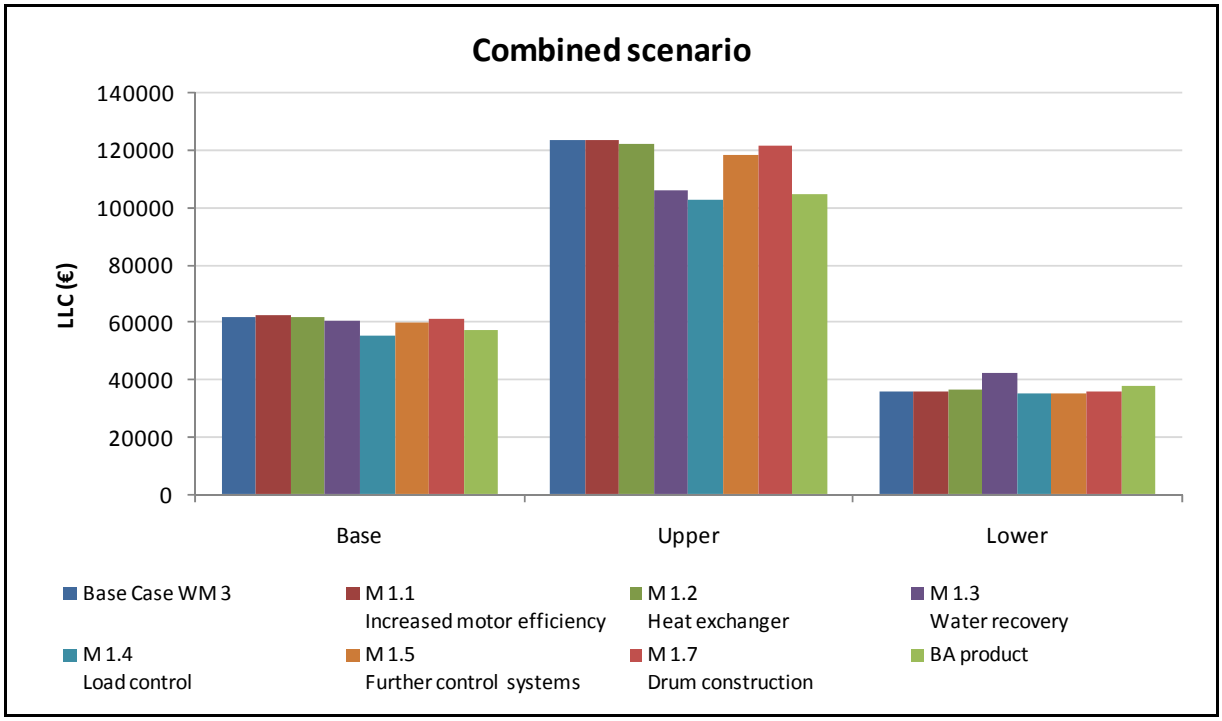


Figure 200 Base case WM 3 and improvement options – impact of combined scenario on LCC by product

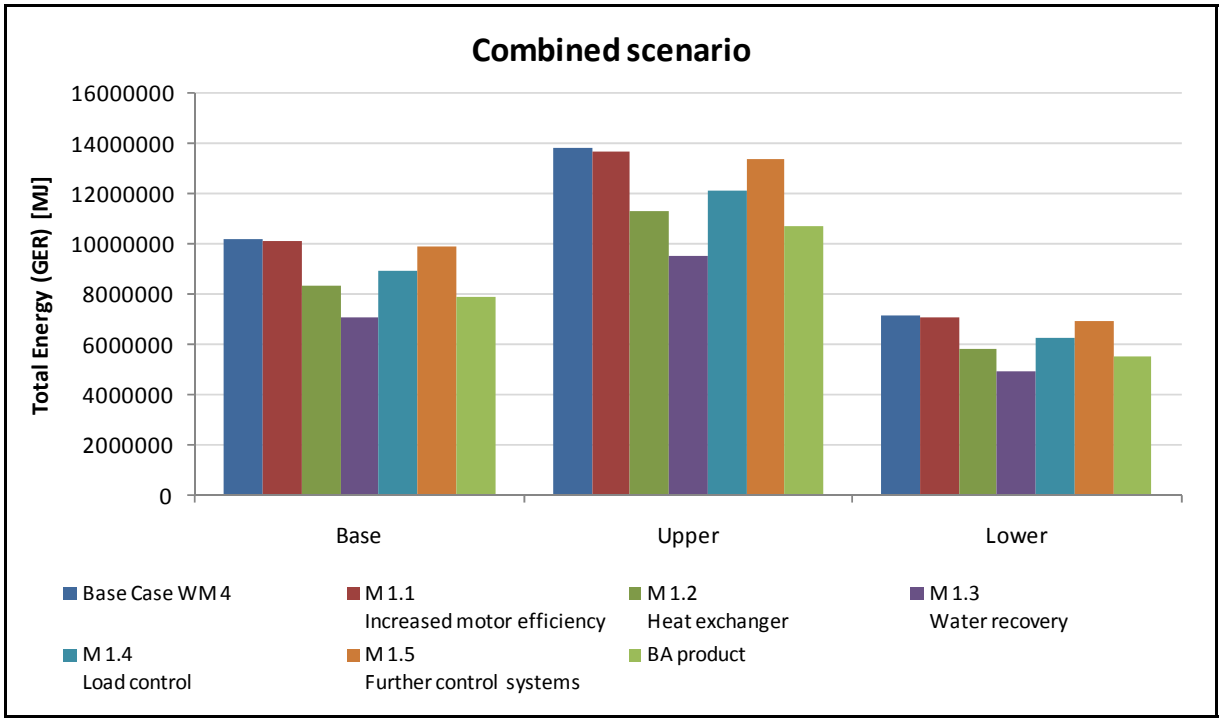


Figure 201 Base case WM 4 and improvement options – impact of combined scenario on total energy over life time by product

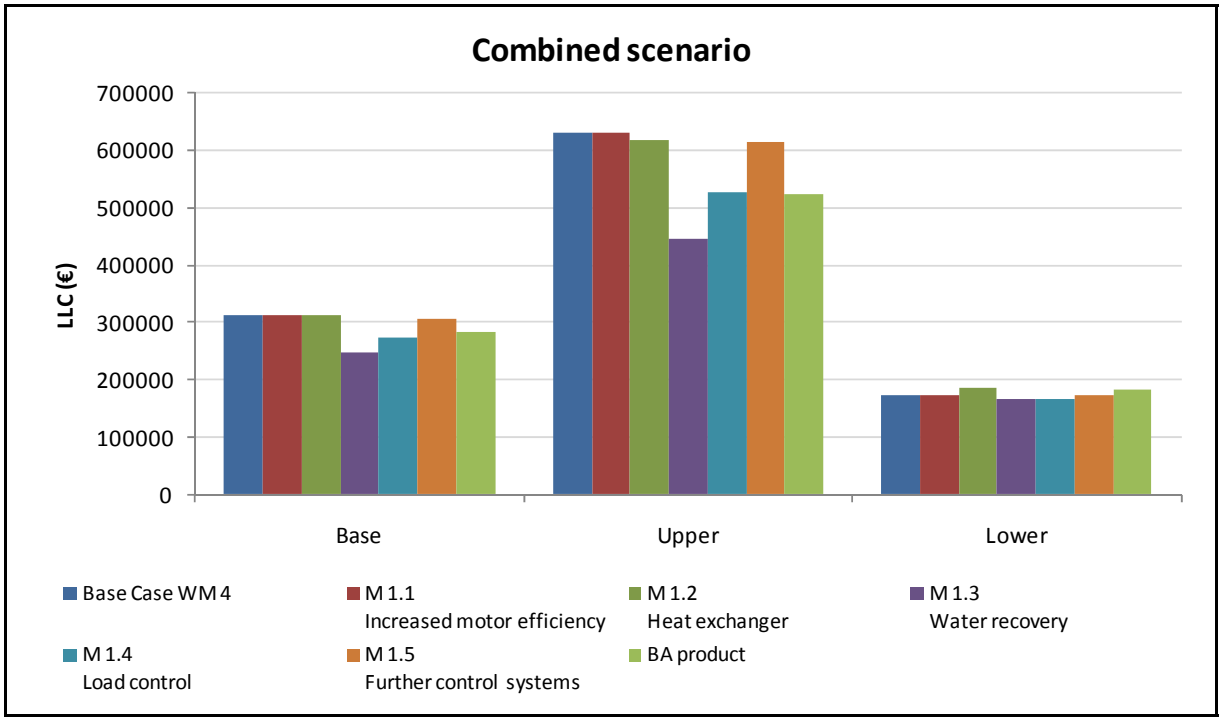


Figure 202 Base case WM 4 and improvement options – impact of combined scenario on LCC by product

