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ACRONYMS

ABS	Acrylonitrile butadiene styrene
ADD	Additional (policy options)
Al	Aluminium
BAT	Best available technology
BAU	Business as usual
BC	Base Case
BNAT	Best not yet available technology
BoM	Bill of Material
Cu	Copper
d	discount rate
e	escalation rate
EC	European Commission
ED	Ecodesign
EEE	Electrical and Electronic Equipment
EL	Energy Label
EoL	End-of-life / costs for end-of-life
EPS	Expanded polystyrene
EU	European Union
HP	Heat pump
ICT	Information and Communication Technologies
LCC	Life-cycle costs
LLCC	Least life-cycle costs
MRC	Maintenance and repair costs
N	product life (years)
N.A.	Not available / not affected
OC	(Annual) operating costs
OE	Annual operating expense
OEM	Original Equipment Manufacturer
OLD	old (policy scenario)
PA	Polyamide
PBT	Pay-back time
PC	(Total) product costs
PCB	Printed Circuit Board
PP	Purchase price
PE	Polyethylene
PMMA	Poly(methyl methacrylate)
POM	Polyoxymethylene
PP	Polypropylene
PP	Purchase price (incl. installation costs) (€)
PUR	Polyurethane
PWF	Present worth factor
std.	Standard
VAT	Value added tax
WD	Washer-dryer
WEEE	Waste electrical and electronic equipment
WM	Washing machine

INTRODUCTION

The Directive 2009/125/EC on Ecodesign establishes a framework for EU Ecodesign requirements for energy-related products with a significant potential for reduction of energy consumption. The implementation of such requirements would contribute to reach the target of saving 20% of primary energy by 2020 as identified in the Commission's Communications on Energy 2020 (European Commission 2010c) and on the Energy Efficiency Plan 2011 (European Commission 2011). Ecodesign measures may be reinforced also through the Directive 2010/30/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

The European Commission has launched the revision of the Ecodesign and Energy-/Resource label implementing measures for the product group 'household washing machines (WM) and washer-dryers (WD)'. The revision study is coordinated by the European Commission's DG of the Environment and DG Energy, and is undertaken by the Commission´s Joint Research Centre (JRC) with technical support from Oeko-Institut and the University of Bonn. The methodology of the revision follows the Commission's Methodology for the Evaluation of Energy related Products (MEErP) (COWI and VHK 2011), consisting of the following steps:

- Task 1 – Scope definition, standard methods and legislation
- Task 2 – Market analysis
- Task 3 – Analysis of user behaviour and system aspects
- Task 4 – Analysis of technologies
- Task 5 – Environmental and economic assessment of base cases
- Task 6 – Assessment of design options
- Task 7 – Assessment of policy scenarios

The comprehensive analysis of the product group following the steps above will feed as research evidence basis into the revision of the existing Energy Label Regulation (EC) 1061/2010 (European Commission 2010a) and the Ecodesign Regulation (EC) 1015/2010 on household washing machines (European Commission 2010b).

The research is based on available scientific information and data, uses a life-cycle thinking approach, and is engaging stakeholder experts in order to discuss on key issues and to develop wide consensus.

A set of information of interest has been already collected. Starting from the initial preparatory study (so called 'ENER Lot 14') prepared in 2007 (ENEA/ISIS 2007a) and the resulting Regulations listed above on Energy Label and Ecodesign for domestic dishwashers and washing machines, a generic review of the fitness of these policies took place as part of the DG ENER project 'Omnibus' (VHK et al. 2014). The Omnibus study identified a number of issues of these Regulations where revision is advisable. Against this background, information is being revised, updated and integrated to reflect the current state of play, following the MEErP methodology. As final result, the JRC will produce an updated preparatory study including a comprehensive techno-economic and environmental assessment for this product group. This will provide policy makers with an evidence basis for assessing whether and how to revise the existing Regulations.

A Technical Working Group (TWG) has been created in order to support the JRC along the study. This Technical Working Group is composed of experts from Member States, industry, NGOs and academia who have voluntarily requested to be registered as stakeholders of the study through the project website (http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/index.html). The TWG is contributing to the study with data, information and written feedback to questionnaires and working documents. Interaction with stakeholders is also taking place through two meetings organised by JRC:

- 1st Technical Working Group (TWG): 24 June 2015, in Seville.
- 2nd Technical Working Group (TWG): 18 November 2015, in Brussels.

Objectives and structure of this report

The present document is prepared as input for the second TWG meeting (18 November 2015, in Brussels). It builds upon the first part consisting of Tasks 1 to 4 of the preparatory study which has been published in June 2015. This document is structured in the following chapters, following Tasks 5 to 7 of MEErP:

- Chapter 5: Definition and environmental and economic assessment of base cases
- Chapter 6: Selection of design options implementing best available technologies to improve the environmental impact for this product group, and environmental and economic assessment of these design options. Description of best not available technologies for further discussion;
- Chapter 7: Policy analysis as basis for the assessment of different scenarios, preliminary impact assessment for industry and consumers, sensitivity analysis of the main parameters to finally derive main policy recommendations per product.

As basis for these task reports, questionnaires have been sent out in July 2015 to stakeholders to collect information for the study regarding Base Case assumptions and design options as well as a draft set of policy options. Feedback received has been reported in this document to the extent possible.

Stakeholder written feedback

Stakeholders are asked to carefully study the assumptions and results presented in the individual chapters of this report, and to point out potential modifications and additions they deem necessary.

A series of QUESTION BOXES have been inserted in the document to point out the parts of the document where the study team sees particularly the need of feedback from stakeholders.

Please note that the written commenting of this report requires firstly registration as stakeholder through the project website (http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/index.html), and takes place using the on-line platform BATIS (further information on access to BATIS is provided upon registration)..

Experts not able to participate in the stakeholder meeting are also welcome to provide written comments, once registered as stakeholders.

5. TASK 5: ENVIRONMENT AND ECONOMICS

The aim of this section is to assess environmental and economic impacts associated to different Base Cases of household washing machines and washer-dryers. The assessment is based on the updated version of the EcoReport Tool (v3.06), as provided with the MEErP methodology (COWI and VHK 2014), and published online in December 2013 on http://ec.europa.eu/growth/industry/sustainability/ecodesign/index_en.htm

5.1. Product specific inputs for the EcoReport tool

According to MEErP methodology, Base Cases (BC) should reflect average EU products. Different products of similar functionalities, Bill of Materials (BoM), technologies and efficiency can be compiled into a single BC, thus it does not always represent a real product. In the following chapters, the Base Cases are then used as reference for modelling the stock of products and improvement design options.
For the identification of the Base Cases for household washing machines and washer-dryers, the most appropriate BC have been selected in accordance with the analysis presented in the previous Tasks 2 (Markets), 3 (Users) and 4 (Technologies).

5.1.1. Base Case for washing machines

In this section, a Base Case for washing machines is developed. Most available data on the operation of WMs stems from testing in standard conditions (IEC/EN 60456). Thus, a reference 'standard data' washing machine is also presented along with the Base Case. This facilitates to understand the assumptions made for the Base Case.

- **Base Case WM**: This machine has been built based on the average capacity and technology currently on the EU market, as presented in Chapters 2, 3 and 4. It has a nominal rated capacity of 7 kg, and average EU technology as recorded in recent surveys of sales. The operation conditions reflect to the extent possible the results from **real-life user behaviour in the EU** (Alborzi et al. 2015), which - as known - is different from the standard conditions under which the machine's energy efficiency and washing performance are tested for the purpose of checking Ecodesign compliance, and Energy labelling classification. The exact parameters for the BC assumed are presented in Table 5.1 below. The annual number of cycles, average loading conditions and frequency of use of different programmes are derived from the results of the consumer survey 2015 (Alborzi et al. 2015). Consumption values for energy, water and detergents have been estimated from the analysis of data for machines on the market and other consumer research studies. A brushless, inverter driven asynchronous DC motor is considered for the Base Case WM.

- **Standard Data WM**: Alongside the Base Case WM, the parameters of a washing machine operating under the **standard test conditions** of IEC/EN 60456 for the Ecodesign and Energy label measurement methods is also presented in Table 5.1, also with a nominal rated capacity of 7 kg. The annual number of cycles, average loading and consumption values for energy, water and detergents are those prescribed in IEC/EN 60456 testing. This WM has thus the annual consumption of washing machines as displayed for consumers on the Energy label, based on the sole use of standard 40°C and 60°C cotton programmes, following the weighted share of those programme cycles with full and half nominal load as described in standard IEC/EN 60456.

Table 5.1 provides the detailed performance characteristics chosen for the Base Case and, as reference, the 'Standard Data' washing machine, both including the respective underlying sources and assumptions.

Table 5.1: Performance characteristics of the chosen Base Case for washing machines, and the reference 'Standard Data'

	Reference: 'Standard Data'	'Real-life' Base Case WM	Sources/Comments
Nominal rated capacity (kg)	7	7	Standard Data WM: Task 2, figure 2-14, showing that >30% of WM models in 2013 had 7 kg capacity. Michel et al. (2015), figure 25: 7kg machines second most important share of total 2014 EU sales with decreasing trend of smaller machines and increasing trend to 7kg and higher capacities; figure 34: largest share of A++/A+++ sales in 2014 BC WM: Identical machine as in Standard Data WM.
Number of cycles per year	220	220	Standard Data WM: Based on the standard number of annual cycles used in the current Ecodesign and Energy label regulations for household washing machines to calculate the Energy Efficiency Index. BC WM: Results of the 2015 consumer survey on washing behaviour (Alborzi et al. 2015) are still in line with the number of standard cycles (229 vs 220).
Average loading (kg)	5	3.4	Standard Data WM': Weighted loading of 7 cycles in the standard measurement (3 times full load at 60°C, 2 times half load at 60°C and 2 times half load at 40°C) referred to in the standard measurement method of the Ecodesign and Energy label regulations: 5=(3*7+4*3.5)/7 BC WM: Kruschwitz et al. 2014, analysis of the arithmetic average amount of clothes per week and person and per wash cycle with standard deviation (n = 2,867 wash cycles). This is confirmed by the results of the 2015 user survey on 11 European countries, which show on average a load of 3.4 kg of laundry per cycle under real life conditions (Alborzi et al. 2015).
Manufacturing cost (in €)	106	106	Standard Data WM: Based on Michel et al. (2015), figure 36: average purchase price (PP) of 7 kg WM sales in 2014: 413 €. The following assumptions allow to relate the manufacturing costs (MC) from the purchase price (PP): PP=MC x (1+MP) x RP x (1+VAT), where: MC=manufacturing costs MP=manufacturing average % profit margin,~28% (varies largely from 20 to 30%, depends on many parameters including volume of sales) RP=aggregated (wholesale-retailer) sales margin: factor 2.5 (varies largely from 1.5 to 4, depending on the number of steps in the chain, inclusion of e.g. aftersales service, transport, installation and the retailer's costs e.g. showroom) VAT: average EU VAT 2015: 21.6% BC WM: Identical machine as in Standard Data WM.
Purchase price for the customer (in €)	413	413	Standard Data WM: Based on Michel et al. (2015), figure 36: average nominal price of 7 kg WM sales in 2014: 413 €; BC WM: Identical machine as in Standard Data WM.
Maintenance and repair costs for the consumer (in €/lifetime)	45	45	Standard Data WM: Task 2, table 2-22, assumptions based on initial stakeholder feedback; own assumption: one repair during lifetime; approximately 150 € costs per repair (Prakash et al. unpublished); according to an Internet based consumer survey in Germany, 42% of washing machines were repaired during their lifetime (total number of respondents: n = 734) (Prakash et al. 2015); for EU28 a lower share of 30% of WM being repaired once in their lifetime at 150 € is assumed; i.e. 45 € is attributed to the repair costs for ALL washing machines. BC WM: Identical machine as in Standard Data WM
Energy	0.84	0.713	Standard Data WM:

	Reference: 'Standard Data'	'Real-life' Base Case WM	Sources/Comments
consumption wash (kWh/cycle)	(average standard programme, corresponding to 0.168 kWh/kg)	(corresponding to 0.210 kWh/kg	Michel et al. (2015), figure 23: average energy consumption of 2014 EU sales: 185 kWh/year; divided by 220 wash cycles per year; Task 2, figure 2-16: average energy consumption of 2013 EU models: 0.83 kWh/cycle. These average energy consumption values are based on the average of 7 measured cycles in the standard cotton programmes (3x60°C full load, 2x60°C half load, 2x40°C half load) and also include a low share of low-power and off-mode energy consumption (cf. Task 2.2.4.2, ATLETE measured data for off-mode (average: 0.2 W/cycle) and left-on mode (on average: 0.6 to 0.9 W/cycle) BC WM: A broad programme portfolio considered, with statistics about the frequency of use of different programmes from (Alborzi et al. 2015). Consumption values estimated from analysis of data for products on the market (see Table 5.3). +63% energy consumption per cycle for the normal cotton 40/60°C programmes. A correction factor for underloading considered based on (Lasic et al. 2015). Details: cf. Section 5.1.1.3
Water consumption (L/cycle)	45 (average standard programme, corresponding to 9 L/kg)	42.86 (corresponding to 12.6 L/kg)	Standard Data WM: cf. Task 2, figure 2-26: average water consumption of 2013 EU models: 45.1 litres/cycle Michel et al. (2015), figure 24: 2014 average water consumption of EU sales: 9,900 litres/year, divided by 220 cycles per year These average water consumption values are based on the average of 7 measured cycles in the standard cotton programmes (3x60° full load, 2x60° half load, 2x40° half load) BC WM: A broad programme portfolio considered, with statistics about the frequency of use of different programmes from (Alborzi et al. 2015). Consumption values estimated from analysis of data for products on the market (see Table 5.3). +11% water consumption per cycle for the normal cotton 40/60°C programmes. A correction factor for underloading considered based on (Lasic et al. 2015). Details: cf. Section 5.1.1.3
Detergent (solid or liquid) consumption (g or ml per cycle)	100 g, solid	75 g, solid (or 75 ml, liquid)	Standard Data WM: For WM, the dosage according to the standard testing method is 40 g + 12 g/kg wash load, with 5 kg average wash load taken as basis (3x full load, 4x half load cycles) BC WM: cf. Task 1, table 1-27 and table 1-28, as well as Task 3, Table 3.4 for powder and liquid detergents
Washing performance class	A	A	Standard Data WM: cf. Task 2, figure 2-22; since 2011 all machines have to fulfil A-performance in standard programmes; BC WM Assumption that washing performance in normal cotton 60°/40° programmes is also A, as in the standard programmes
Spin drying performance class	B	B	Standard Data WM: cf. Task 2, figure 2-23: 56% of 2013 EU models have spin-drying class B; BC WM Assumption that spin drying performance in normal cotton 60°/40° programmes is the same as in the standard programmes
Noise washing/spinning (dB(A))	56/75	56/75	Standard Data WM: cf. Task 2, figure 2-32 BC WM: assumption that the noise in normal cotton 60°/40° programmes is the same as in the standard programmes
Cycle time (min)	171	112	Standard Data WM: cf. Task 2, table 2-10: average programme time of 50 tested models of 2012/2013 (ATLETE II results) BC WM: A broad programme portfolio considered, with statistics about the frequency of use of different programmes from (Alborzi et al. 2015). Consumption values estimated from analysis of data for products on the market (see Table 5.3). Minus28% programme duration time for

	Reference: 'Standard Data'	'Real-life' Base Case WM	Sources/Comments
			the normal cotton 40°/60°C programmes. A correction factor for underloading considered based on (Lasic et al. 2015). Details: cf. Section 5.1.1.3)
Lifetime (years); calculation basis	12.5	12.5	Standard Data WM: cf. Task 4, table 4.18: First useful service life of washing machines replaced due to a defect (i.e. technical product lifetime) BC WM: identical machine as in Standard Data WM. It is assumed as default that the technical lifetime is not significantly influenced by the substitution of cotton normal to standard programmes. It is also assumed that the 12.5 lifetime refers to real-life machines that use a combination of programmes (cf. Table 5.3), where some of the programmes are more demanding (e.g. normal cotton, 90°C), and others are less (short programmes, synthetics).