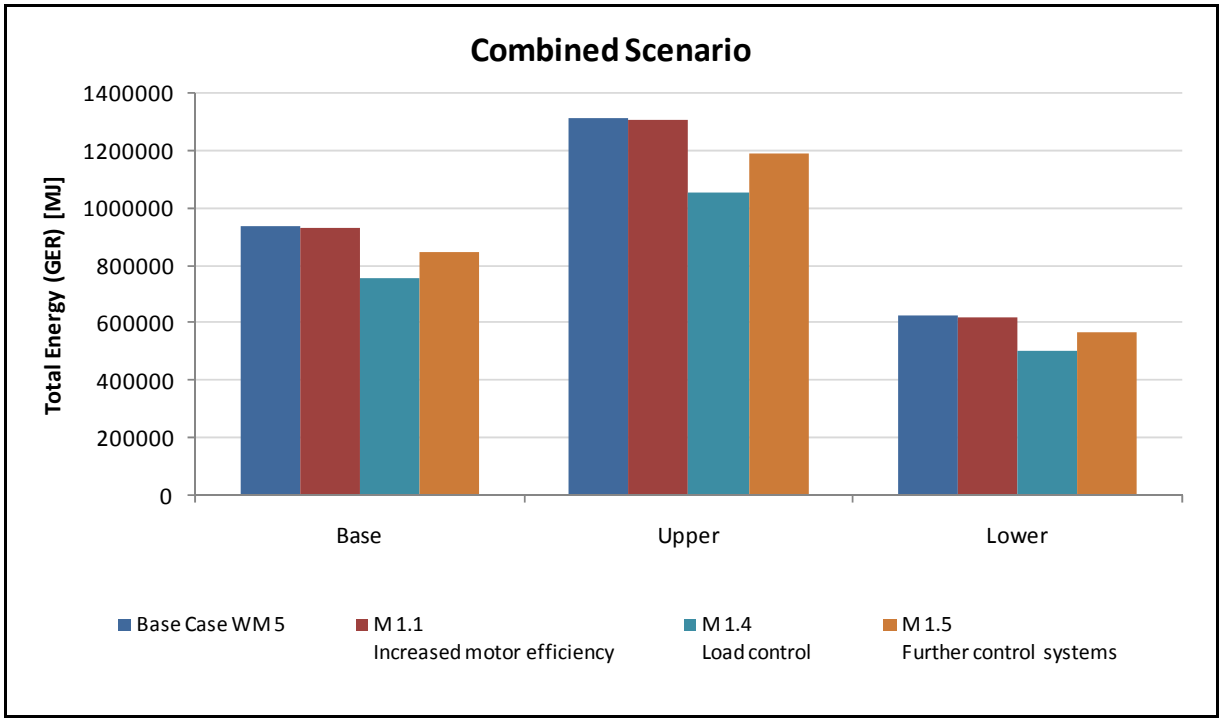


Figure 203 Base case WM 5 and improvement options – impact of combined scenario on total energy over life time by product

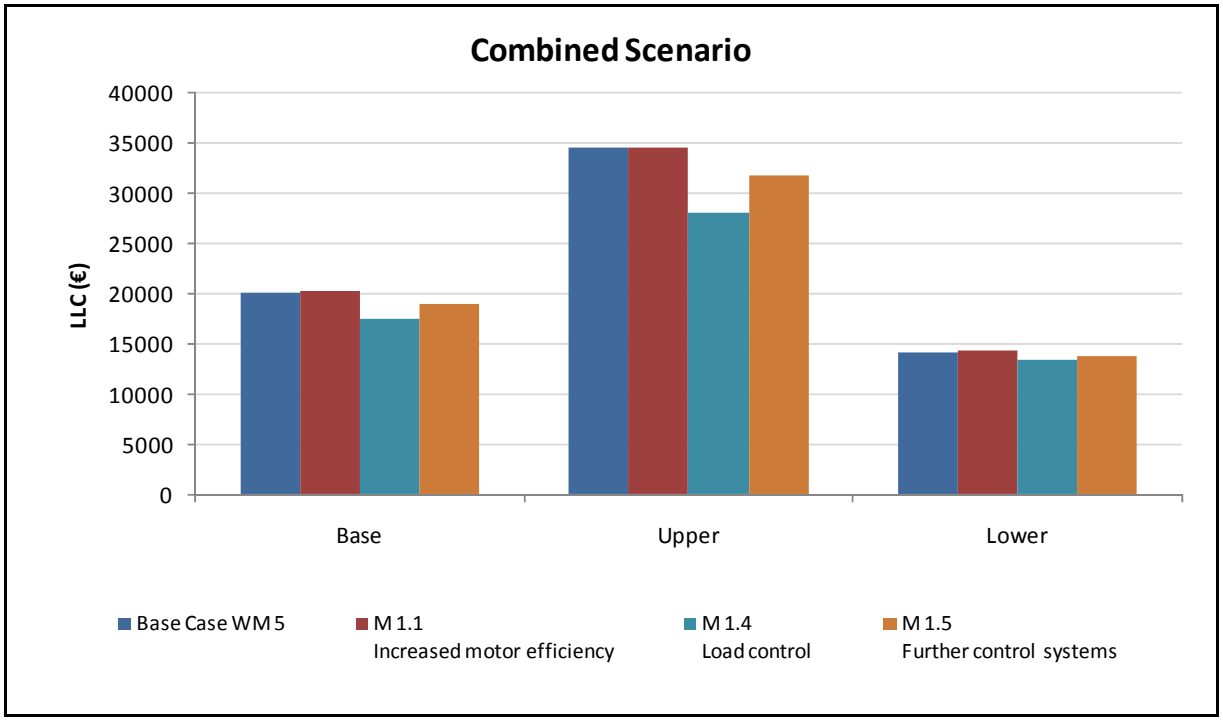


Figure 204 Base case WM 5 and improvement options – impact of combined scenario on LCC by product

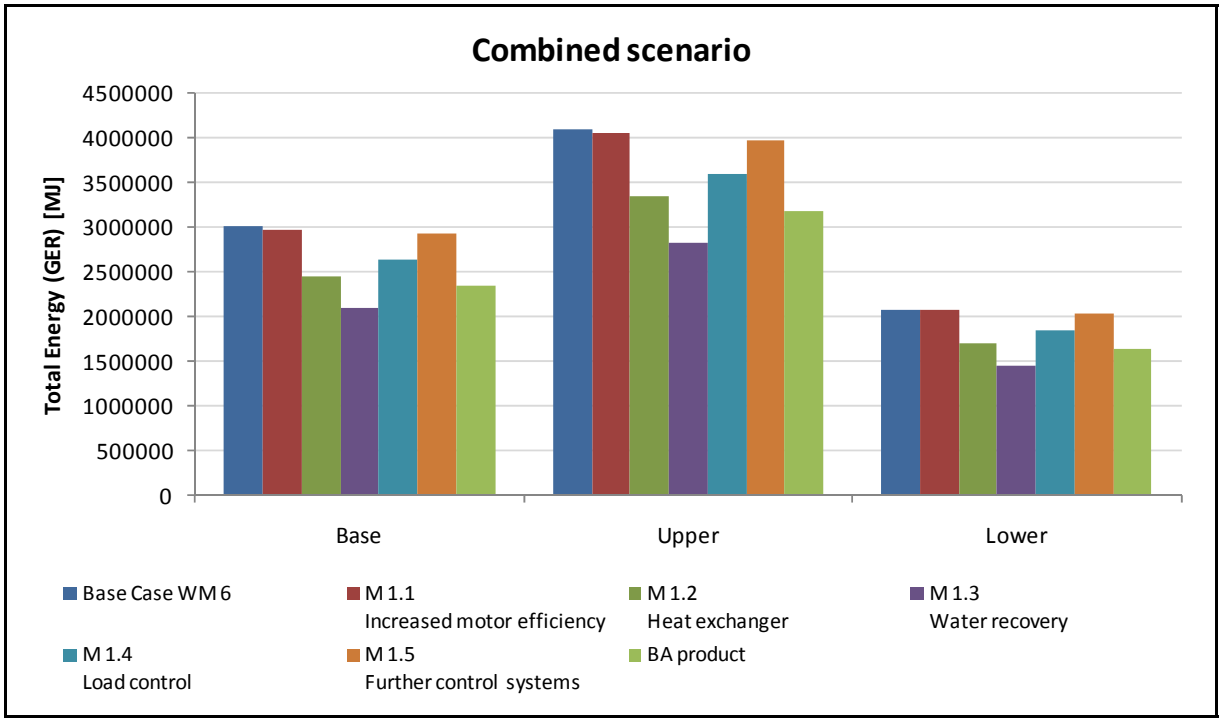


Figure 205 Base case WM 6 and improvement options – impact of combined scenario on total energy over life time by product