5.1.1.1. WM: Raw materials use and manufacturing of the products: Bill Of Materials (BoM)

The manufacturing phase includes the extraction and production of materials, including the following steps necessary to produce and assemble one product. The MEErP EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

1.1.1.1.1 Materials extraction and production

The Bill of Materials (BoM) of the Base Case product has been selected based on the analysis of the information provided by stakeholders, completed with a number of qualified modelling assumptions. Thus, the BoM of the Base Case does not refer to a real product, but to a virtual product considered to represent as best as possible an average appliance in terms of technology and use.

To compile the BoM considered for the household washing machine Base Case, it is important to note that some materials are missing in the database available in the Ecoreport tool. Thus, the materials not included in the database have been allocated to similar existing material categories. The following assumptions were made:

- EPDM rubber has been considered as LDPE. This assumption was also done in Lot 14 (ENEA/ISIS 2007b). According to stakeholder feedback, the environmental impacts are not comparable to those of LDPE. However, this assumption is not considered to affect results considerably since rubber content in the product is much lower than other materials.
- Glass for the door / window complex has been considered as 'glass for lamps'. This approach was also followed in Lot 14 (ENEA/ISIS 2007b). According to stakeholder feedback, the environmental impact of this borosilicate / sodium glass is not comparable to glass for lamps. However, this assumption is not considered to affect results considerably since glass content in the product is much lower than other materials.
- POM has been considered as HDPE as this approach was chosen in Lot 14 (ENEA/ISIS 2007b). Contribution of POM to the BoM is marginal
- Electronic components have been considered as controller board.

An overview of the general material categories is provided in Table 5.2, comparing it to the composition of the household washing machine taken as Base Case in the 2007 preparatory study (ENEA/ISIS 2007b). A detailed BoM list including underlying manufacturing processes is provided in the Annex.

Table 5.2: BoM considered for the household washing machines Base Case; for comparison: BoM of Lot 14(ENEA/ISIS 2007b)

Component / Material	BoM (2015) Weight (g)	For comparison: BoM of Lot 14 (ENEA/ISIS 2007b)
Bulk Plastics	5,982	11,536
Technical Plastics	6,457	298
Ferrous metals	28,527	33,850
Non-ferrous metals	4,082	3,804
Electronics	225	172
Extra	66	0
Auxiliaries (detergents)	0	0
Refrigerant (only relevant for design options equipped with heat pumps)	0	0
Miscellaneous (mainly glass, concrete, paper and wood from packaging)	24,266	22,653
SUM	**69,603**	**72,313**

Compared to the Base Case used in the Ecodesign preparatory study of 2007 by (ENEA/ISIS 2007b) (cf. Task 4.2, Table 4.13), it can be observed that the total weight of the analysed 7-kg washing machine is lower compared to that 5-kg model of 2007. Compared to the BC inputs of 2007, the current Base Case has less ferrous materials, and instead slightly more non-ferrous and miscellaneous materials (which is for washing machines concrete, glass and packaging material), but overall the differences are small (<4%). A noticeable difference, however, is the larger share of technical plastics in 2015, and the lower share of bulk plastics. However, summing up these two categories, the total weight of plastics is comparable; indicating possibly differences in interpretation of the definitions of technical vs bulk plastics. It is not possible to draw general conclusions regarding the material composition change of washing machines from 2007 to 2015 since the differences found may be also due to the analysis of different models and input information, or different allocation of material categories.

QUESTIONS BOX: BoM FOR WM

1. Do you agree with the **assumptions made for materials missing** in the Ecoreport tool database? If not, could you either propose a material category which fits better or provide specific environmental impact data for those materials?
2. Can the Bill of Materials in Table 5-2 be sufficiently **representative for the Base Case** of Washing Machines?
3. For the current BoM there are **changes compared to 2007**; do you have an explanation of reasons for that (Material changes in today's WM compared to 2007 WM? Different models with different materials available, also today? Are there any other reasons?)

1.1.1.1.2 Manufacturing

For calculating the manufacturing of metals and plastics components, most of the inputs in the MEErP Ecoreport tool are fixed values on a weight basis. Specific weights per process are calculated automatically from the BOM section. The only variable that can be edited is the default 25% percentage of sheet metal scrap. As indicated in Task 4.2.2., Lot 14 (ENEA/ISIS 2007b) used 5% as input for the sheet metal scrap. Stakeholder feedback received on this issue indicates a range from negligible (0.18%) to

12.2%. For further calculation of the environmental impacts, an average value of **5% sheet metal scrap** will be taken.
The Ecoreport tool does not allow introducing energy consumption values for the manufacturing process of a WM. According to feedback from stakeholders, the energy consumption can for instance vary from 37.1 kWh/unit to 60.4 kWh/unit, depending on the extent of automation. Considering 220 cycles per year and a lifetime of 12.5 years, this would correspond to very small amounts of energy from a lifecycle perspective (2-3%). Based on this, no modifications to the Ecoreport tool have been applied.

5.1.1.2. WM: Distribution phase: volume of packaged product

This phase includes the distribution of the packaged product. According to the MEErP Methodology report (BIO Intelligence Service 2013), the section on Final Assembly and Distribution covers all activities from OEM (Original Equipment Manufacturer) components to the final customer. The only design variable, however, is the volume of the final (packaged) product; the impact then also depends on what type of product is concerned (selectable, if the analysed product is an ICT or Consumer Electronics product and/or an installed product).
According to Section 4.2.3 of Task 4, the average volume of the final packaged product is 0.447 m^3 for washing machines and 0.450 m^3 for washer-dryers. Given the similarity of both values and for convenience, for both washing machines the input is set to **0.450 m^3**.

5.1.1.3. WM: Use phase

To calculate the environmental impacts of the use phase, the average product service life in years has to be defined. For WM, according to Section 4.2.5.1 of Task 4, the first useful service life of WM which are replaced to a defect, i.e. corresponding to the technical product lifetime, is **12.5 years** (i.e. 2,750 cycles in case of 220 cycles per year). It is assumed that this average corresponds to the use of average machines, using an average mix of programmes (and not the standard programmes only).
For 'maintenance, repairs and service', in Lot 14 the travelling distance of maintenance and repair services over the product life of washing machines has been set to 160 km (ENEA/ISIS 2007b). As for the current Base Case it is assumed that only one repair will be done during the product's lifetime, it has been estimated that the travel distance for repair is **50 km** for the calculations.
The input parameter for the weight of spare parts is by default set at 1% of the total weight of the analysed product.
For the 'Real-life' Base Case WM, empirical data of current consumer behaviour has been taken as basis for the assumptions. For the reference Standard Data WM, the standard conditions are taken as well as the consumption values measured under standard conditions. For this reference, the 'average' loading is based on a weighted number of washing cycles (3 times full load 60°C, 2 times half load 60°C and 2 times half load 40°C), which leads to an average load of 5 kg for a washing machine with 7 kg rated capacity. For the 'Real-life' Base Case WM, consumer research shows that the average amount of load is only 3.4 kg/cycle (Kruschwitz et al. 2014). This is confirmed by the results of the 2015 user survey on 11 European countries, that show on average a load of 3.4 kg of laundry per cycle under real-life conditions (Alborzi et al. 2015). In a BC WM of 7 kg, this means 48.6% loading.
In a reference Standard Data WM, the calculation formula of the Annual Energy Consumption AE_C foresees by default 220 cycles per year, which is equivalent to wash 1,100 kg/yr (5 kg x 220 cycles/yr) of laundry per year in a 7 kg capacity washing machine (71.4% loading). The 2015 consumer survey (Alborzi et al. 2015) shows that in real-life the European average number of wash cycles has not significantly changed over the past years (4.4 cycles per week, i.e. 229 cycles per year). Based on this, the number of cycles has been kept to 220 also for the Base Case WM. In the BC, the annual load of laundry washed per year would be 220cycles/yr x 3.4kg = 748 kg per year.
During the use phase, household washing machines generally consume electricity in on-mode, low-power modes (e.g. delay-start, left-on mode) and off-mode (e.g. standby for the internal clock). In the reference Standard Data WM, energy consumption values include low-power and off-modes, as these are taken into account for the calculation of annual energy consumption AE_C and related Energy Efficiency Index EEI. However, the contribution of low-power and off-modes to the total energy consumption of washing

machines is very small (up to 2.5%). Following the standby regulation, the power management system switches the appliances to off-mode after 30 minutes, and requires thresholds of 0.5 W for the (standby) off-mode (cf. section 1.4.2.5 of Task 1). The same considerations have been made also for the 'Real-life' Base Case WM.

Apart from electricity, WM consume also water, and detergents to remove soiling from the clothes. This forms a wastewater stream that flows to the sewage systems.

According to the results from consumer surveys reported in Task 3, consumers use regularly a mix of programmes, and do not preferably choose the 'standard' cotton 40/60°C programmes, for different reasons. The standard cotton 40°C and 60°C programmes represent 10% and 7% of all chosen cycles respectively (Alborzi et al. 2015). To wash cotton textiles, 'normal' cotton programmes are also selected: 15% for the normal cotton 40°C programme and 11% for the normal cotton 60°C programme (Alborzi et al. 2015). The normal programmes may currently reach higher temperatures and have shorter duration than the standard programmes, but would consume more energy and water than the standard programmes, as they are not optimised to energy efficiency. Besides the cotton programmes, also other programmes are used by consumers, as the following results of the 2015 consumer survey on washing machines show (Alborzi et al. 2015).

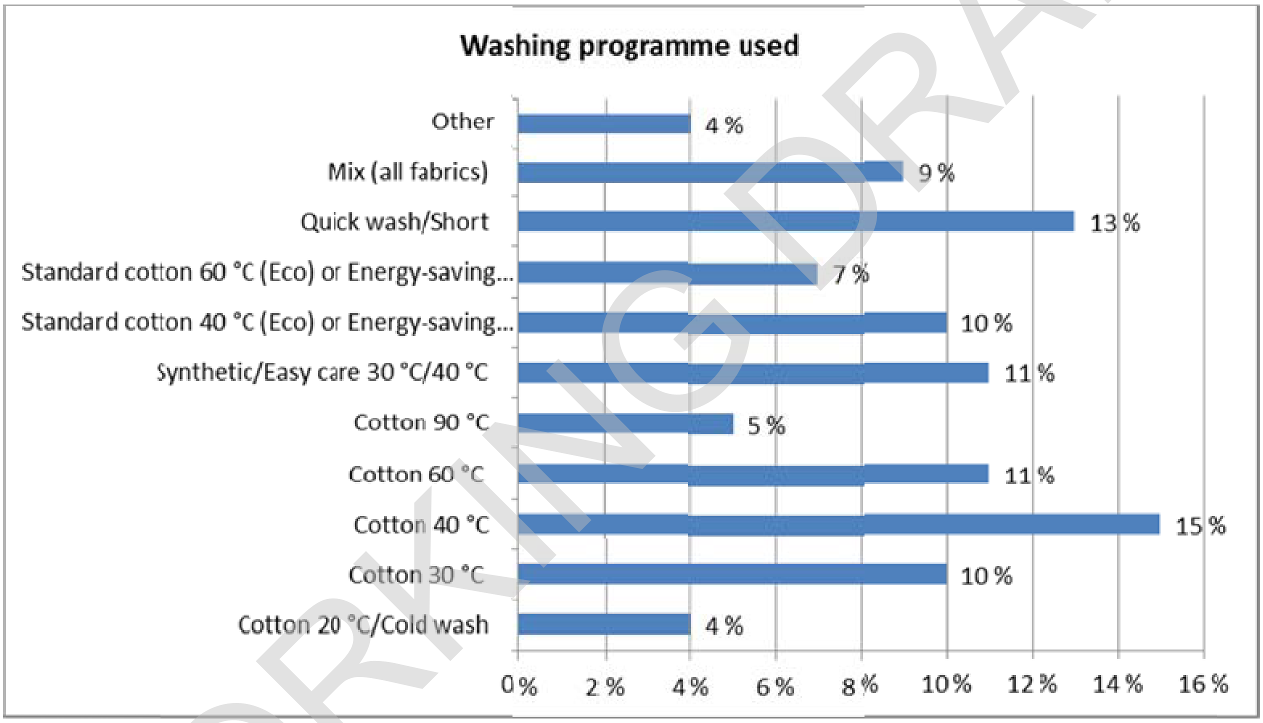

Figure 5.1: Washing behaviour of European consumers 2015, washing programmes used (source:(Alborzi et al. 2015))

Consumption values for typical programmes offered in washing machines have been gathered from manufacturers, and from user manuals of the most sold machine models. Information has been analysed and elaborated to estimate average consumption values, as shown in Table 5.3. The data presented cover 95% of the wash cycles selected. However, it has to be mentioned that, except values for standard cotton programmes, data are self-disclosed by manufacturers, and are thus not necessarily based on standard measurement methods, and only provide indications on the expected consumption values.