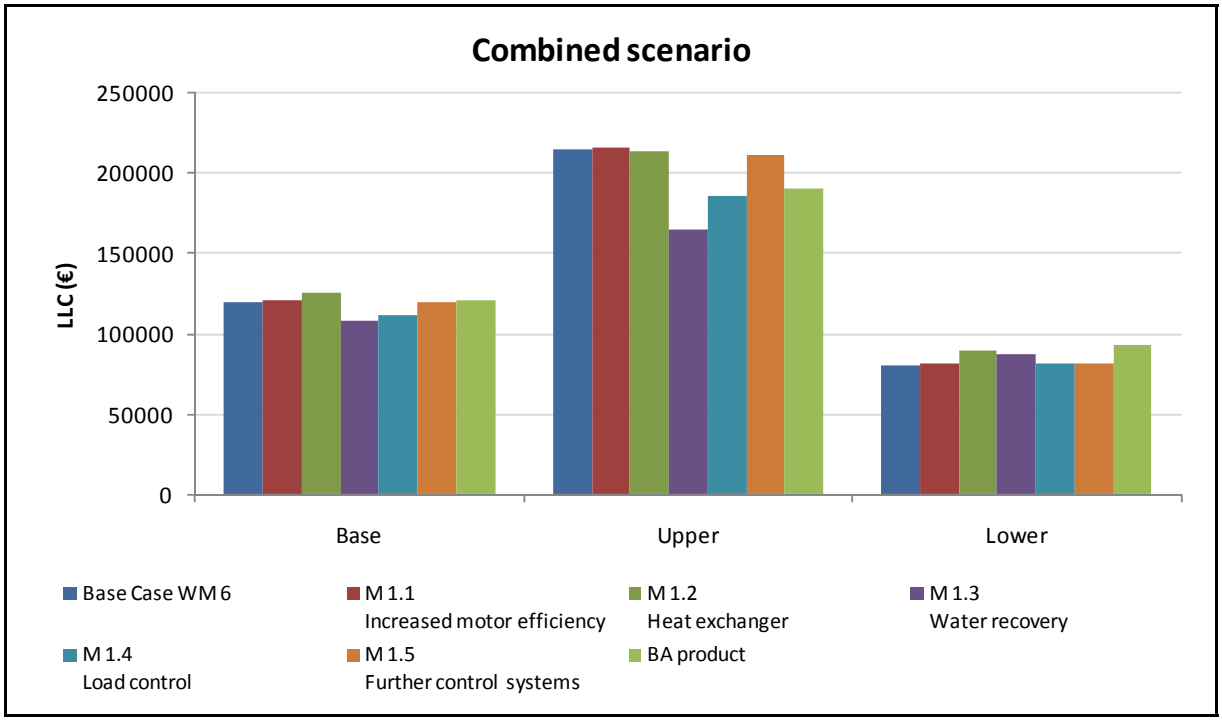


Figure 206 Base case WM 6 and improvement options – impact of combined scenario on LCC by product

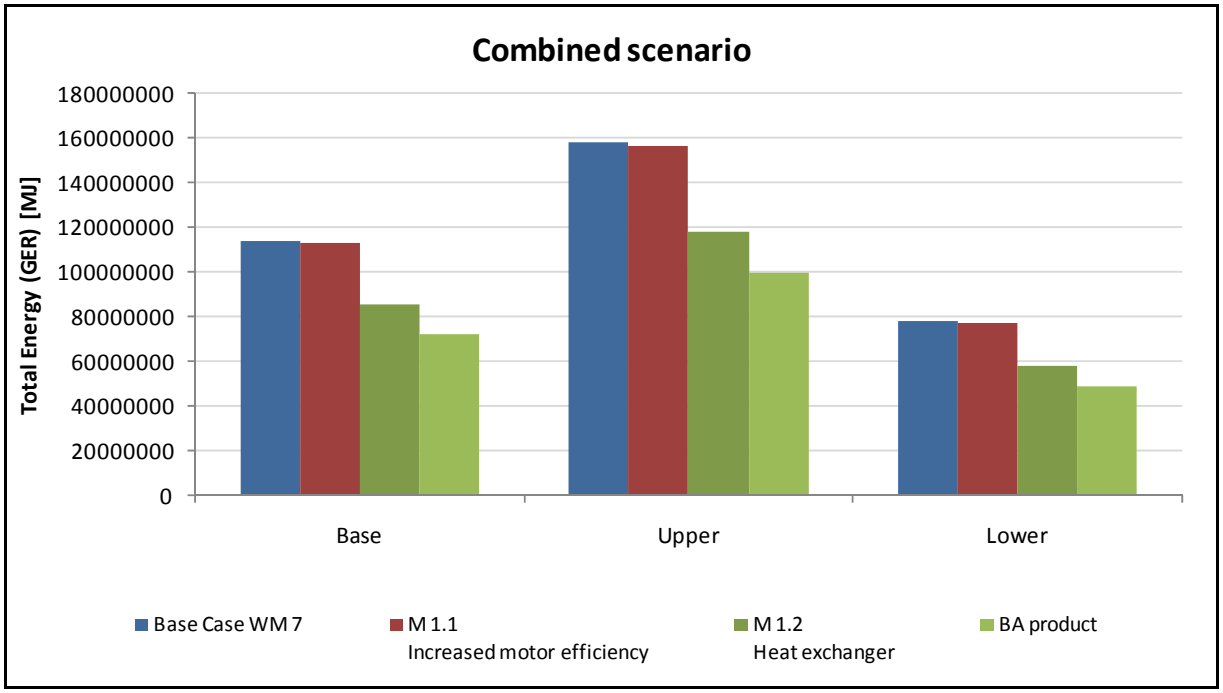


Figure 207 Base case WM 7 and improvement options – impact of combined scenario on total energy over life time by product

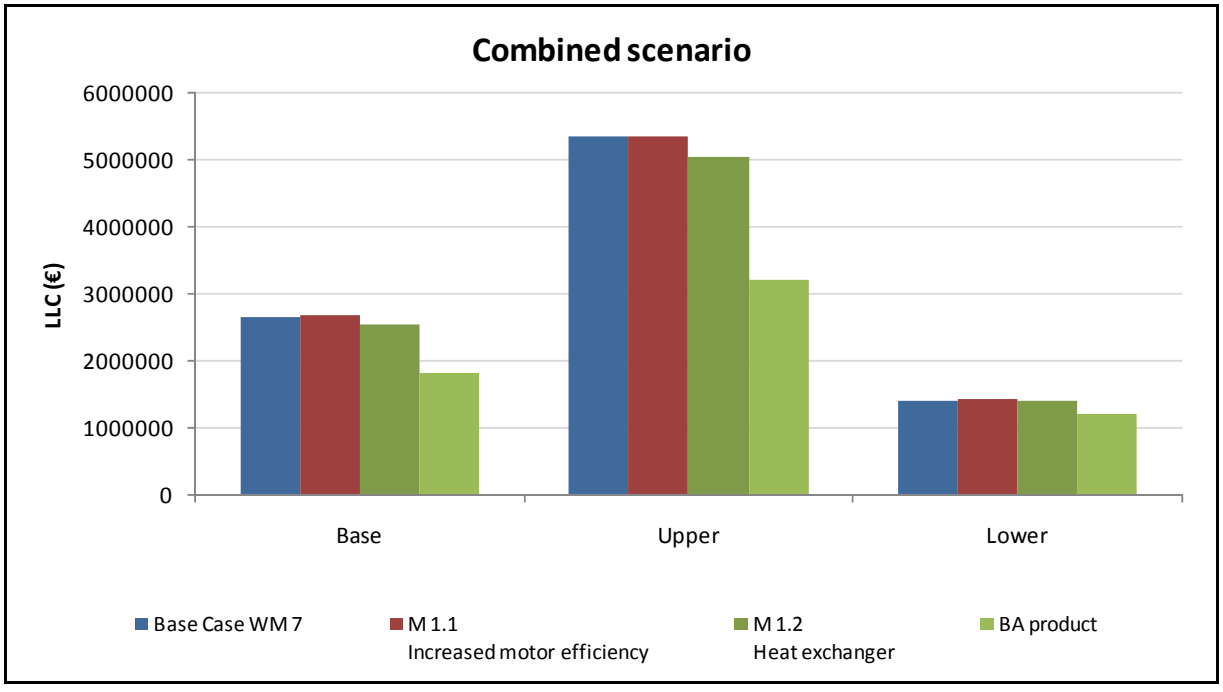


Figure 208 Base case WM 7 and improvement options – impact of combined scenario on LCC by product