The energy consumption values of standard cotton programmes are provided in conditions of overload if compared to the average amount of laundry for real-life (e.g. base case, 3.4 kg). Loading is instead comparable in real life and self-declarations for other programmes such as 'Quick', 'Synthetic/easy care 30/40°C' and 'Mix' programmes. A correction factor for loading has been estimated for each programme, based on the model provided in (Lasic et al. 2015), and has been applied to those programmes where there is significant difference between standard references (or self-declarations) and real-life loading (cf. Table 5.4).

Based on the assumptions listed above, a **weighted average energy consumption of 0.713 kWh/cycle** and **water consumption of 42.9 litres/cycle** has been calculated for the **'Real life' BC WM**.

Table 5.3: Estimated consumption values for different washing programmes used in the Base Case modelling and real-life frequency of use (Sources: (Alborzi et al. 2015) and own elaboration based on data collected from manufacturers and user manuals)

Parameter	Share of use (%)	Energy Consumption (kWh/cycle)			Water consumption (L/cycle)			Programme Duration (minutes/cycle)			Average loading conditions (kg)		Comments / sources
		av.	min	max	av.	min	max	av.	min	max	Reference	'Real life'	
Standard cotton 40°/60° programmes	17%	0.84	N.A.	N.A.	45	N.A.	N.A.		N.A.	N.A.	5	3.4	
Normal 40°/60° cotton programmes (average deviation compared to standard ones)	26%	+63%	+45%	+79%	+11%	+2%	+18%	-28%	-48%	-13%	5	3.4	Based on 4 models of different size
		+42.3%	+1.1%	+101%	+23.1 %	+0%	+69.2%	N.A.	N.A.	N.A.	5	3.4	Based on 50 tested models tested in the Atlete II project
Quick/Short programme	13%	0.27	0.2	0.34	40	30	50	25	20	30	3.5	3.4	Based on 2 models working with 3.5 kg rated capacity
Synthetic/easy care 30/40°C	11%	0.44	0.43	0.45	59.3	53.5	62.7	103	94	110	3.5	3.4	Based on 3 models of 7 kg (3.5 kg for this programme)
Cotton 30°C	10%	0.43	N.A.	N.A.	52.9	N.A.	N.A.	131	N.A.	N.A.	7	3.4	Estimation from 2 data points for 7/8 kg machines
Mix	9%	0.60	N.A.	N.A.	45.0	N.A.	N.A.	45	N.A.	N.A.	3.5	3.4	Based on 1 model of 7 kg (3.5 kg for this programme, same values for a 8 kg model)
Cotton 90°C	5%	2.23	2.20	2.26	82.5	75.0	90.0	168	165	170	7	3.4	Based on 3 models of 7 kg
Cotton 20°C	4%	0.21	0.16	0.25	61.0	42.0	80.0	140	114	165	7	3.4	Based on 3 models of 7 kg
Other programmes	5%	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	3.4	No information available

Table 5.4: Estimated correction factors for the consumption values of different cotton programmes operating in underloading conditions and used in the Base Case modelling (source: own elaboration based on (Lasic et al. 2015))

Programme	Load (kg)	Rated capacity (kg)	Temp (°C)	time (min)	Water cons.		Energy cons.			
					L/cycle	Correction factor	kWh/cycle	Correction factor	kWh/kg	Correction factor
Average of standard cotton 40/60°C programmes	5	7	34	171	56.3		1.607		0.321	
	3.4	7	34	137	46.6	83%	1.376	76%	0.405	126%
Average of normal cotton 40/60°C programmes	5	7	49	123	56.3		1.773		0.355	
	3.4	7	49	98	46.6	83%	1.541	84%	0.4534	128%
Cotton 20°C programme	7	7	20	140	68.3		1.534		0.219	
	3.4	7	20	140	46.6	68%	1.012	59%	0.298	136%
Cotton 30°C programme	7	7	30	131	68.3		1.711		0.2445	
	3.4	7	30	131	46.6	68%	1.190	72%	0.350	143%
Cotton 90°C programme	7	7	90	168	68.3		3.004		0.429	
	3.4	7	90	134	46.6	68%	2.482	87%	0.730	170%
Note: No correction factor has been applied to 'Quick', 'Synthetic/easy care 30/40°C' and 'mix' programmes, as the loading used for the provision of data (3.5kg) is nearly the same as the BC loading (3.4kg)										

In the measurement standard for testing the performance of washing machines, the detergent consumption is determined based on the machine's average loading. For the BC WM, an average dosage of 75 g of solid detergent per cycle has been assumed, based on research results of Tasks 1 and 3. In case of liquid detergents, 75 mL per cycle would be used. This includes the experience that people in practice do not use the full loading potential of the WMs, despite larger capacity, and thus do not adapt significantly their usual dosage behaviour to the larger capacities.
In the Ecoreport tool, only a dataset of environmental unit indicators for dishwashing detergents is included. This has been adapted to washing machines by modifying those indicators for which specific unit values for washing detergents were definable based on (Blepp & Gensch 2013). For the other indicators, still the default values for dishwashing detergents are taken (cf. Table 5.5). Additional auxiliaries such as fabric softeners or bleaching agents have not been taken into account due to missing input data. They would further increase the environmental impacts caused by consumables; however, an analysis of such effects is out of the scope of the present study.

Table 5.5: Environmental unit indicators considered for washing detergents

Indicator	Unit	Value	Source
Primary Energy	MJ	42.03	Blepp & Gensch 2013
Electrical energy	MJ	0.00	Dishwashing detergents in Ecoreport
Feedstock energy	MJ	0.00	Dishwashing detergents in Ecoreport
Process Water	L	0.76	Dishwashing detergents in Ecoreport
Cooling Water	L	0.00	Dishwashing detergents in Ecoreport
Hazardous Waste	g	0.74	Dishwashing detergents in Ecoreport
Non-hazardous Waste	g	37.10	Dishwashing detergents in Ecoreport
Global Warming Potential	kg CO2 eq.	1.89	Blepp & Gensch 2013
Acidification	g SO2 eq.	8.92	Blepp & Gensch 2013
Volatile Organic Compounds	mg	0.01	Dishwashing detergents in Ecoreport
Persistent Organic Pollutants	ng i-Teq	0.21	Dishwashing detergents in Ecoreport
Heavy metals (to air)	mg Ni eq.	0.00	Dishwashing detergents in Ecoreport
Polycyclic Aromatic Hydrocarbons	mg Ni eq.	0.06	Dishwashing detergents in Ecoreport
Particulate Matter	g	0.18	Dishwashing detergents in Ecoreport
Heavy Metals (to water)	mg Hg/20	0.21	Dishwashing detergents in Ecoreport
Eutrophication	mg PO4	1256.38	Blepp & Gensch 2013

The BC does not contain heat pump technology, and therefore refrigerants are not part of the BoM used in the Ecoreport of the Base Case. However, HP technology is one of the design options, cf. section 6.1, and the impact of this in the BoM, environmental impact and EoL is analysed there.

QUESTIONS BOX: KEY ASSUMPTIONS FOR WM

1. Do you agree with the input value of **50 km for travel distance for repairs** per lifetime?
2. Do you consider the **characterisation of programmes reported in Table 5-3** be representative of typical uses of average products? If not, which modifications would you apply?
3. Do you think the **correction factors in Table 5-4**, introduced to take into account for underloading conditions compared to standard references / self-declarations, reflects the real-life situation well enough? If not, how would you propose to modify them?
4. To your knowledge or experience, is the assumption of an **average dosage of 75 g of solid detergent per cycle, or 75 ml if liquid detergents** are taken, corresponding to a real-life dosage?
5. In Table 5-5 some environmental unit indicators for washing detergents have been adapted from those reported in Ecoreport tool database for dishwashing detergents (because of missing data). Do you think that these data can provide an indication about the environmental unit indicators for washing detergents or are you aware of any further significant modification that should be applied?

5.1.1.1. WM: Comparison of the 'Real life' Base Case WM with alternative scenarios of use

The 'Real-life' Base Case WM can be compared to the theoretical situation in which only the standard programmes are used in a washing machine (Standard Data WM). As comparison basis, 220 cycles per year have been considered for both analysis scenarios. The underlying assumption is that consumers wash a certain number of cycles per week, and do not strive to wash a certain amount of laundry (most consumers even do not know the weight of their wash load). This comparison would illustrate the theoretical maximum saving potential per kilogram of laundry washed if washing machines were only equipped with the standard cotton 40°C and 60°C programmes, as reported in the Energy Label. Inbetween those extremes is an 'adapted BC' scenario where the normal cotton 40/60°C of the programme mix used in the Real-life Base Case are fully replaced by the standard cotton 40/60° programmes, and keeping the use pattern of the remaining programmes (mix, short, etc.) as in the Base Case. This would better reflect the theoretical saving potential due to the use of the standard programmes.
As reported above, for the 'Real life' BC WM a weighted average consumption of 0.713 kWh and 42.9 litres of water per cycle has been calculated. For the 'Adapted' Base Case WM, energy and water consumption values per cycle are respectively **20%** and **3% lower** than those corresponding to the 'Real life' BC WM.
In both Base cases above, data is available for 95% of the programmes used. The available data has been scaled up as to represent 100% of the total.
The hypothetical scenario of a WM only equipped with standard cotton programmes only has been also calculated. In such case, energy and water consumption values per cycle are respectively **18% and 5% higher** of those corresponding to the 'Real life' BC WM. This can be explained by the fact that

1. The programme portfolio of the 'Real life' BC WM includes programmes (e.g. short, delicate, easy care, synthetic, mix, cold cotton wash) that consume less energy and water compared to the cotton standard programmes.
2. The two scenarios refer to different loading conditions: 220 cycles per year and 5 kg of laundry washed per cycle in the Standard Data WM vs. 220 cycles per year and 3.4 kg of laundry washed per cycle in the 'Real life' BC WM. The Standard Data WM thus refers to a situation in which the appliance works with a higher amount of laundry, which necessarily implies higher demand for water and energy.

Referring the energy and water consumption values above to the same amount of laundry washed, it results that:

- The **'Real life' BC WM** consumes **0.210 kWh/kg and 12.6 L/kg**
- The **'Adapted' BC WM** consumes **0.168 kWh/kg (-20%) and 12.3 L/kg (-3%)**
- The '**Standard Data' WM** consumes **0.168 kWh/kg (-20%) and 9 L/kg (-29%).**

All in all, this highlights the differences between operation of WM under standard and real life conditions, and the potential savings in loading WMs closer to their maximum capacity as far as possible.

Table 5.6: Differences of parameters between the Real life Base Case and alternative scenarios of use (Extract and further elaboration of Table 5.1)

	Standard Data WM	**Real-life BC**	**Adapted BC**
Average loading (kg/cycle)	5	3.4	3.4
Number of cycles per year	220	220	220
Total amount of load washed per year (kg)	1,100	748	748
Energy consumption wash (kWh/cycle) (kWh/kg average load)	0.84 (average standard programme) 0.168	0.713 0.210	0.573 0.168
Water consumption (L/cycle) (L/kg average load)	45 (average standard programme) 9	42.9 12.6	41.7 12.3
Detergent (solid or liquid) consumption (g or ml per cycle) (g/kg average load)	100 g, solid 20	75 g, solid (75 ml for liquid) 22	75 g, solid (75 ml for liquid) 22
Average cycle time (min)	171	112	126

QUESTIONS BOX: SCENARIOS OF USE FOR WM

1. Do you agree with the **approach proposed** comparing different scenarios of use?

5.1.1.4. WM: End-of-Life phase (disposal and recycling)

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials and this is modelled in EcoReport tool as credits (avoided impacts), i.e. negative impacts.
The 'product (stock) life', i.e. the period between the WM purchase and discard, has been assumed to be 12.5 years. This is the same as for the product service life, i.e. the period that the product is in use and operational, because for WM it is assumed that consumers do not keep the product stocked before they decide to throw it away. The same assumption is applied to washer-dryers (cf. section 5.1.2.4).
The current fraction of materials contained in appliances on the market has been characterised based on the material shares of the current BoM. For the fraction of products manufactured in the past, the share of material inputs is taken from the BoM of Lot 14. Table 5.7 shows the comparison, once without and as well including detergents as auxiliaries, as asked for in the 'Disposal & Recycling' section of the Ecoreport tool. It can be seen that the fraction of materials of household washing machines about 10 years ago slightly differs to that of today's washing machines. However, it has to be noted that this effect might also be caused by the different data sources and their underlying assumptions and inputs. For washer-dryers, no data on material fractions of these appliances about 10 years ago is available.

Table 5.7: Comparison of the current share of materials in household washing machines with former fractions

Materials	Current fraction, in % of total mass	Fraction x years ago, in % of total mass	Current fraction, in % of total mass	Fraction x years ago, in % of total mass
	Without detergents		With detergents	
Bulk Plastics	8.6%	16.0%	2.2%	2.6%
Tec Plastics	9.3%	0.4%	2.3%	0.1%
Ferrous	40.9%	46.8%	10.3%	7.6%
Non-ferrous	5.9%	5.3%	1.5%	0.9%
Coating	---	---	---	---
Electronics	0.3%	0.2%	0.1%	0.0%
Misc.	34.9%	31.3%	8.8%	5.1%
Extra	0.1%	---	0.02%	---
Auxiliaries (detergents)	---	---	74.8%	83.7%
Refrigerant	---	---	---	---

Further, the Ecoreport tool requires input on the destination of the EoL available mass over 5 fractions: re-use, recycling (material), recovery (heat), incineration and landfill/missing/fugitive. For metals, the credit is already taken into account on the basis of the given fixed percentages (94% recycling, 5% landfill, and 1% reuse). For the other materials, the default values can be edited which has been done by own expert judgement. The following input parameters are used for washing machines and washer-dryers, taking into account that the European collection rates for washing machines and washer-dryers is still less than 100%, thus a share of appliances at their end will not be fed into proper EoL treatment (i.e. higher proportion of EoL mass fraction to landfill/missing/fugitive, whereas in case of higher collection rates followed by proper EoL treatment the recycling and recovery rates would be higher):

- Miscellaneous: for washing machines and washer-dryers, this category covers mainly glass (from the door), concrete (as counterbalance weight), as well as paper and wood from the packaging. According to Task 4 section 4.2.6.2, glass is assumed to be going either to recycling or landfill, and concrete – the main share per weight of this category – is disposed together with inert construction and demolition waste. Wood, paper and cardboard are recycled. The default values of the Ecoreport tool have been adapted as follows: 10% material recycling instead of 64%, 88% landfill instead of 29% due to the large share of concrete and glass, 0% incineration without energy recovery instead of 5%; reuse and heat recovery (each 1%) remain unchanged.

- Refrigerants (only relevant for design options with heat pumps): If collected, refrigerants will be incinerated; else they will escape to the atmosphere. Thus, the default values of the Ecoreport tool have been adapted as follows: 0% recycling instead of 30%, 35% incineration without energy recovery instead of 5%; 64% fugitive, 1% reuse and 0% heat recovery.

- Auxiliaries: For washing machines, only detergents are subsumed under this category. As consumables, they are not undergoing any reuse, recycling or recovery process at their end of life but go with the wastewater to the respective treatment/discharge; thus, the default values in this Ecoreport 'Disposal & Recycling' section have been changed to 100% fugitive accordingly.

- Re-use, Plastics, Metals, Electronics, Extra: For these fractions, the default values of the Ecoreport tool have been taken.

Two important parameters for the modelling are the recycled content and recyclability of materials. The recycled content is the proportion of material input to the production process that has been recycled in a previous system. The recyclability rate is the proportion of a certain material in the product that will be

recycled in a subsequent system. This takes into account any inefficiency in the collection and recycling processes (Allacker et al. 2014).
The Ecoreport tool requires to define qualitatively the 'EoL recyclability'. This relates to the potential of the new products to change the course of the materials flows, e.g. due to faster pre-disassembly or other ways to bring about less contamination of the mass to be recycled. Therefore it is economically likely that the recycled mass at EoL will displace more virgin material in other applications. The recyclability does not influence the mass balance but it does give a reduction or increase up to 10% on all impacts of the recycled mass. It is forward looking, e.g. values different from 'avg' (=base case) might only be filled in for certain design options.
For the definition of the Base Case, an **average recyclability** of the fractions is chosen.

Table 5.8: Destination of the EoL available mass over 5 fractions: re-use, recycling (material), recovery (heat), incineration and landfill/missing/fugitive

	Bulk Plastics	Tec Plastics	Ferrous	Non-ferrous	Coating	Electronics	Misc. , excluding refrigerant & Hg	Refrigerant	Hg (mercury), in mg/unit	Extra	Auxiliaries
EoL mass fraction to re-use, in %						1%			1%		0%
EoL mass fraction to (materials) recycling, in %	29%	29%		94%		50%	10%	0%	39%	60%	0%
EoL mass fraction to (heat) recovery, in %	15%	15%		0%		0%	1%	0%	0%	0%	0%
EoL mass fraction to non-recovery, incineration, in %	22%	22%		0%		30%	0%	35%	5%	10%	0%
EoL mass fraction to landfill/missing/fugitive, in %	33%	33%		5%		19%	88%	64%	55%	29%	100%
TOTAL	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*
EoL recyclability	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg

QUESTIONS BOX: EoL OF WM
1. To your knowledge or experience, do you agree with the **adaptions made to the default values** for miscellaneous, refrigerants and auxiliaries of the Ecoreport tool in order to better reflect the specific EoL situation of the WM fractions?

5.1.2. Base Case for washer-dryers

The following Base Case has been identified and chosen to further assess the environmental and economic impacts over the life cycle of washer-dryers:

- Base Case WD: Household washer-dryer with a nominal rated capacity of 7 kg and a water based condensation system.

The washing function of WD is assumed identical to the WM, both in terms of technology and use. Thus, an average loading of 3.4 kg and 220 cycles per year are assumed.
The 2015 user survey on WD (Stamminger, R. et al. 2015, unpublished) has relevant information for the estimation of the drying and washing-drying functions of the WD BC:
Washer-dryers are used on average 4.6 times per week. In 63% of those cases (2.9 times per week), the clothes are then dried in the WD, either in continuous wash+dry operation (1.5 times per week, i.e. 32.6% of the washes), or with a time gap (1.4 times per week, 30.4% of the washes) after washing. In the rest of cases (37% of cycles), other methods for drying are used, e.g. a clothes line, i.e. the WD is used purely as a WM.
Additionally, this study has relevant estimates on the energy and water consumption of the wash+dry and the dry-only functions:

Table 5.9: Estimation of consumption values for WD, adapted from (Stamminger, R. et al. 2015, unpublished)

	Loading	Energy use (kWh/cycle)	Water use (L/cyle)
Drying only	7 kg – Cupboard dry	4.28	48
	3.5 kg – Ironing dry	2	20
Wash+dry	5 kg – Cupboard dry	1.0+3.1=4.1	45+35=80
	2.5 kg – Ironing dry	0.8+1.6=2.4	30+15=45

The estimations of the table include:

- Drying energy is proportional to load (weight).
- Half load washing reduces energy consumption by 20% on average.
- Iron dry compared to cupboard dry saves 10% of energy.
- 3 l are needed for the flushing of the filters in drying.

The data in Table 5.9 seems comparable with the data received from manufacturers in response to JRC questionnaires. Table 5.10 provides the detailed performance characteristics chosen for the washer-dryer Base Case including the respective underlying sources and assumptions.

Table 5.10: Performance characteristics of the chosen Base Case for washer-dryers

	BC WD	Source
Washing nominal capacity / real load (kg)	Nominal: 7 Real: 3.4	Cf. Task 2, figures 2-34 and 2-35, most (around 35%) WD models in 2013 had 7 kg washing capacity. The real loading for washing has been considered the same as for WM.
Drying nominal / real loading (kg)	Nominal: 5 Real: 2.1 (normalised to 220 wash cycles)	Cf. Task 2, figures 2-34 and 2-36, most (< 30%) WD models in 2013 had 5 kg drying capacity According the results of the 2015 user survey, 63% of the cycles run on a WD yearly (239.2 according to the survey) include washing and drying, be it in continuous form (32.6%) or separated by a time gap (30.4%). Normalised to operation of 220 wash cycles yearly, this means a load of 2.1 kg per cycle (1.1 for continuous, and 1 kg for elapsed in time).
Number of wash cycles	220	Normalised to match the number of washing cycles. According to the 2015 survey covering UK, IT, FR and DE, the average number of cycles is 239.2 cycles/yr)
Number of drying cycles	Dry only: 72 Wash & Dry: 67	In 63% of the wash cycles, clothes are then dried in the WD, either in continuous wash+dry operation (32.6% of the washes) or with a time gap (30.4% of the washes) after washing. In the rest of cases (37% of cycles), other methods for drying are used, e.g. a clothes line, i.e. the WD is used purely as a WM.
Manufacturing cost (in €)	212	Assumption: costs are twice those of WM, as the retailer purchase prices are also ca. twice for WD than for WM (based on the analysis of the first Top19 sales on a number of retailers, e.g. Mediamarkt, Saturn)
Purchase price for the customer (in €)	826	The retailer purchase prices are ca. twice for WD than for WM (based on the analysis of the first Top19 sales on a number of retailers, e.g. Mediamarkt, Saturn)
Repair and maintenance costs (in €)	45	Assumption: same costs as for WM, cf. Table 5.1
Energy consumption - wash only	0.713	Consumption value of the 'Real life' Base Case WM The value is comparable to that from the data provided by manufacturers for most sold models of washer-dryers (6-8 kg rated

	BC WD	Source
(kWh/cycle)		washed capacity).
Energy consumption - drying only (kWh/kg)	0.59	Average consumption values have been estimated from Table 5.9, as follows: • 2 kWh/cycle for 3.5 kg – iron dry • 4.28 kWh/cycle for 7 kg – cupboard dry On average, 0.59 kWh are consumed to dry 1 kg of laundry (1 kg dried per total number of wash cycles)
Energy consumption - wash & dry (kWh/kg)	0.89	Average consumption values have been estimated from Table 5.9, as follows • 2.4 kWh/cycle for 2.5 kg – iron dry • 4.1 kWh/cycle for 5 kg – cupboard dry On average, 0.89 kWh are consumed to wash and dry 1 kg of laundry (1.1 kg dried per total number of wash cycles)
Water consumption - wash only (L/cycle)	42.9	Consumption value of the 'Real life' Base Case WM The value is comparable to that from the data provided by manufacturers for most sold models of washer-dryers (6-8 kg rated washed capacity).
Water consumption - drying only (L/kg)	6.29	Average consumption values have been estimated from Table 5.9, as follows • 20 L/cycle for 3.5 kg – iron dry • 40 L/cycle for 7 kg – cupboard dry On average, 6.29 L of water are consumed to dry 1 kg of laundry (1 kg per total number of wash cycle). Water is consumed in drying for direct contact or heat exchange water-air condensation, and for fluff flushing. Air condensation, HP or air venting technologies may thus not use water for drying.
Water consumption - wash & dry	17 L/kg	Average consumption values have been estimated from Table 5.9, as follows • 45 L/cycle for 2.5 kg – iron dry • 80 L/cycle for 5 kg – cupboard dry On average, 17 L are consumed to wash and dry 1 kg of laundry (1.1 kg dried per total number of wash cycles)
Average consumption of WD	Energy: 2.07 kWh/cycle Water: 54.4 L/cycle	Virtual machine that operates 220 cycles/yr on a weighted average (based on user survey results) of the three functions: washing only with drying elsewhere (37% of cycles), continuous wash+dry (32.6%), and interrupted wash + dry (30.2%). Contribution from washing estimated to be • 34% for energy • 76% for water
Detergent consumption (g/cycle)	75 g, solid (or 75 ml, liquid	Same as Real-life BC WM Fixed detergent consumption in standard testing method
Washing performance class	A	Cf. Task 2, figure 2-46: >95% of 2013 EU WD models
Maximum spin speed (rpm)	1400	Cf. Task 2, figures 2-47 to 2-49: average of 2013 EU WD models

	BC WD	Source
Noise washing/ spinning/drying (dB(A))	55/76/62	Cf. Task 2, figure 2-53: average of 2013 EU WD models
Cycle time wash (min)	112	Calculated from data provided by manufacturers for most sold models of washer-dryers (6-8 kg rated washed capacity). Values adapted to 7 kg washing capacity. Most used programmes for washing machines considered. Calculated value is comparable to that for the real BC
Cycle time wash + dry (min)	290 (wash ~112 / dry ~180)	Stiftung Warentest, test 10/2012; split of cycle time on wash / dry programme: own assumption
Lifetime (years); calculation basis	12.5	General assumption: same lifetime as for WM

QUESTIONS BOX: KEY ASSUMPTIONS FOR WD

1. To your knowledge or experience, do the **consumption values estimated for WD** and reported in Table 5-9 well reflect the real loading, energy and water use of the different programmes?
2. Do you agree with the **underlying assumptions of drying energy?**

   – drying energy proportional to load (weight),
   - half load washing reduces energy consumption by 20% on average,
   - 'iron dry' saving 10% of energy compared to 'cupboard dry', and
   - 3 L of water are needed for the flushing of the filters in drying
3. Do you agree with the a**pproach for the estimation of the energy and water consumption of the Base Case WD**, described in Table 5-10?

5.1.2.1. WD: Raw materials use and manufacturing of the products: Bill Of Materials (BoM)

The Bill of Materials (BoM) of the Base Case product has been selected based on the analysis of the information provided by stakeholders, completed with few qualified modelling assumptions. It was assumed that plastics and metals have around 7% higher share in WD, whereas electronics, glass and concrete, as well as the packaging remain unchanged compared to the current Base Case of washing machines. Thus, the BoM of the Base Case as provided in Table 5.11 does not refer to a real product, but to a virtual product considered to represent as best as possible an average appliance in terms of technology and use.

In the Ecodesign preparatory study of 2007 by (ENEA/ISIS 2007b), no Base Case for washer-dryers was analysed, so that no changes over the past years can be analysed.

Table 5.11: BoM considered for the household washer-dryers Base Case WD

Component / Material	BoM (2015) Weight (g)
Bulk Plastics	6,393
Technical Plastics	6,954
Ferrous metals	30,724
Non-ferrous metals	4,396
Electronics	225
Extra	66

Component / Material	BoM (2015) Weight (g)
Auxiliaries (detergents)	0
Refrigerant (only relevant for design options equipped with heat pumps)	0
Miscellaneous (mainly glass, concrete, paper and wood from packaging)	24,266
SUM	**73,023**

QUESTIONS BOX: BOM FOR WD
1. Can the Bill of Material in Table 5-2 be considered enough **representative for the Base Case of Washer-dryers**, also in comparison to the Base Case Washing machine?
2. Are any relevant **materials missing** compared to WM?

5.1.2.2. WD: Distribution phase: volume of packaged product

For the distribution phase of washer-dryers, the same assumptions as for washing machines have been applied (cf. section 5.1.1.2).

5.1.2.3. WD: Use phase

For some input parameters of the use phase, the same assumptions as for washing machines have been taken (cf. section 5.1.1.3 for details):

- Average product service life: **12.5 years**
- Travel distance for maintenance, repairs and service: **50 km**.
- Weight of spare parts: fixed at 1% of the total weight of the analysed product.