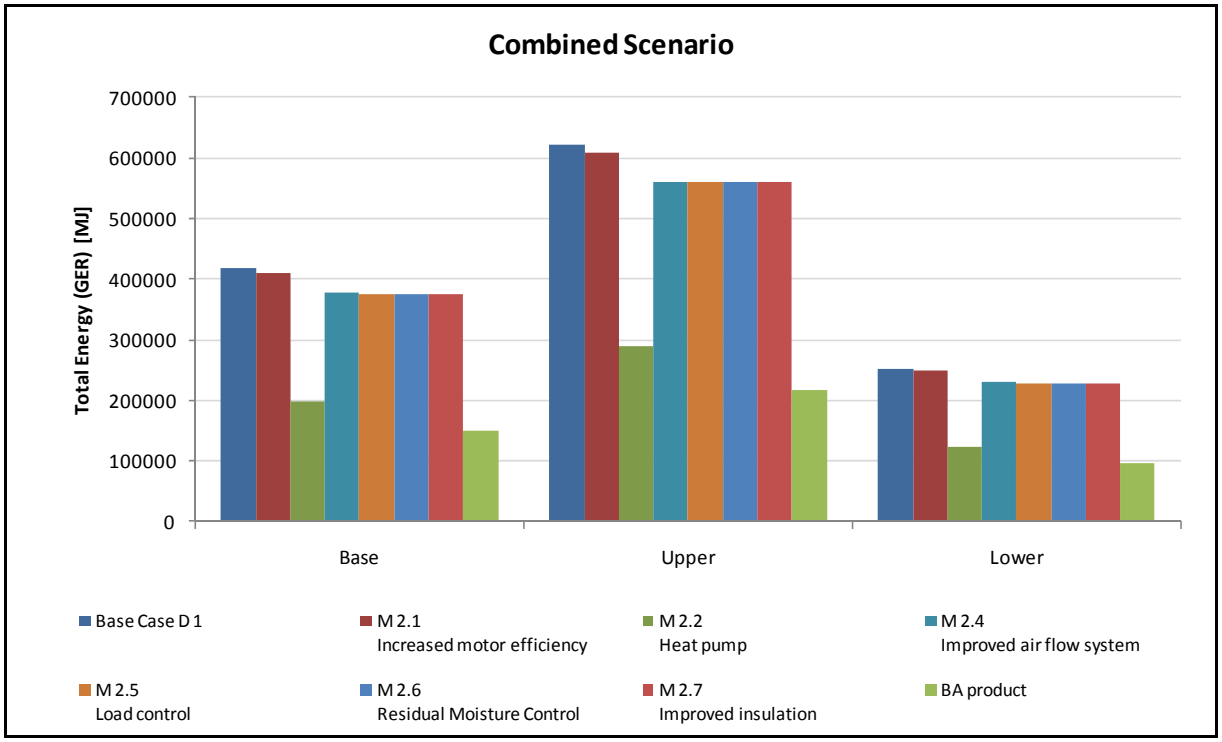


Figure 209 Base case D 1 and improvement options – impact of combined scenario on total energy over life time by product

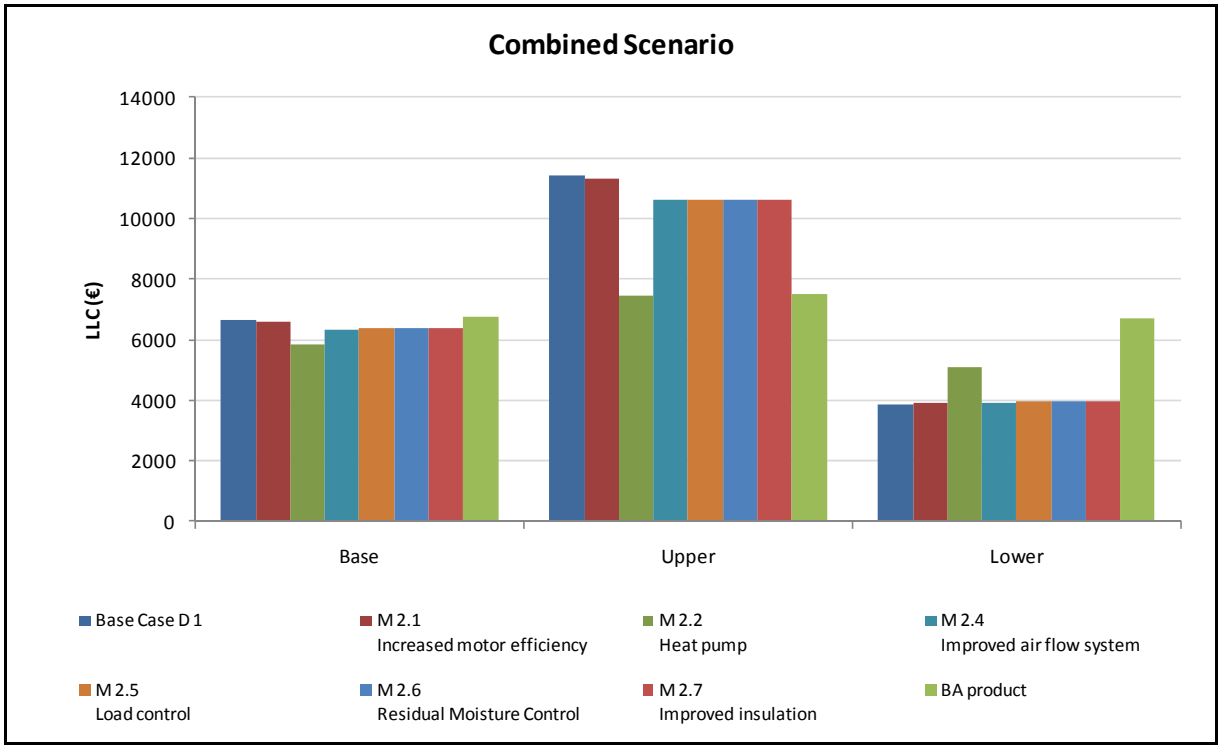


Figure 210 Base case D 1 and improvement options – impact of combined scenario on LCC by product

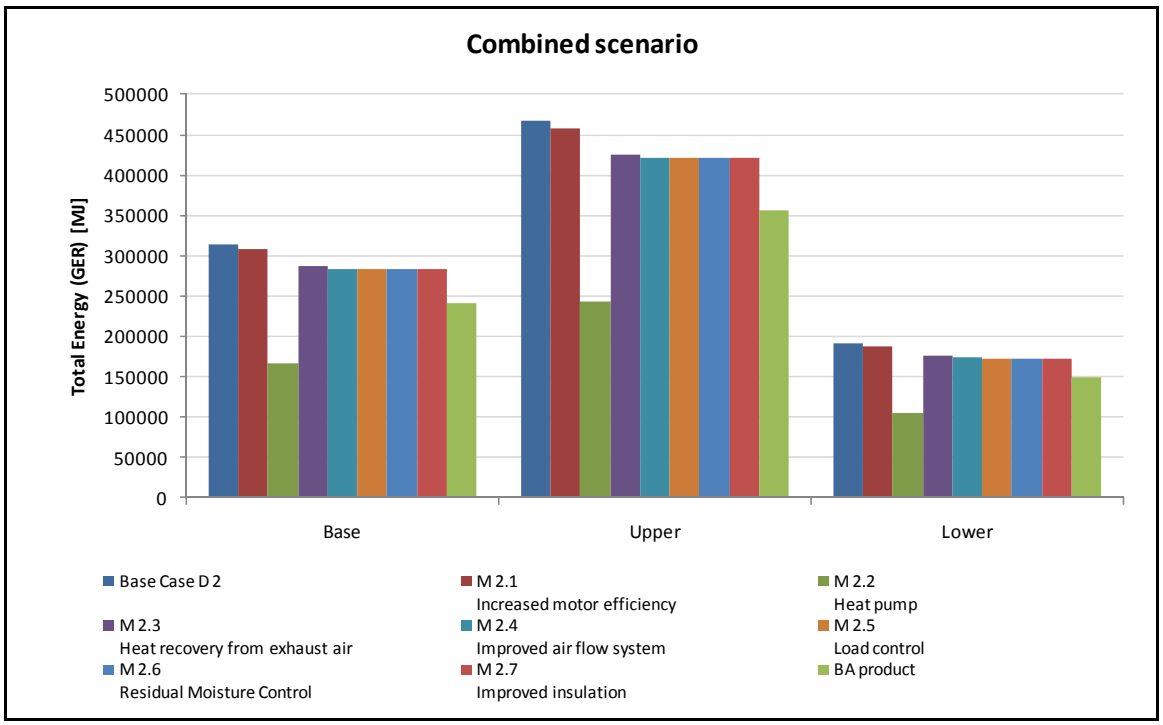


Figure 211 Base case D 2 and improvement options – impact of combined scenario on total energy over life time by product.