During their use phase, household washer-dryers generally consume electricity in on-mode, standby-mode and off-mode, as well as consumables (water, detergents). The specific input parameters for the use phase are listed in Table 5.10. For the electricity consumption, aggregated annual energy consumption per year has been chosen for the Base Case, as standby and off-mode are of minor relevance for the total energy consumption of WD (cf. section 1.4.2.5 of Task 1). Refrigerants as used in heat pump appliances are not taken into account for the Base Case; however, they are possible design options of the BC, cf. section 6.1.

5.1.2.4. WD: End-of-Life phase (disposal and recycling)

For the EoL phase of washer-dryers, the same assumptions as for washing machines have been applied (cf. section 0).

5.1.3. Life Cycle Cost (LCC) inputs for washing machines and washer-dryers

Average market and consumer expenditure data have been mainly derived from the analysis of the information reported in Task 2.
Regarding **stock** data, (VHK 2014) assumes for the year 2015 a stock of **196.8 million units of washing machines** (cf. Task 2, Table 2.8). This figure fits well with the approximate 213 million households in EU-28 in 2011 (Eurostat 2011), combined with an average EU household penetration rate of 92% of washing machines in 2013 (cf. Task 2.2.3.2), resulting in around 196 million units. For washer-dryers, the average EU penetration rate is assumed to be around 4% (cf. Task 2.2.3.2), which would result in a stock of around **8.56 million washer-dryers**.
For **sales** data, (VHK 2014) projected annual sales for 2015 of around 13 million units. According to (Michel et al. 2015) based on GfK data, annual sales have been 15.2 million units in 2014 for EU-21 which covers all EU Member States expect Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Luxembourg and

Malta which together represent only 3% of all European households (Eurostat 2011). Adding these missing 3% to the GfK sales data for EU-21, for EU-28 the sales would be approximately 15.7 million units. The ratio between stock and sales of washing machines in 2015 is 12.5 (yr), which is the average lifetime estimated, meaning that the number of sold and replaced appliances matches.

If one is to estimate the evolution of sales on a saturated market, if the variables above are constant, the sales shall be the same year after year. However, several reasons may cause the sales to change from year to year, including increase/decrease of the lifetime of appliances, or change in the number of households. In the EU, the size of households decreases gradually, and with a stable population this results in a gradual increase of the number of households, about 4% from 2010 to 2030) (European Environment Agency 2005).

According to stakeholder feedback (cf. Task 2, section 2.2.3.3), in 2013 the sales of washing machines were around 25 million units. However, this number seems to be too high since the stock in 2030 would be 66% higher considering a replacement of 15.7 million units per year.

Assuming that the market of washing machines is nearly saturated and that the number of households in 2030 is 4% higher than in 2015, the stock of washing machines in 2030 would be 204.7 million of units. Annual sales are calculated in order to compensate the replacement of old or defective appliances (15.7 million units per year in 2015, 16.0 million as average for the period 2015-2030) and increase the stock according to the assumptions made (0.5 million units per year for the period 2015-2030).

Based on the information above, an average of **16.6 million washing machines sales** per year is taken for further calculations.

For the unit sales 12.5 years ago (i.e. corresponding to the current product lifetime), (VHK 2014) indicated 9 million units sold in 1990 and 13.099 million units sold in 2010; Lot 14 calculated 9.5 million units sold in 2007. For further calculations, **11.6 million units are taken as sales 12.5 years ago** (calculated as interpolation of VHK data).

For **washer-dryers**, according to stakeholder feedback (cf. Task 2, section 2.2.3.3.), sales were around 1 million units in 2013. **1 million units of washer-dryers** are considered to be sold in 2015 and to increase by 4% from 2010 to 2030 due to an increase of the number of households in Europe, in analogy with washing machines. The number of units replaced can be instead estimated as the ratio between stock and lifetime (i.e. only 0.68 million per year in 2015). This would mean an increase of penetration rate and stock for this product, trend which is in alignment with the findings of Task 2. Based on these assumptions, the stock would increase by 35% from 2015 to 2030, for a penetration rate of about 5% in 2030 (compared to the current 4%). These preliminary estimations will be checked and adapted if new data is available. No data is available for the unit sales of washer-dryers 12.5 years ago (i.e. corresponding to the current product lifetime). Assuming that sales of washer-dryers are proportional to washing machines, **0.7 million units of washer-dryers are taken as sales 12.5 years ago**.

The average **sales price** in 2014 for 7 kg washing machines (the capacity of the chosen WM Base Case) was 413 Euro according to (Michel et al. 2015). According to GfK data for 14 Western European countries, the average price per unit was 434 Euro in 2012 with an overall declining trend over the past years (cf. Task 2, section 2.3.1). According to stakeholder feedback (cf. Task 2, section 2.2.3.3), in 2013 the average sales price of *all* machines was around 220 Euro per unit, however, as this value is quite far from other market data on sales prices, it is assumed that this value does not refer to the final sales price for the consumer. Based on this information, an approximate **purchase price of 413 Euro/WM** is taken for further calculations, assuming VAT is included. Research on washer-dryers indicates purchase prices of washer-dryers are approximately the double than of washing machines. Thus, a **purchase price of 826 Euro/WD** is estimated, VAT included.

Installation costs for consumers are in most cases included in the price of the machine. Only in some countries an authorised installer is required. For **maintenance and repair costs**, assuming that about 30% of all washing machines are repaired once in their lifetime and the cost of the repair amounts to 150 € (Prakash et al. unpublished), the repair cost for all washing machines can be set at **45 € per product service life** of 12.5 years VAT included. The same is assumed to be valid for washer-dryers

Electricity prices: according to (Eurostat 2015), the EU-28 average electricity price for households was **0.208 Euro/kWh** in 2014 (including taxes, levies and VAT). The electricity prices vary between Member

States by a factor of three: the highest prices are found in Denmark (0.304 Euro/kWh) and Germany (0,297 Euro/kWh), whereas the lowest prices are found in Bulgaria (0.090 Euro/kWh) and Hungary (0.115 Euro/kWh). High prices are also registered in Spain (0.237 Euro/kWh) and Italy (0.234 Euro/kWh), while France (0.175 Euro/kWh) and the UK (0.201 Euro/kWh) have a medium price level.

Regarding **water prices**, (European Environment Agency 2003) states that there are wide variations in water charges within individual countries, and between different countries in Europe. This is because of the wide range of factors that determine local water prices, and whether there is a full recovery of costs, including those for water treatment and supply, for sewage treatment and for environmental damage. (COWI and VHK 2011) proposed taking 3.70 Euro/m^3 as European average for the year 2011. (COWI and VHK 2011) also proposed long-term growth rates for electricity rates (5%) and water rates (2.5%). Applying the growth factor of 2.5% to deviate the current water rate from the 2011 costs, in 2014 the water rate would be **3.98 Euro/m^3**.

For **detergents**, according to stakeholder feedback it is rather difficult to derive statistical average costs in Europe as there are many variations in the kind of detergents (powder, compact, liquids, heavy duty detergents, colour detergents, etc.) and different price levels within the Member States. Task 2, section 2.3.2 indicates a range between 0.11 Euro and 0.32 Euro per cycle for compact solid laundry detergents in Germany. For the further calculations, an intermediate value of 0.20 Euro/cycle is taken for both washing machines and washer-dryers. Assuming a dosage of 75 g per cycle, the average costs for detergent would be **2.67 Euro/kg**.

The price of 0.20 Euro/cycle is comparable with an estimation provided by the detergency industry association (A.I.S.E / Insites 2014, personal communication 2015): 0.23 Euro/cycle (+15%), obtained by dividing the total annual turnover value (8,155,800 thousands euros, irrespective of the product form) by the total number of washes in the EU-28 per year (considered to be 34,284,338,400).

Industry also provided indications about the cost variation for different types of detergent in 2014 (Euromonitor / A.I.S.E, personal communication 2015):

- Solid laundry detergents (13,654,666,667 wash cycles): 0.225 Euro/cycle (calculated considering a total value of 3,078,500,000 Euros, a retail volume of 1,024,100,000,000 g, a dosage of 75g/cycle)
- Liquid laundry detergents (13,784,000,000 wash cycles): 0.293 Euro/cycle (calculated considering a total value of 4,044,600,000 Euros, a retail volume of 1,033,800,000,000 ml, a dosage of 75ml/cycle and
- Compact Powder Tablet Detergents (2,191,428,571 wash cycles): 0.127 Euro/cycle (calculated considering a total value of 278,200,000 Euros, a retail volume of 76,700,000,000 g, a dosage of 35g/cycle)
- Liquid Tablet Detergents (2,560,000,000 wash cycles): 0.295 Euro/cycle (calculated considering a total value of 754,500,000 Euros, a retail volume of 89,600,000,000 ml, a dosage of 35ml/cycle).

This gives an average cost of 0.25 Euro/cycle (+27% compared to the average value considered in the following calculations), with the cost of specific types of detergents ranging from 0.127 Euro/cycle (-37%, compared to 0.20 Euro/cycle) to 0.295 Euro/cycle (+48%, -compared to 0.20 Euro/cycle).

In the EcoReport tool the total Life Cycle costs for end users are expressed in Euros and calculated according to equation 5-1:

Eq. 5-1: $$LCC = PP + \sum_1^N PWF * OE + EoL$$

With:

- LCC: Life Cycle Costs for end-users
- PP: Purchase price (including installation costs)
- OE: annual operating expenses for each year of use
- EoL: End-of-life costs for end-users (i.e. costs for disposal)
- PWF: Present Worth Factor, calculated according to Eq. 5-2

$$PWF = 1 - \left(\frac{1+e}{1+d}\right) \cdot \left[1 - \left(\frac{1+e}{1+d}\right)^{N}\right] \qquad (d \neq e)$$

Eq. 5-2:

Where

- e is the aggregated annual growth rate of the operating expense ('escalation rate')
- d is the discount rate in %
- N is the product life in years.

Thus, to calculate the PWF the discount rate (d) and the escalation rate (e) of the operating expenses have to be defined. (COWI and VHK 2011) recommend to apply 4% for the discount rate (d = interest - inflation). The 4% result from an assumed MEErP interest rate of 6.5% and an inflation rate of 2.5% and is also the required discount rate of the impact assessment guidelines of the Commission.
The escalation rate (e = inflation corrected running cost price increase) is the weighted average of the annual growth rates of the different operating expenses. (COWI and VHK 2011) suggest a default value of 4% which is assumed to reflect satisfactorily the situation.
In that case, as the discount rate is the same as the escalation rate, then the Present Worth Factor is 1 to the power of the product life N. Additionally, end-users in Europe do not have separate costs for the disposal of household washing machines. The formula can be thus simplified as shown in equation 5-3.
Eq. 5-3: $LCC = PP + \sum_{1}^{N} OE$

Table 5.12 summarizes the data input for carrying out the economic assessment of the Base Cases.

Table 5.12: Inputs for the LCC for household washing machines and washer-dryers (data is considered to be representative for EU-28 in 2014)

Input parameter	Washing machines	Washer-dryers
Annual sales (million units/year)	16.6	1
EU stock (million units)	196.8	8.5
Purchase price (€)	413	826
Installation costs	0	0
Indicative maintenance and repair costs (€), referred to the total product service life	45	45
EoL costs to consumers (disposal and recycling) (€)	-	-
Product service life (years)	12.5	
Electricity rate (€/kWh)	0.208	
Water rate (€/m³)	3.98	
Detergent costs (€/kg)	2.67	
Discount rate (interest minus inflation) (%)	4.0%	
Escalation rate (annual growth of running costs) (%)	4.0%	

QUESTIONS BOX: LCC ASSUMPTIONS

1. Base on your knowledge, can you confirm **the annual sales and stock data** as calculated or would you propose any modifications?
2. Do you agree with our assumption of the **purchase price for WD being twice of the WM purchase price**?
3. Do the **calculated manufacturing costs for WM / WD**, based on estimated average factors for manu-facturing profit margin (28%), sales margin (factor 2.5) and VAT 21.6% correspond to your knowledge?
4. Do you agree with the assumption of on **average repair cost** per lifetime at 150 Euro for around 30% of appliances being repaired at all?
5. Do you agree with the **other input parameters for the LCC** as presented in Table 5-12?

5.1.4. Estimation of EU impacts for the installed stock

The Ecoreport tool allows simplified life cycle impact estimation per year of the EU stock. This is done by introducing an indication of the ratio between the energy consumption of the average new product sold on the market today (i.e. the Base Case) and the energy consumption of the average product already installed (i.e. the 'stock'). The simplified assumption that all other input parameters do not change compared to the Base Case is made.

For the stock, the Ecoreport tool takes the average product sold half a product lifetime ago (i.e. 6.25 years ago from 2015, i.e. approximately in 2009) as a reference for the stock. Referring to 2007, information contained in Lot 14 has been considered representative for the installed stock and used to estimate the related energy efficiency correction factor.

For washing machines, it results from Lot 14 that an average appliance on the market in 2007 was consuming about 1 kWh per cycle with the standard 60°C cotton programme at full rated capacity (5 kg). This would correspond to about 0.2 kWh per kg of laundry washed. However, it has to be noted that not all the programmes offered today were available at that time.

In absence of more detailed information about the use of washing machines at that time, 0.2 kWh/kg has been compared with the consumption per kg considered for the average standard programmes in the Base Case: 0.168 kWh/kg (i.e. 0.84 kWh/cycle divided by 5 kg). For the stock this would result in 84% of the energy efficiency of the current base case. The calculated energy efficiency improvement appears

rather higher if it is considered that the current Real-life BC not only includes the standard 60°C cotton programme, but a use mix of all programmes of which some are consuming less compared to the standard cotton programmes.
Specific energy consumption has also been compared with the energy consumption values for the standard and normal 60°C cotton programmes of a today's average machine of 7 kg: 0.83 and 1.65 kWh/cycle at full load, on the basis of the information gathered in the present study. Considering that the ratio of the frequency of use of these 2 programmes is about 2:3, an average value of 1.32 kWh per cycle or 0.189 kWh per kg is calculated. Based on such information, the energy efficiency of the stock would be 94% of the current base case.
Considering the different results from the application of the two estimation approaches, an **average energy efficiency of 89% for the stock of washing machines** has been considered.
For washer-dryers, it is reported in Task 2 (see figure 2.42) that specific energy consumption has decreased from 2007 to 2013:

- From 0.87 kWh/kg to 0.74 kWh/kg (-15%) for the wash&dry process;
- From 0.19 kWh/kg to 0.16 kWh/kg (-16%) for the wash only process.

Considering the similar trends for washing and drying processes, an **average energy efficiency of 85% for the stock of washer-dryers** has been considered.

QUESTIONS BOX: EFFICIENCY OF OLD APPLIANCES

1. Do you consider sensate that, on average, **the energy efficiency of the stock of WM installed in households is 89% of the energy efficiency of new products** on the market?
2. Do you consider sensate that, on average, **the energy efficiency of the stock of WD installed in households is 85% of the energy efficiency of new products** on the market?
3. Do you have **alternative proposals / additional for estimating the average difference in performance** between products already installed and sold on the market based your experience or knowledge?

5.2. Environmental Impacts of Base-Cases

The environmental impacts have been calculated with the MEErP EcoReport tool, using the data inputs presented in the previous sections, in the categories:

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

Results are shown in this study as environmental impacts per product over the whole life cycle and as EU impacts of new models sold in the reference year over their expected lifetime. Lifecycle impacts per year of the installed stock differ only for the energy efficiency correction factor described in section 5.1.4.

5.2.1. Base Case WM

The following Table 5.13 shows the material flows over the whole life cycle for the 'Real life' Base Case WM corresponding to a household washing machine with 7 kg capacity. The material consumption during the production essentially mirrors the input values of the bill of materials. The materials consumed during the use phase correspond to 1% of the bill of materials, which is the amount of detergents used over the life cycle, and materials/spare parts used for maintenance and repair. Resources at the End-of-Life phase are split between disposal, recycling and 'stock'. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

Table 5.13: Material flows over the whole life cycle for the 'Real life' Base Case WM (rated capacity: 7 kg)

Maerials	Unit	PRODUCTION	Distribution-	USE	END-OF-LIFE		
					Disposal	Recycling	Stock
Bulk Plastics	g	**5,982**		**60**	2,763	2,261	1,017
TecPlastics	g	**6,457**		**65**	2,506	2,051	1,964
Ferro	g	**28,527**		**285**	734	13,953	14,125
Non-ferro	g	**4,082**		**41**	87	1,652	2,383
Coating	g	**0**		**0**	0	0	0
Electronics	g	**225**		**2**	38	39	150
Misc.	g	**24,266**		**243**	8,673	1,183	14,653
Extra	g	**66**		**0**	26	41	0
Auxiliaries	g	**0**		**206,250**	161,945	0	44,305
Refrigerant	g	**0**		**0**	0	0	0
Total weight	g	**69,603**		**206,945**	176,773	21,180	78,597

Table 5.14 shows the environmental impacts over the whole life cycle of the 'Real life' Base Case WM. Relative magnitude of each life cycle stage is shown in Figure 5.2 split between: 1) production, 2) distribution, 3) use and 4) end of life. Results are represented for each impact category as the contributions (%) to the sum of all the phases summing up to 100% in absolute value. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 5.14: Environmental impacts over the whole life cycle (12.5 years) of the 'Real life' Base Case WM

Life Cycle phases	Unit	PRODUCTION			Distribution	USE	END-OF-LIFE		TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	
Resources & Waste									
Total Energy (GER)	MJ	3 312	934	**4 246**	**650**	**27 092**	543	-456	**32 075**
of which, electricity (in primary MJ)	MJ	816	560	**1 376**	**1**	**18 398**	0	-87	**19 688**
Water (process)	ltr	1 846	8	**1 854**	**0**	**163 925**	0	-316	**165 463**
Water (cooling)	ltr	2 377	261	**2 638**	**0**	**841**	0	-264	**3 216**
Waste, non-haz./ landfill	g	36 110	3 112	**39 223**	**376**	**17 490**	1 755	-6 770	**52 074**
Waste, hazardous/ incinerated	g	103	0	**103**	**7**	**444**	0	-9	**545**
Emissions (Air)									
Greenhouse Gases in GWP100	kg CO2 eq.	229	52	**281**	**43**	**1 177**	2	-36	**1 467**
Acidification, emissions	g SO2 eq.	2 143	224	**2 367**	**130**	**5 334**	17	-344	**7 505**
Volatile Organic Compounds (VOC)	g	6	0	**6**	**9**	**413**	0	-1	**428**
Persistent Organic Pollutants (POP)	ng i-Teq	455	14	**469**	**2**	**91**	0	-85	**477**
Heavy Metals	mg Ni eq.	2 904	32	**2 936**	**19**	**215**	2	-551	**2 621**
PAHs	mg Ni eq.	99	0	**100**	**23**	**56**	0	-12	**167**
Particulate Matter (PM, dust)	g	450	35	**485**	**1 539**	**115**	8	-59	**2 088**
Emissions (Water)									
Heavy Metals	mg Hg/20	1 963	1	**1 964**	**1**	**142**	1	-356	**1 753**
Eutrophication	g PO4	65	0	**65**	**0**	**263**	69	-11	**387**

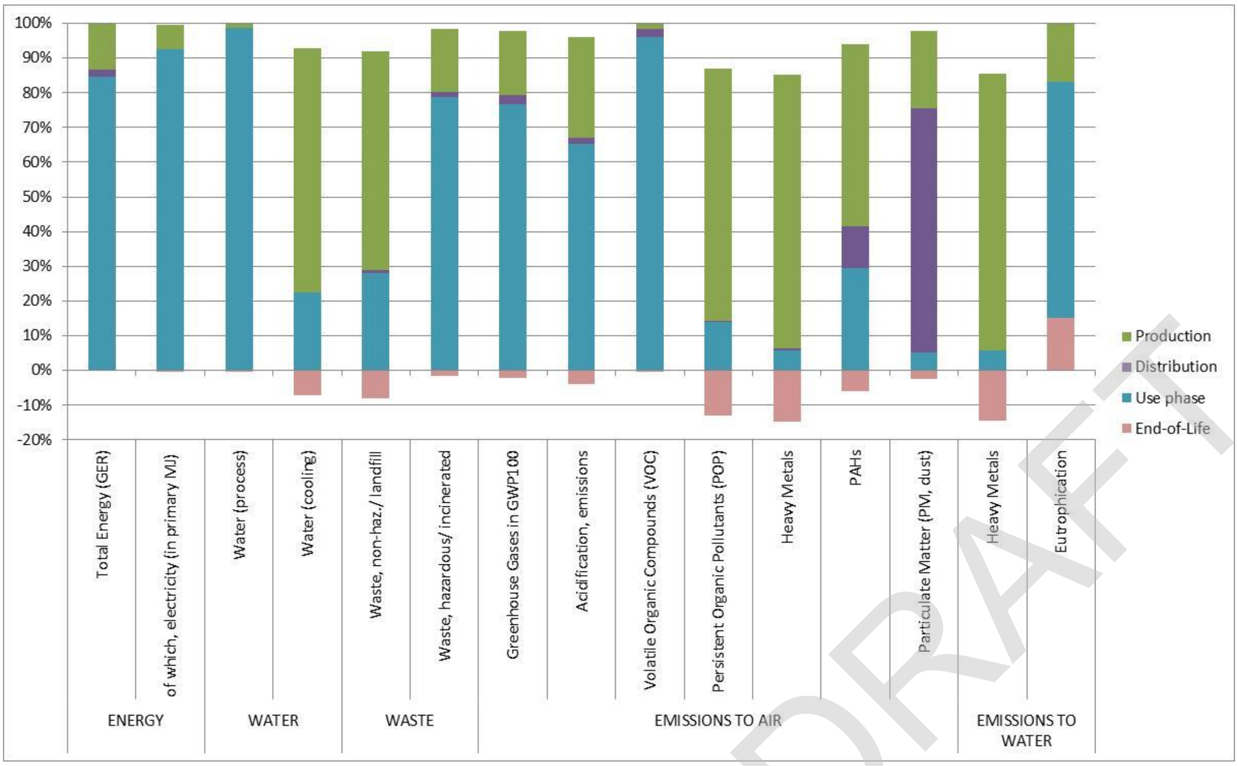

Figure 5.2: Relative magnitude of single life cycle stages to the environmental impacts of the 'Real-life' Base Case WM. Note: 100% is the sum of the absolute values of the contributions from the life-cycle stages

The results above show the dominant contribution of the use phase for

- Consumption of total energy (84%), electricity (93%) and process water (99%).
- Production of hazardous / incinerated waste (79%).
- Global warming potential (77%), acidification potential (65%), emission of VOCs (96%), eutrophication potential (68%).

With the exception of process water, almost totally due to the water consumed during the washing cycle, and eutrophication potential, mainly due to the use of detergents, consumption of electricity during the use phase is the main contribution in all these impact categories (see Table 5.14). In particular, the breakdown of the total demand for primary energy is the following: 55% electricity, 27% detergents, 13% materials, 5% other processes.

The manufacturing stage is the most important contribution for

- Production of non-hazardous waste (63%)
- Emissions of Persistent Organic Pollutants (73%), Heavy Metals to air (79%) and water (80%)

For the emission of PAHs, importance of manufacturing (52%) and use phase (30%) is more similar. The smaller contribution of the use phase to these indicators is mainly due to the consumption of electricity, while impacts in the manufacturing stage are significantly embedded in materials (59-100%).

The distribution phase is relevant only for the emissions of PM (70%) and PAHs (12%) and such impacts are due to the transport of the packaged products.

The EoL presents a significant negative impact in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL is -13% for the emissions of POPs, -15%, for the emissions of HM to air and -14% for the emissions of HM to water. Only for the Eutrophication potential the impact of the End-of-life phase is +15%, as it is mainly caused by detergents.

5.2.2. Base Case WD

Table 5.13 shows the material flows over the whole life cycle for the Base Case WD corresponding to a household washer-dryer with 7 kg capacity. Same considerations made for washing machines apply to this product. Flows of materials are higher for WD as a consequence of the higher weight (+5%). In particular, compared to the Base Case WM, the average washer-dryer modelled presents:

- +7% bulk plastics;
- +8% technical plastics
- +8% ferrous metals
- +8% non-ferrous metals

Table 5.15: Material flows over the whole life cycle for the 'Real life' Base Case WM (rated capacity: 7 kg)

Materials	Unit	PRODUCTION	Distribution-	USE	END-OF-LIFE		
					Disposal	Recycling.	Stock
Bulk Plastics	g	**6 393**		**64**	2 798	2 289	1 370
TecPlastics	g	**6 954**		**70**	2 699	2 209	2 115
Ferro	g	**30 724**		**307**	744	14 127	16 160
Non-ferro	g	**4 396**		**44**	88	1 673	2 679
Coating	g	**0**		**0**	0	0	0
Electronics	g	**225**		**2**	38	40	149
Misc.	g	**24 266**		**243**	8 781	1 197	14 530
Extra	g	**66**		**0**	26	41	0
Auxiliaries	g	**0**		**206 250**	163 967	0	42 283
Refrigerant	g	**0**		**0**	0	0	0
Total weight	g	**73 023**		**206 980**	179 142	21 576	79 286

Table 5.14 shows the environmental impacts over the whole life cycle of the Base Case WD. Impacts are higher than those calculated for the Base Case WM (from +3.1% for Eutrophication Potential to +175.3% for emission of VOCs), because of the higher material and energy input. It is however to be highlighted that, differently from WMs, WDs can fulfil two functions, i.e. washing and drying the laundry, to which such impacts are allocated.
Relative magnitude of each life cycle stage is shown in Figure 5.2: Relative magnitude of single life cycle stages to the environmental impacts of the 'Real-life' Base Case WM. Note: 100% is the sum of the absolute values of the contributions from the life-cycle stages

split between: 1) production, 2) distribution, 3) use and 4) end of life. Results are represented for each impact category as the contributions (%) to the sum of all the phases summing up to 100% in absolute value. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 5.16: Environmental impacts over the whole life cycle (12.5 years) of the Base Case WD

Life Cycle phases	Unit	PRODUCTION			Distribution	USE	END-OF-LIFE		TOTAL
		Material	Manuf.	Total			Disposal	Recycl.	
Resources & Waste									
Total Energy (GER)	MJ	3 515	1 004	**4 519**	**650**	**60 879**	561	-465	**66 145**
of which, electricity (in primary MJ)	MJ	845	601	**1 446**	**1**	**52 183**	0	-89	**53 542**
Water (process)	ltr	1 979	9	**1 988**	**0**	**207 821**	0	-322	**209 487**
Water (cooling)	ltr	2 553	280	**2 833**	**0**	**2 344**	0	-280	**4 898**
Waste, non-haz./ landfill	g	38 842	3 346	**42 188**	**376**	**34 928**	1 802	-6 869	**72 425**
Waste, hazardous/ incinerated	g	109	0	**109**	**7**	**977**	0	-10	**1 084**
Emissions (Air)									
Greenhouse Gases in GWP100	kg CO2 eq.	244	56	**300**	**43**	**2 619**	2	-36	**2 927**
Acidification, emissions	g SO2 eq.	2 288	241	**2 529**	**130**	**11 717**	17	-349	**14 044**
Volatile Organic Compounds (VOC)	g	6	0	**7**	**9**	**1 167**	0	-1	**1 182**
Persistent Organic Pollutants (POP)	ng i-Teq	490	15	**505**	**2**	**170**	0	-86	**591**
Heavy Metals	mg Ni eq.	3 120	35	**3 155**	**19**	**559**	2	-558	**3 177**
PAHs	mg Ni eq.	104	0	**104**	**23**	**135**	0	-12	**250**
Particulate Matter (PM, dust)	g	470	37	**508**	**1 539**	**251**	8	-60	**2 245**
Emissions (Water)									
Heavy Metals	mg Hg/20	2 113	1	**2 114**	**1**	**289**	1	-362	**2 042**
Eutrophication	g PO4	70	0	**70**	**0**	**270**	70	-11	**399**