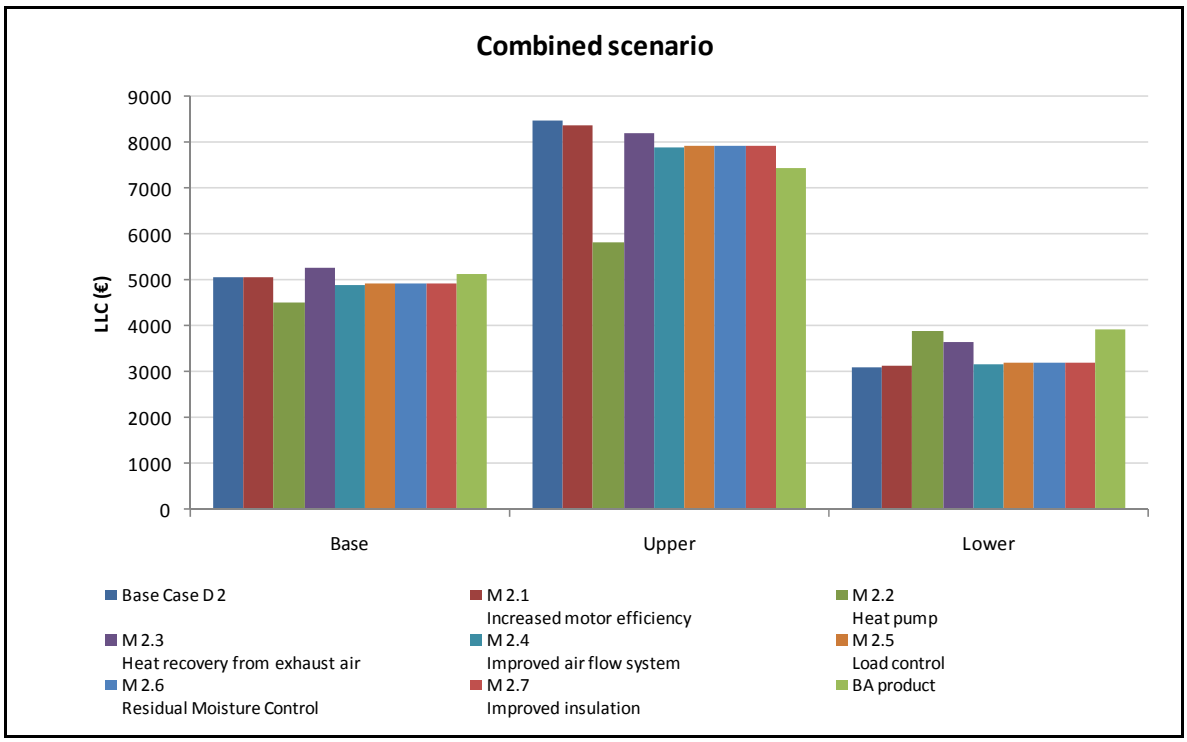


Figure 212 Base case D 2 and improvement options – impact of combined scenario on LCC by product

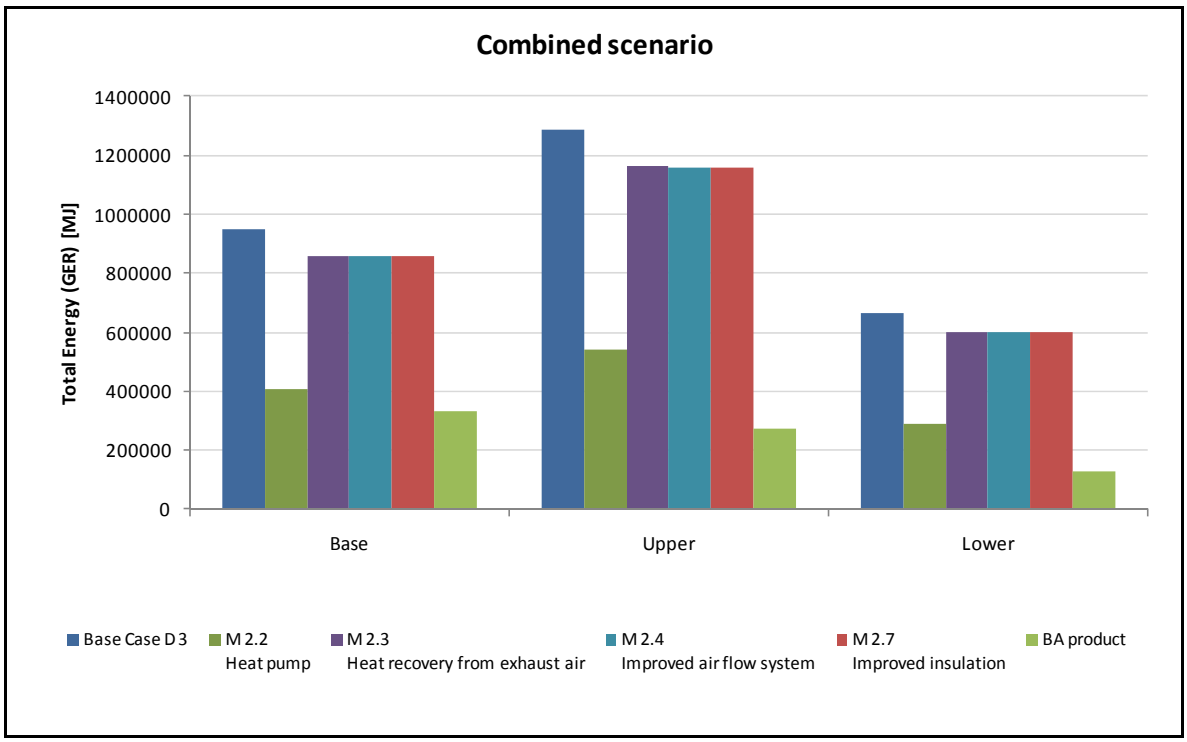


Figure 213 Base case D 3 and improvement options – impact of combined scenario on total energy over life time by product.

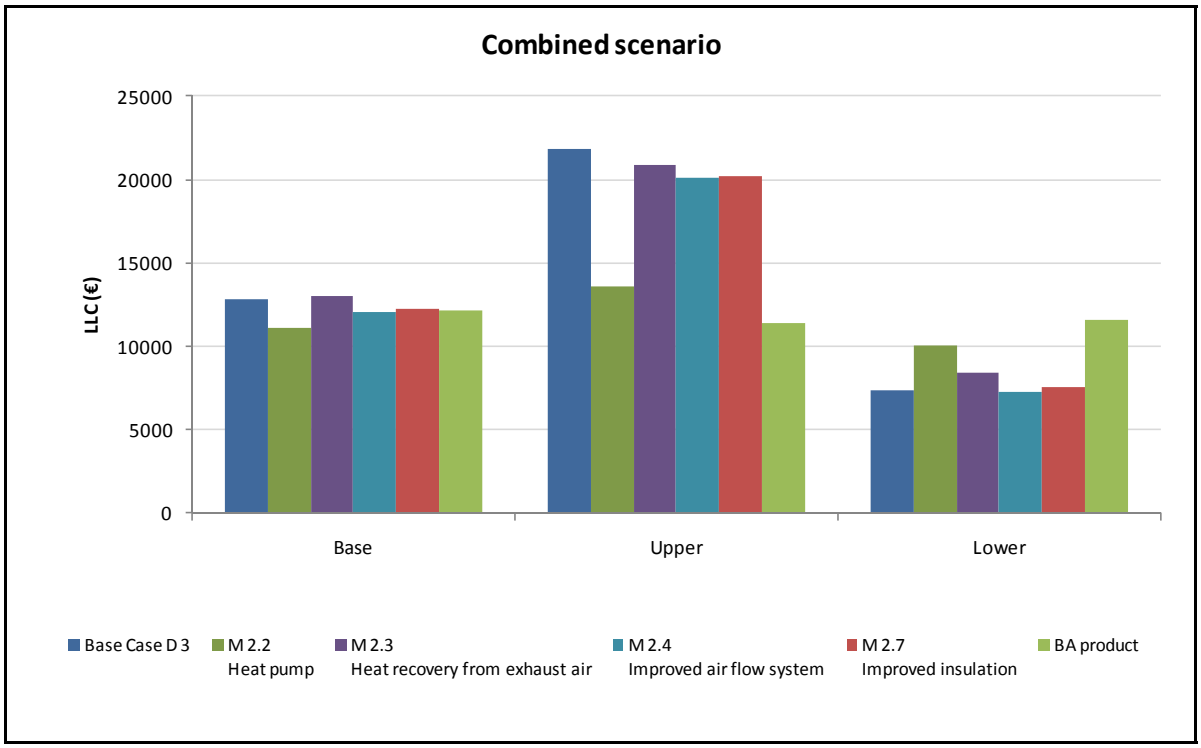


Figure 214 Base case D 3 and improvement options – impact of combined scenario on LCC by product

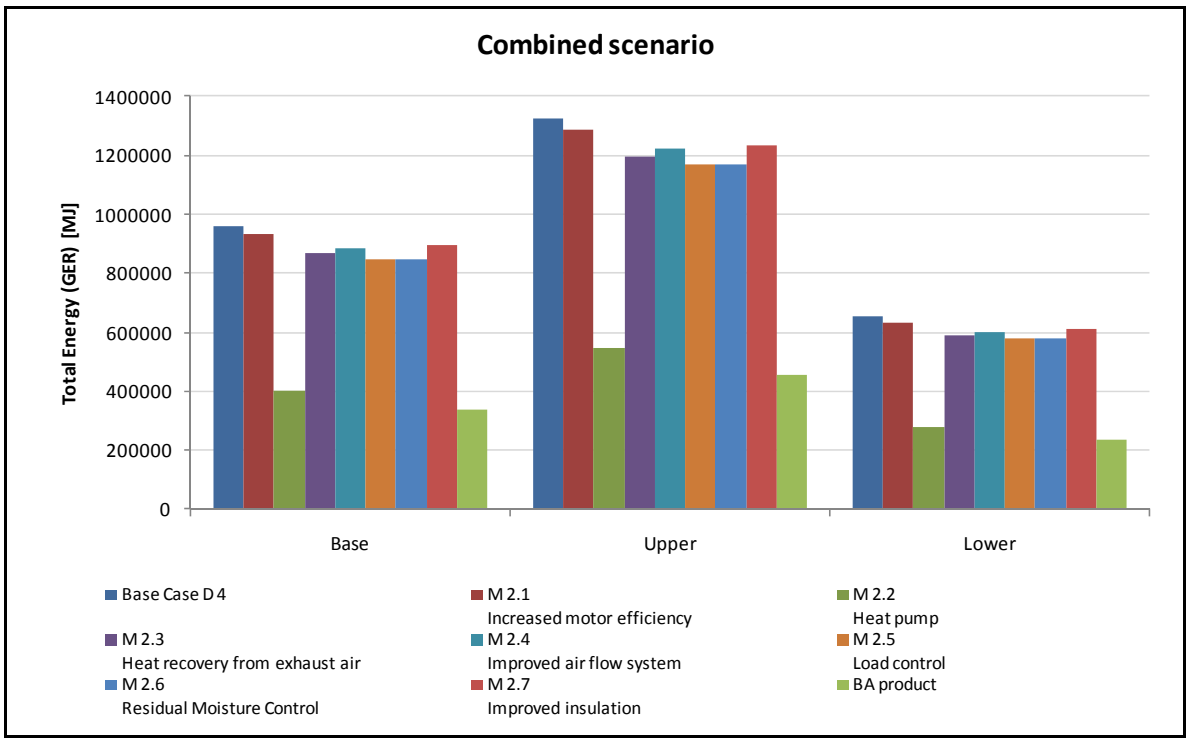


Figure 215 Base case D 4 and improvement options – impact of combined scenario on total energy over life time by product.

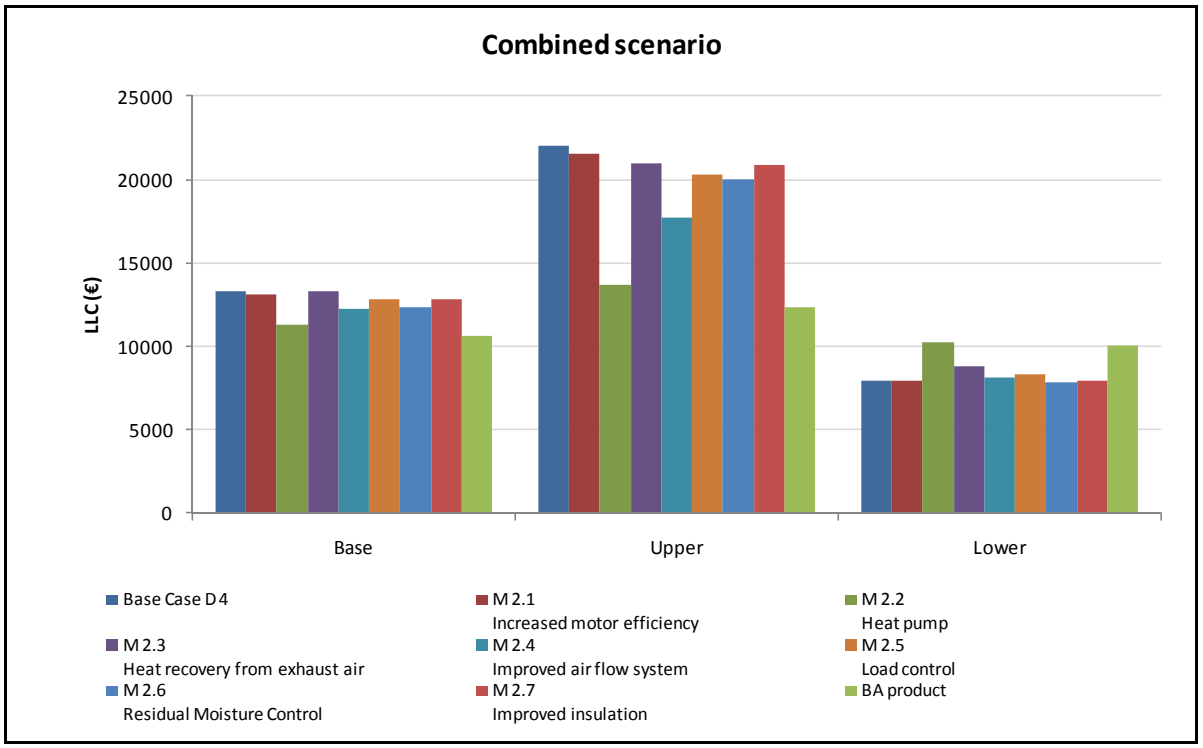


Figure 216 Base case D 4 and improvement options – impact of combined scenario on LCC by product

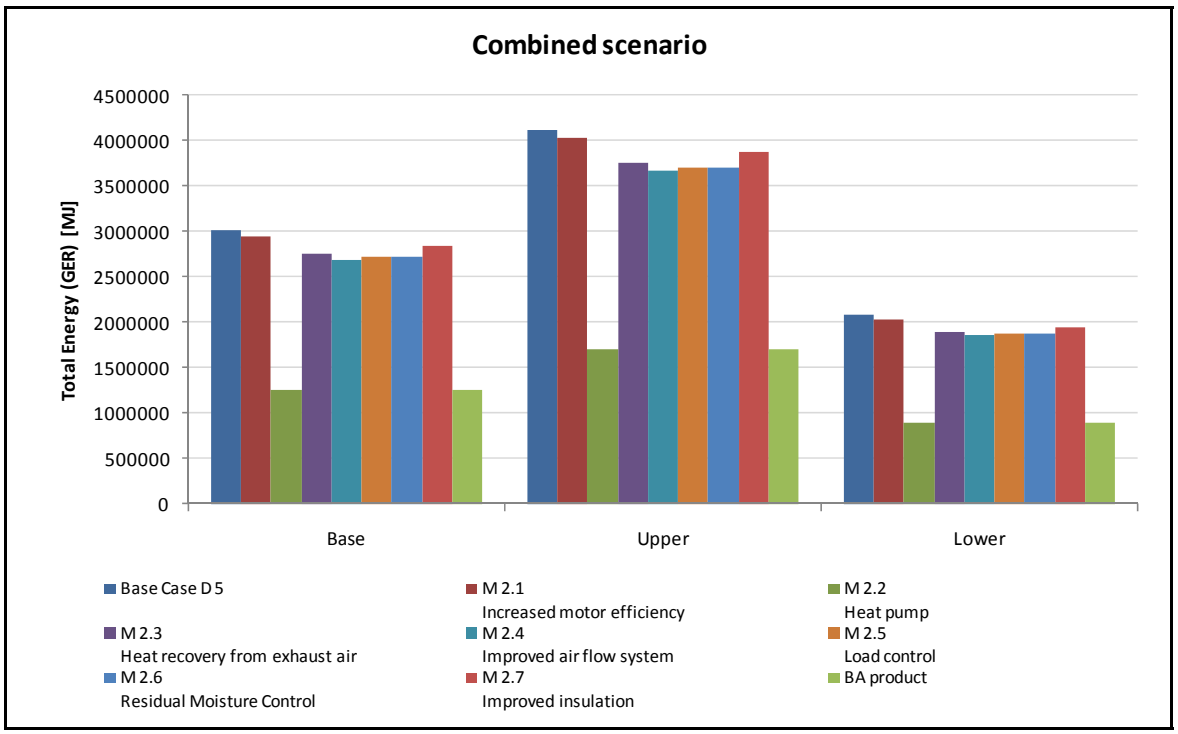


Figure 217 Base case D 5 and improvement options – impact of combined scenario on total energy over life time by product.