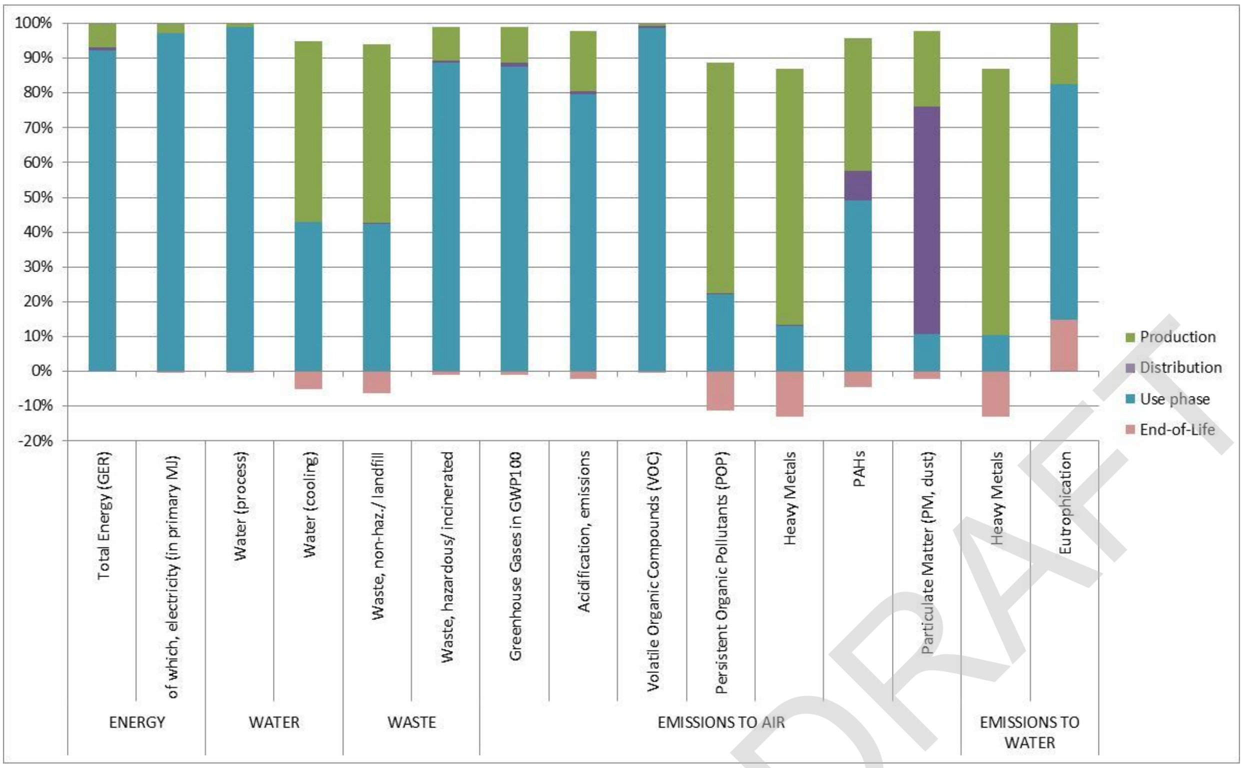

Figure 5.3: Relative magnitude of single life-cycle stages to the environmental impacts of the Base Case WD. Note: 100% is the sum of the absolute values of the contributions from the life-cycle stages

The results above show the dominant contribution of the use phase for

- Consumption of total energy (92%), electricity (97%) and process water (99%).
- Production of hazardous / incinerated waste (89%).
- Global warming potential (87%), acidification potential (80%), emission of VOCs (99%), eutrophication potential (68%).

With the exception of process water, almost totally due to the water consumed during the washing cycle, and eutrophication potential, mainly due to the use of detergents, consumption of electricity during the use phase is the main contribution in all these impact categories (see Table 5.14). In particular, the breakdown of the total demand for primary energy is the following: 77% electricity, 13% detergents, 7% materials, 3% other processes.

The manufacturing stage is the most important contribution for emissions of Persistent Organic Pollutants (66%), Heavy Metals to air (74%) and water (76%). Impacts in the manufacturing stage are significantly embedded in materials (58-100%). Impacts of manufacturing and use phase are more similar for production of non-hazardous waste (51% and 42%) and emission of PAH (38% and 49%). The contribution of the use phase to these indicators is mainly due to the consumption of electricity.

All in all, for WDs it is possible to observe the increased importance of electricity consumption in the results, as a consequence of the higher energy demand of this product necessary to deliver the drying function.

The distribution phase is relevant only for the emissions of PM (65%) and PAHs (8%) and such impacts are due to the transport of the packaged products.

The EoL presents a significant negative impact in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL is -11% for the emissions of POPs, -13%, for the emissions of HM to air and -13% for the emissions of HM to water. Only for the Eutrophication potential the impact of the End-of-life phase is +15%, as it is mainly caused by detergents.

5.3. Life Cycle Costs of Base-Cases

Life Cycle Costs (LCC) per appliance for the whole life cycle of 12.5 years have been calculated through the EcoReport tool. Results are shown in Table 5.17. Product purchase price, energy and water costs, repair and maintenance costs as well as costs for detergents during the whole life cycle have been considered, in accordance with Table 5.12.

Table 5.17: Life cycle costs (in Euro) over the whole life cycle (12.5 years) for the Base Case WM and for the Base Case WD

	Base Case WM		Base Case WD	
Product price	413 €	21.9%	826 €	25.8%
Electricity	425 €	22.5%	1,184 €	37.0%
Water	456 €	24.1%	595 €	18.6%
Detergent	551 €	29.1%	551 €	17.2%
Repair & maintenance costs	45 €	2.4%	45 €	1.4%
Total	**1,890 €**	**100%**	**3,201 €**	**100%**

LCCs of the 'Real life' Base Case WM is € 1,890. Normalised to 1 year of use, they correspond to € 151 per year. Results of Table 5.17 show that the detergent costs represent the highest costs along the life cycle of the Base Case WM, followed by the costs for water, and energy. As described in Section 5.1.3, it has to be pointed out that the cost of detergents can vary largely depending on the detergent type and dosing, and deviate as much as -37% to +48% from the average value calculated.
It is important to note that the life-cycle costs of the consumables over the lifetime exceed largely the average purchase price of the appliance. Product acquisition is on average ~20% of the LCC, and the operating costs of energy, water and detergent make up for ~75%. Repairs & maintenance is on average a marginal cost that affects randomly the appliances.
LCCs for the Base WD are 3,201 € (256 €, normalised to 1 year of use), +69% of those calculated for the Base Case WM. This is in particular due to the increased energy consumption for washing and drying the laundry (+179%), which becomes the most important cost factor (37%), followed by the product price (25.8%), which is the double of that of the Base Case. The increase of the costs related to water consumption is instead more limited (+31%).

5.4. Impacts at EU level

The environmental impacts and the LCC data of the Real-Life Base-Case WM shown in sections 5.2 and 5.3 are aggregated to EU-28 level ('EU totals') by introducing in the EcoReport tool the sales and stock input defined in section 5.1.3, on the basis of the market information contained in Task 2. As a result, the following outputs are provided:

- Total EU life cycle environmental impacts and LCC of new products sold in 2014;
- Life cycle environmental impacts per year and annual monetary costs for consumers due to the installed stock in 2014.

5.4.1. Environmental impacts in the EU-28

The following Table 5.18 and

Table 5.19 show a comparison of the total environmental impacts embedded in current stock of washing machines and washer-dryers and new appliances put on the market in 2014. This provides a rough indication of how much progress has been already made for these product groups. In particular, it is interesting to observe that impacts due to new sales of WD are higher than those calculated for the installed stock, as a consequence of the current market trends showing increased sales for this appliance.

Table 5.18: EU-28 total environmental impacts from the installed stock and the annual sales of household washing machines ('Real-life' BC WM)

Indicator	Units	EU28 environmental impacts		
		Stock, 1 year of use	Annual sales, whole life cycle	Annual sales, normalised to 1 year of use
Resources & Waste				
Total Energy (GER)	PJ	**561**	**532**	**44**
of which, electricity (in primary PJ)	PJ	**348**	**327**	**27**
Water (process)	mln. m^3	**2 931**	**2 747**	**229**
Water (cooling)	mln. m^3	**59**	**53**	**4**
Waste, non-haz./ landfill	kt	**967**	**864**	**72**
Waste, hazardous/ incinerated	kt	**10**	**9**	**1**
Emissions (Air)				
Greenhouse Gases in GWP100	Mt CO_2 eq.	**26**	**24**	**2**
Acidification, emissions	kt SO_2 eq.	**136**	**125**	**10**
Volatile Organic Compounds (VOC)	kt	**8**	**7**	**1**
Persistent Organic Pollutants (POP)	g i-Teq	**9**	**8**	**1**
Heavy Metals	ton Ni eq.	**53**	**44**	**4**
PAHs	ton Ni eq.	**3**	**3**	**0**
Particulate Matter (PM, dust)	kt	**36**	**35**	**3**
Emissions (Water)				
Heavy Metals	ton Hg/20	**35**	**29**	**2**
Eutrophication	kt PO_4	**6**	**6**	**1**

Table 5.19: EU-28 total environmental impacts from the installed stock and the annual sales of household washer dryers (BC WD)

Indicator	Units	EU28 environmental impacts		
		Stock, 1 year of use	Annual sales, whole life cycle	Annual sales, normalised to 1 year of use
Resources & Waste				
Total Energy (GER)	PJ	**54**	**66**	**5.29**
of which, electricity (in primary PJ)	PJ	**43**	**54**	**4.28**
Water (process)	mln. m^3	**169**	**209**	**16.76**
Water (cooling)	mln. m^3	**5**	**5**	**0.39**
Waste, non-haz./ landfill	kt	**71**	**72**	**5.79**
Waste, hazardous/ incinerated	kt	**1**	**1**	**0.09**
Emissions (Air)				
Greenhouse Gases in GWP100	Mt CO_2 eq.	**2**	**3**	**0.23**
Acidification, emissions	kt SO_2 eq.	**12**	**14**	**1.12**
Volatile Organic Compounds (VOC)	kt	**1**	**1**	**0.09**
Persistent Organic Pollutants (POP)	g i-Teq	**1**	**1**	**0.05**
Heavy Metals	ton Ni eq.	**4**	**3**	**0.25**
PAHs	ton Ni eq.	**0**	**0**	**0.02**
Particulate Matter (PM, dust)	kt	**2**	**2**	**0.18**
Emissions (Water)				
Heavy Metals	ton Hg/20	**2**	**2**	**0.16**
Eutrophication	kt PO_4	**0**	**0**	**0.03**

5.4.2. Economic impacts in the EU-28

Table 5.20 shows an estimation of the total annual expenditure in the EU-28 linked to the use and operation of new washing machines and new washer-dryers. It assumes that the BC WM and the BC WD represent the average appliance produced in 2014 (reference year). The values shown provide an idea of the order of magnitude of the yearly expenditure associated to the function of household washing machines and washer-dryers in the EU28.

Table 5.20: EU-28 total annual expenditure for household washing machines (ref. 2014) in millions of Euro ('Real-life' BC WM)

	EU total annual expenditure (millions of euro)			
	Annual sales of WM, whole life cycle (12.5yr)	**Annual sales of WM, normalised to 1 year of use**	**Annual sales of WD, whole life cycle (12.5yr)**	**Annual sales of WD, normalised to 1 year of use**
Product price	6,856	548	826	66
Electricity	6,421	514	811	65
Water	7,392	591	408	33
Detergents	8,670	694	377	30
Repair & main-tenance costs	708	57	31	2
Total	**30,048**	**2,404**	**2,452**	**196**

As the table shows, the purchase and operation of new washing machines over the entire life cycle is in the range of EUR 30 billion, equivalent to EUR 2.4 billion per year. The purchase and installation costs in the EU28 add up to EUR 6.9 billion, whereas the running costs amount to EUR 22.5 billion.
Because of the much lower penetration in the EU market, total expenditure is much lower for washer-dryers: EUR 2,452 billion (8% of that for washing machine).

6. TASK 6: DESIGN OPTIONS

6.1. Improvement options

In Task 4, several possible design options for household washing machines and washer-dryers have been described in detail. The following tables summarize and cluster these initial design options for washing machines and the washing programme of washer-dryers (Table 6.1) and the drying function of washer-dryers (Table 6.2) and provide a rationale for each of the selection of options, to be further analysed in the following tasks.