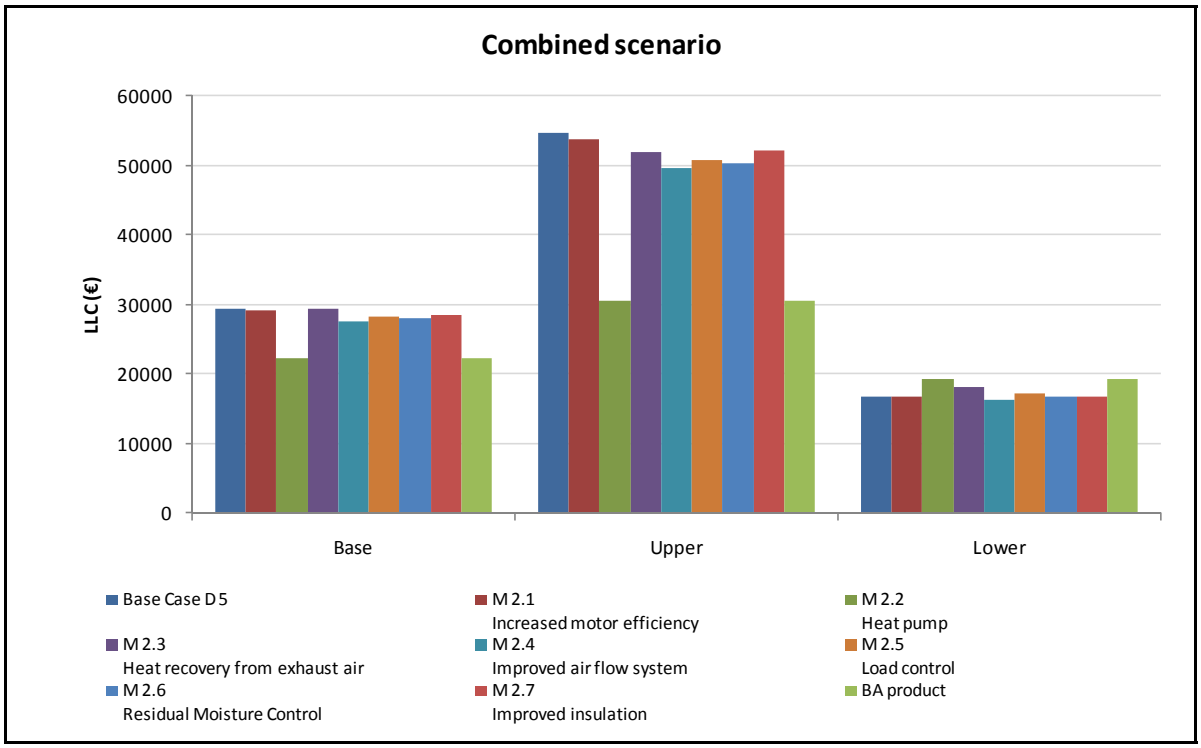


Figure 218 Base case D 5 and improvement options – impact of combined scenario on LCC by product

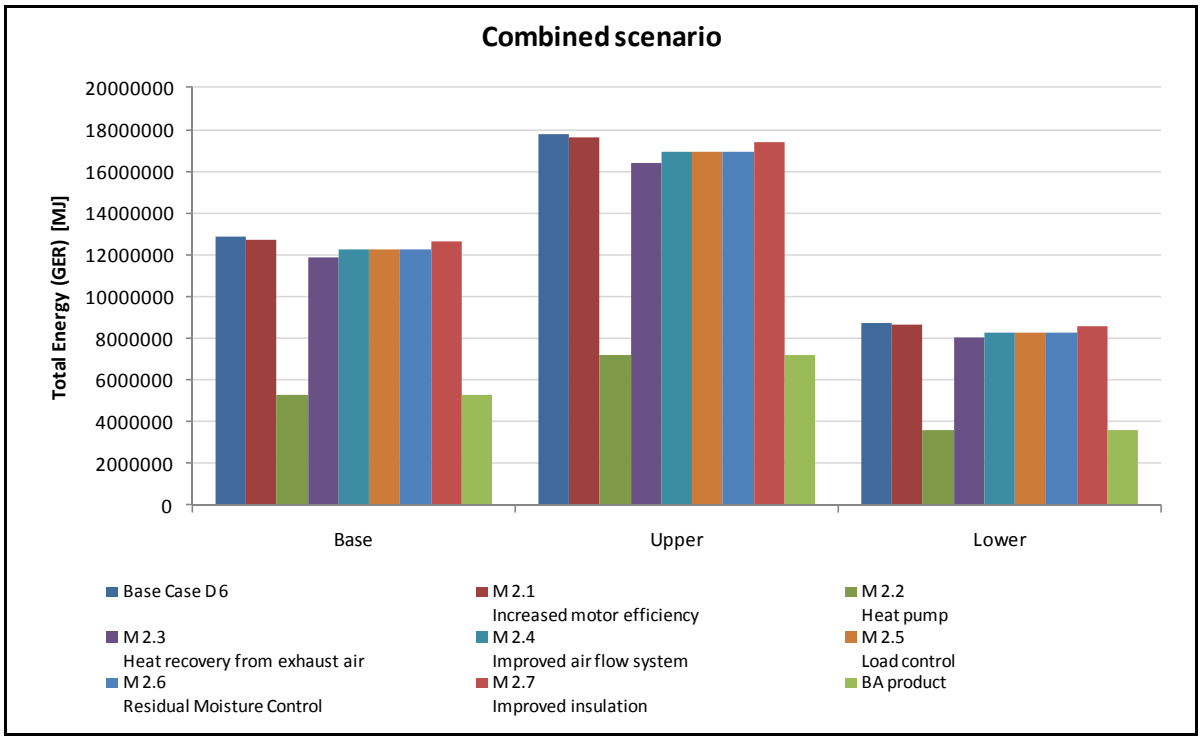


Figure 219 Base case D 6 and improvement options – impact of combined scenario on total energy over life time by product.

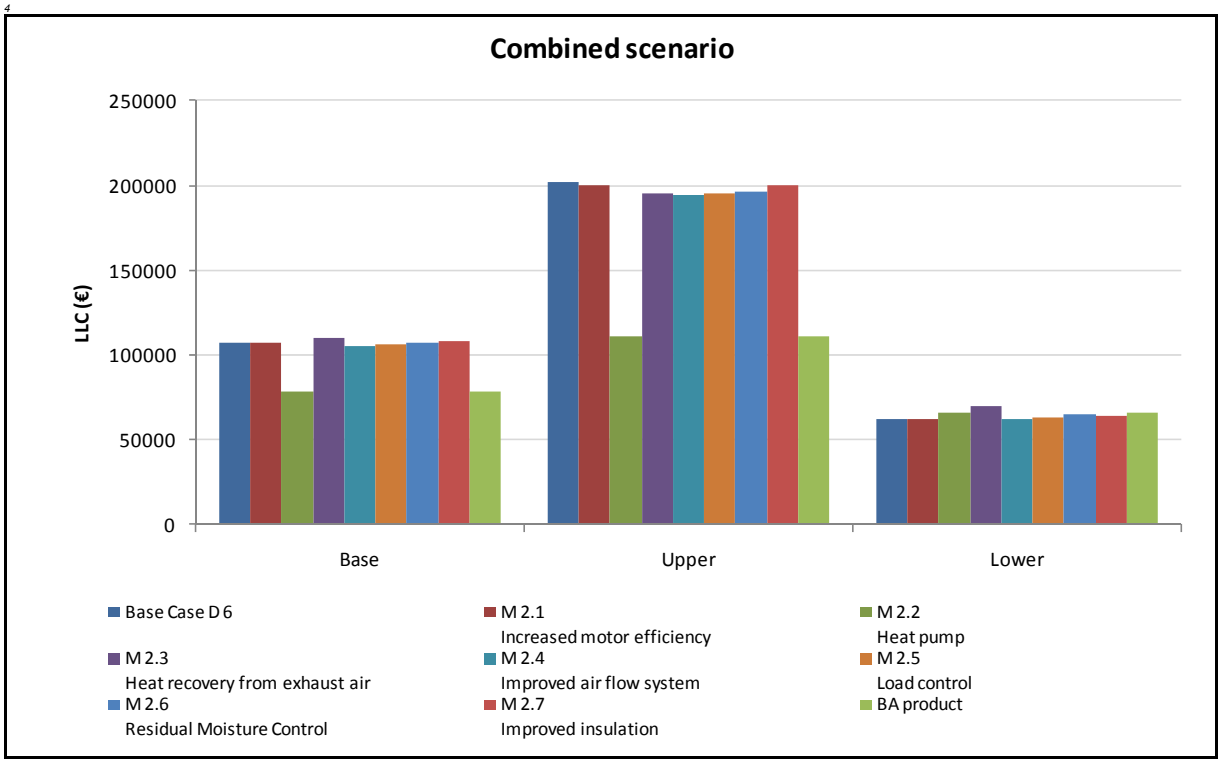


Figure 220 Base case D 6 and improvement options – impact of combined scenario on LCC by product

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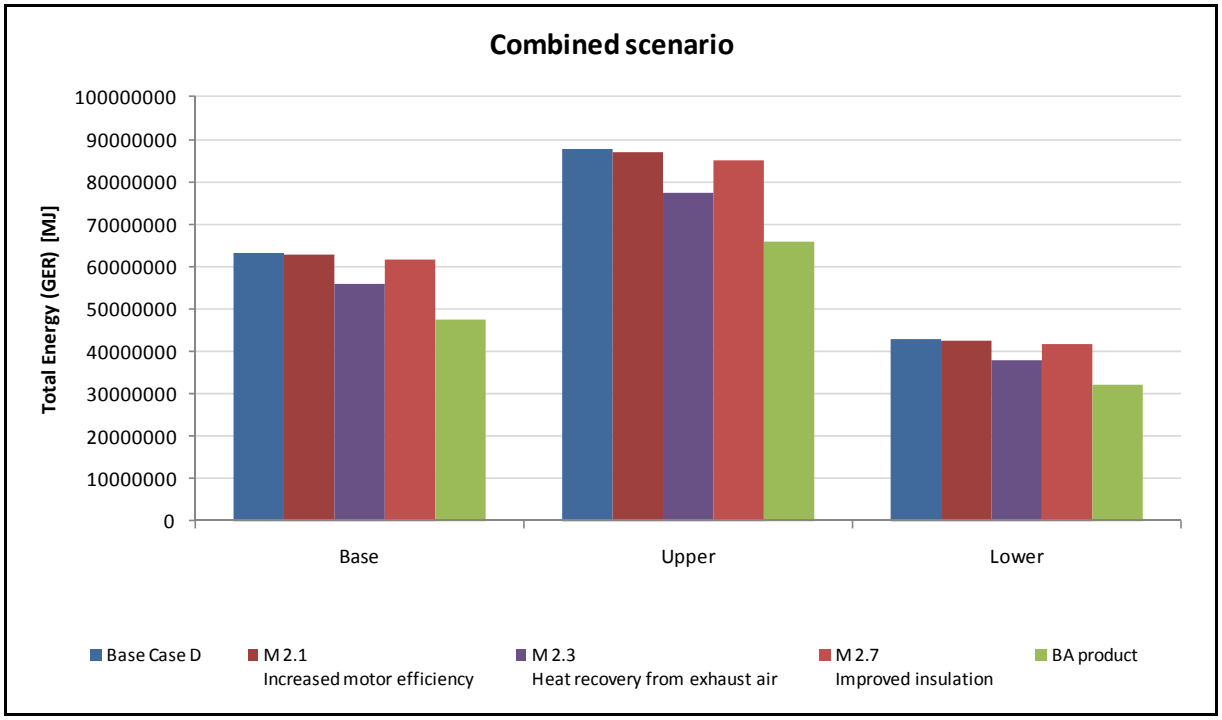


Figure 221 Base case D 7 and improvement options – impact of combined scenario on total energy over life time by product.

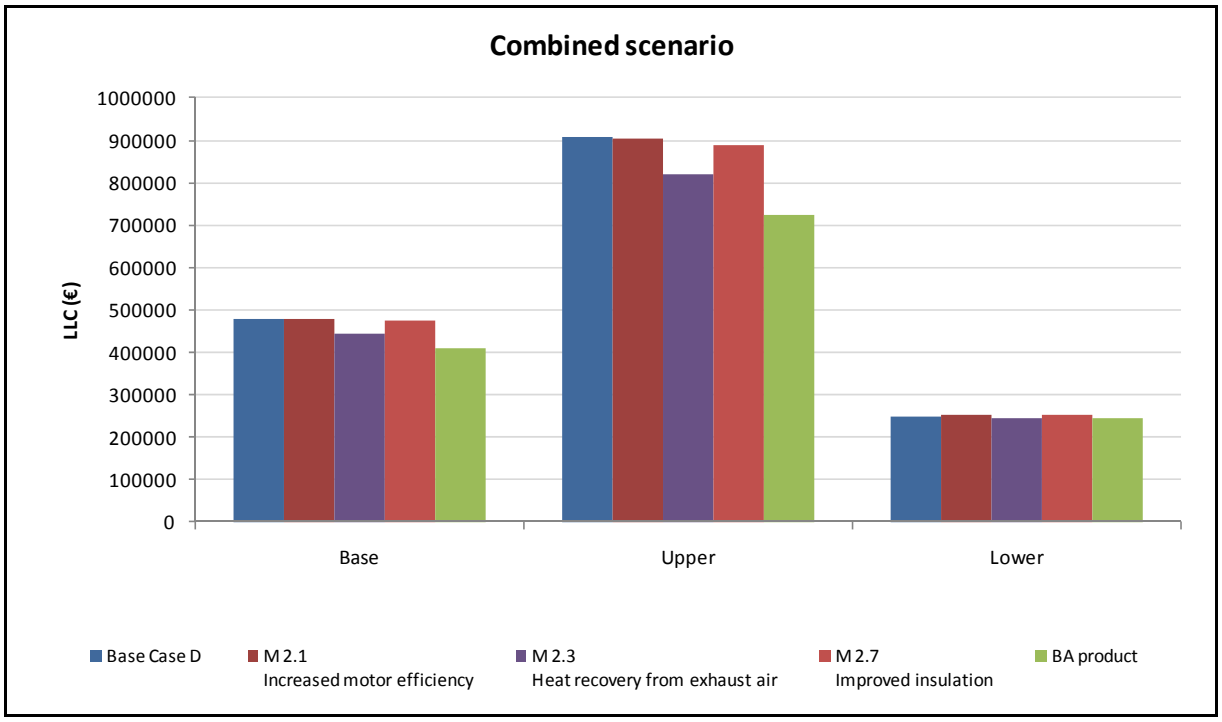


Figure 222 Base case D 7 and improvement options – impact of combined scenario on LCC by product

5 Conclusions

Task 8 summarises the outcomes of the economic and environmental analysis of the study and puts them in the context of policy implementation.

Generic eco-design requirements are proposed, such as the general provision of information related to the performance of different programmes and modes available for a given product. Together with the definition of a 'standard programme' for each laundry appliance category clearly being understandable by the users, the information might help overcoming the additional consumption due to the influence of consumer behaviour. The overall need for harmonised standards for testing and measuring the performance of professional laundry machines and dryers is seen as the most necessary step before implementing any further specific eco-design requirements like a labelling programme, benchmarking values or requirements on energy efficiency in the EU. Based on the combined economic and environmental analysis made in Task 7, specific eco-design requirements on energy and water consumption are suggested, based on the inputs and assumptions considered in the study. Besides, Green Public Procurement could also be used as a tool to drive the market towards the most efficient appliances and GPP eco-design requirements (more ambitious than the specific eco-design requirements on energy and water consumption) are also proposed. Room for improvement in each product category is clearly demonstrated in the study.

In the sensitivity analysis, it is shown that the variation of single or combined parameters can change the ranking of the options in terms of life cycle cost. Thus, for example, an improvement option that is worth implementing in one Member State for a given product and sector might not be a relevant solution in a different situation or location. Task 8 also presents a scenario analysis that compares the environmental and economic outputs of three scenarios: Business-as-Usual (BAU), Least Life cycle Cost (LLCC), and Best Available Technology (BAT). The LLCC scenario would enable to save 23.7% of the primary energy consumption in comparison with the BAU scenario in 2025, i.e. 17.5 PJ. The BAT scenario would enable to save 25.2% of the primary energy consumption compared to the BAU scenario in 2025, i.e. 18.6 PJ.