Table 6.1: Overview of design options for household washing machines and the washing process of washer-dryers (options selected for further analyses are highlighted)

Design options	Description	Rationale for the selection of design options (for further follow up)
Option 1: Machine / drum construction	The drum geometry and/or the rated capacity can influence the specific energy and/or water consumption or performance of household washing machines. Possible examples are: 1a) Increasing the drum volume without increasing the rated capacity (i.e. increasing the volume-to-load ratio). This could be done by manufacturers to obtain better mechanical action and reduce programme times, and energy and water use. However, as this is not commonplace, it is assumed that the savings are less than those obtained by full loading to the appliance's capacity. **1b) Increasing the rated capacity from 7kg (base case) to 9 kg** 1c) Multi-drum washing machines (two side-by-side or above washing drums for parallel washing processes; water might be reused between the drums)	1a: Not selected; there is a general market trend of increasing the rated capacities 1b: Selected; trend to higher capacities observed; however, under real-life conditions these capacities are not fully exploited, which leads to higher consumption per kg wash load. 1c: Not selected; These machines are popular in other markets (e.g. China) where e.g. children and adult clothes are washed separately. The concept has been presented in the EU market, but the separation is of normal vs delicate clothes. An improvement in efficiency is not expected for this product unless the small drum also can handle normal washes, in which case a fully loaded small drum may be more efficient.
Option 2: Increased motor efficiency	Compared to the older universal commutator motors with brushes, more energy efficient motors have become common in household washing machines. Advantages are also claimed in terms of better steering options, lower noise, partly less volume and weight, and longer lifetime due to absence of brushes. Examples are 2a) Brushless, inverter driven asynchronous DC motors **2b) Brushless, permanent magnet synchronous DC motors (PMSM)**	2a: Considered the average type of motor for the BC 2b: Selected; higher motor efficiency would have an effect on all programmes, not only the standard labelling programmes.
Option 3: Temperature - time trade off	Lowering the machine's wash temperature compared to the temperature declared in the programme name, combined with increasing cycle times, leads to lower energy consumption for heating, and can still match the requested performance. Examples	Selected. 4 hours would be too near to the Base Case assumption and the average time of the standard

Design options	Description	Rationale for the selection of design options (for further follow up)
	are **3a) Extension of programme duration and lowering of washing temperature – moderate scenario (e.g. 4-5 hours)** **3b) Extension of programme duration and lowering of washing temperature – extreme scenario (e.g. up to 6.5 hours)**	programmes (3-3.5 hours). Data provided by stakeholders show that the current maximum duration of the standard programmes is 4.8 hours which is expected not to further increase. To show the effect of the temperature/time trade-off, an extension of the programme duration to about 4.5 hours is considered (average wash temperature decreased to 29°C). Since 20% of consumers are willing to select longer programme durations to save energy, an extension of the programme duration up to 6.5 hours is also evaluated (average wash temperature decreased to 20°C).
<u>Option 4</u>: Alternative heating systems	Alternative heating systems try to reduce the electricity demand of the washing machine for water heating, by using (totally or partially) external heating sources. Examples are **4a) Heat pump technology for the washing function:** the electric energy usually used to heat the machine/laundry/water is replaced by using the heat of the ambient air and/or the waste water **4a1) either with common refrigerant R134a** **4a2) or with alternative refrigerant with lower GWP (e.g. propane, isobutane)** This requires the availability of a heat storage system, e.g. in a phase-change material tank (a commercial model of this is the V-Zug Adora SLQ WP) **4b) Heat-fed machines:** The electric heating elements of the appliance are replaced by a hot water circulation loop using a heat exchanger to transfer the heat from a hot water circulation to the machines. The hot water is generated e.g. by central or district heating and does not need to have drinking water quality. The appliance itself is connected to the cold water tap. **4c) Hot fill (connection of the appliance to a hot water supply):** the machine has 2 water inlets, one of which for hot-water heated through, e.g., solar heating or a gas boiler. Water does not need to be heated internally by the machine itself, but just blended with cold water to reach the right temperature.	4a1: Selected. Heat pump adds technical complexity to the machine but commercial models are available. It has additional drawbacks in terms of speed of heating, reduced capacity for washing, duplication of heating systems, or EoL management. It is well proven in other appliances such as tumble dryers. 4a2: Selected as BNAT 4b: Selected as BNAT; no more electricity needed for the heating process, just for the motor and electronics. It is very dependent on the proper working of an external installation. 4c: Selected. The efficiency of the system depends largely of the nature and efficiency of the heating system that supplies the hot water, and the length and insulation of the hot water pipes.

Design options	Description	Rationale for the selection of design options (for further follow up)
Option 5: Improved drenching systems / improved detergent dissolution	Different systems are available on the market for improving the laundry drenching using less water, as well as for a better process of detergent dissolution, distribution and penetration in the fabrics. These effects can be achieved by recirculating fractions of water and by mixing air, water and detergent, and it is claimed to result in improved washing performance, less detergent loss and, sometimes, lower water and energy use. Examples of those systems on the market or in development are improved Water Circulation, Ecobubble™technology, Spray-technology, or PowerWash 2.0 technology.	Selected: Some manufacturers offer different variations of such systems.
Option 6: Higher water extraction by spinning	The more water is removed by mechanical treatment (usually through spinning in the washing machine at the end of the programme) the less thermal energy is required for subsequent drying and/or ironing. The additional energy demand through higher spin speed is negligible compared to the reductions in thermal energy demand of drying in tumble dryers and indoor clothes line. **Compared to 1,400 rpm of the Base Case, the maximum spin speed can be reasonably set at 1,600 rpm**	Selected; Estimation of a credit to the following drying process. Some drying methods (e.g. outdoor line drying), do not benefit from too high spinning, as this forms wrinkles in clothes that have to be later removed by ironing.
Option 7: Sensors and automatic controls	Certain electronic controls can steer the use of energy and water, and detergent dosing. Examples are: **7a) Automatic load detection, which adapts the water consumption and thus the energy demand to heat that water, to partial load of the machine** **7b) Automatic detergent dosage systems, which supposedly leads to reduced under- or overdosing.**	7a: Selected; Most systems are based on water level (pressure) gauges in the tub, and are very widespread. There are currently some differences in the effectiveness of such sensor systems with regard to adapting the energy and/or water demand to the real load and textile type. Water-based systems work ONCE the programme starts. Other systems for load detection such as weight sensors are more seldom. They allow feedback to consumer BEFORE starting the programme, and thereby help instruct the consumer to full load. 7b: Selected; Trend to automatic systems; resource savings might be possible.
Option 8: Consumer feedback mechanisms	Feedback to consumer (via display, led lights, etc.) on certain aspects of the functioning of the machine might lead to optimized consumer behaviour in terms of e.g. loading and dosage. Examples are: **8a) Displaying the actual loading (e.g. by weight sensors on the drum)** 8b) Displaying a detergent dosage recommendation 8c) Displaying the different energy and water demands (expected, of after use) of the chosen programmes	Selected, without analysing all single sub-options (only 8a for the moment)

Design options	Description	Rationale for the selection of design options (for further follow up)
	8d) Displaying maintenance requirements (e.g. 90°C machine hygiene programme, filter clogging)	
Option 9: Improved interconnectivity between appliance, user and technical systems	Interconnectivity between appliance, user and technical systems can improve the flexibility of use of the product. Examples are 9a) Internet connectivity (Smart appliances) 9b) Electronic update of the programmes / diagnostics in case of failures **9c) 'Smart-grid ready' products, with the ability to operate on a demand-response basis**	9a / 9b: Not selected as no direct energy improvement potential is seen or is quantifiable. 9c: selected as BNAT
Option 10: Material selection	The choice of materials might not have direct impacts on the energy or water consumption of washing machines but might improve the overall resource efficiency or durability of the appliances. Examples are: 10a) Use of recycled materials (plastic) **10b) Increased durability of appliance / components**	10a: Not selected as not clear if feasible and effective 10b: Selected
Option 11: Alternative washing systems	Examples are 11a) Ultrasonic cleaning technologies (an ultrasonic device brings high pressure bubbles into the water (cavitation); the system is assumed to save energy) 11b) Polymer bead technology (the nylon beads added to the water are supposed to better absorb the dirt - savings of water are claimed and lower residual moisture content of the laundry which shall lead to lower energy demand of the subsequent drying processes 11c) Steam care / steam finishing: the laundry is not only treated with water but also with steam (to reduce micro-organisms at low washing temperatures, reduce odours and wrinkles); usually separate programmes to be selected in addition to the 'normal' wash programmes	11a / 11b / 11c: Not selected as no quantifiable energy use improvement effect has been recorded

For household washer-dryers, it is assumed that for the washing only process, the design options listed above for washing machines are applicable. For the drying and continuous wash&dry cycles, the following specific design options are proposed, and selected for further follow-up
.

Table 6.2: Overview of design options for the drying process of household washer-dryers (options selected for further analyses are highlighted)

Improvement options	Description	Rationale for the selection of design options (for further follow up)
Option 1: Alternative condensing systems	Compared to common water condensing systems, the technology used for the base-case, alternative condensing systems try to reduce the electricity and/or the water demand of the washer dryer: **1a) Air condensing systems.** **1b) Heat pump technology (for the drying function)**	Both 1a and 1b selected as BAT
Option 2: Smart design of combined wash&dry programmes	When warm textiles are spun, the remaining moisture will be lower as if they are cold. At the beginning of the drying phase in a continuous wash&dry process a spinning is extracting water which will not need to be evaporated in the drying phase.	Considered to be common (BC)
Option 3: Heat pumps for washing and for drying	Heat pumps can potentially offer energy saving for both washing and drying processes. This may take place with two distinct heat pumps (in a limited space), one for water-refrigerant and other for air-refrigerant, or a single pump that is able to deliver heat to two condensing elements, one for water (washing), and one for air (drying).	BNAT, challenging from a technical point of view and not foreseeable on the market in the coming years
Option 4: Energy storage systems	Normally, the heat of the washing phase is drained away with the drainage water. To save energy, however, it could be ideal to use as much energy from the washing phase as possible for the subsequent drying phase. This can be done for example through internal storage systems based on phase change latent heat.	BNAT, not assessed because of lack of data (input from stakeholders is welcome)
Option 5: Alternative heating systems	Electricity supplied heating for the drying process could be in theory substituted with alternative systems as central/district heating.	BNAT, not assessed because of lack of data (input from stakeholders is welcome)

Based on a questionnaire distributed during the summer 2015, manufacturers have been asked to provide technical and cost data on single improvement options and combinations of such options. This information was coupled with data gathered from the literature and experts in order to analyse the changes induced by the improvement options to the Base Cases defined in section 5.1.1 for washing machines and section 5.1.2 for washer-dryers, with regard to:

- Performance parameters (e.g. consumption of energy, water and detergents)
- Material resources (compared to the BoM of the Base Cases) and product lifetime
- Manufacturing costs and maintenance and repair costs

The assumptions made for the environmental and economic assessment of selected options are described in the following section. In particular, variations of energy and water consumption associated to different improvement options have been estimated through the adaptation and tuning of the models developed for the Base Case WM and the Base Case WD. It should be observed that, while some options can have an impact on all programmes of an appliance (e.g. improved motor efficiency), some options are considered to play a role for a narrower set of programmes (e.g. the cycle duration extension applies only to the cotton standard programmes).
Stakeholders are asked to check such assumptions and to provide estimations of the current market penetration and future potential of the improvement options, as well as indications about any incompatibility of different options in the same appliance.

6.2. Analysis of single improvement options for washing machines

Selected improvement options (BAT and BNAT) for WM and estimated variations compared to the BC are listed in Table 6.3. Resulting variation of the Ecoreport tool's input parameters are reported in Table 6.4.

QUESTIONS BOX: SINGLE IMPROVEMENT OPTIONS FOR WM

Please check the following Tables 6-3 and 6-4 carefully.

1. Does the **selection of improvement options** (BAT / BNAT) reflect the market developments appropriately? Do you think that any relevant design options should be further added to the analysis? Should some of the chosen improvement options be deleted from the analysis? Please explain your reasons.
2. Can the **assumptions made** (consumption, costs, materials, and lifetime) be considered to reflect appropriately the main changes of improvement options compared to the BC? Is there the need of any MAJOR changes?
3. If known, please provide us with **additional data on market and penetration potential** of single options.

Table 6.3: Selected improvement options (BAT and BNAT) for WM and estimated variations compared to the BC

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	**Water consumption**	**Detergent consumption**	**Lifetime (years)**	**Manufacturing costs**	**Repair and maintenance costs**	**Materials**
WM1: Increasing the rated capacity from 7 kg to 9 kg (Hp. No increase of load compared to the BC)	The average consumption per cycle (kWh/cycle) increases by ca. +20%, measured under standard conditions of loading. The consumption per kg (kWh/kg) decreases by 6% on average. Under real life conditions (3.4 kg load), it is estimated that energy consumption per cycle increases by ca. +9%.	The average consumption per cycle (L/cycle) increases by ca. +21%, measured under standard conditions of loading. The consumption per kg (L/kg) decreases by 6% on average. Under real life conditions (3.4 kg load), it is estimated that water consumption per cycle increases by ca. +7%.	+29% under standard conditions. Not affected under real-life conditions	Not affected	+20€ (bigger and stiffer drum, larger bearings, stronger motor, improved balancing system, improved sensors for unbalance)	Not affected	BOM increased by 21% proportionally
WM2: Brushless, permanent magnet synchronous DC motor (PMSM)	Up to - 0.1 kWh for the standard programmes, proportionally varied for other programmes depending on estimated cycle durations. -7% of the total energy consumption under real life conditions (-10% for the adapted BC).	Not affected	Not affected	The lifetime of the motor can be longer (e.g. + 5 years) but this is not considered to affect the lifetime of the appliance	+10 € (improved motor and inverter)	Not affected	BOM not affected significantly
WM3: Extension of programme duration and lowering of washing temperature - moderate scenario (about 4.5 hours)	An average temperature of 29°C is considered for the standard programmes (compared to the 34°C of the BC) Up to 0.15 kWh (-18%) under standard conditions. -4% of the total energy consumption under real life conditions (-10% for the adapted BC).	Not affected	Not affected	Not affected (if not frequently used otherwise longer running time may increase wear and tear which would have material and cost implications whose quantification is seen difficult)	Not affected	Not affected	BOM not affected
WM4: Extension of programme duration and lowering of washing temperature - extreme scenario (up to 6.5 hours)	An average temperature of 20°C is considered for the standard programmes (compared to the 34°C of the BC) Up to -0.44 kWh (-52%) under standard conditions. -10% of the total energy consumption under real life conditions (-28% for the adapted BC).	Not affected	Not affected	Not affected (if not frequently used; otherwise longer running time may increase wear and tear which would have material and cost implications whose quantification is	Not affected	Not affected	BOM not affected

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	Water consumption	Detergent consumption	Lifetime (years)	Manufacturing costs	Repair and maintenance costs	Materials
				seen difficult)			
WM5: Heat pump technology for the washing function, with common refrigerant R134a	Up to -0.4 kWh (-47%) under standard conditions Proportional savings expected for other programmes depending on temperature (up to a maximum of 50% of the programme energy consumption value) -49% of the total energy consumption under real life conditions (-47% for the adapted BC).	Not affected	Not affected	Not affected	+ 150 € (Heat pump, circulation and drainage pumps, heat exchangers, heat storage material (e.g. phase change material), tank, refrigerant)	Not affected	+13 kg (plastics: 2.8 kg, copper: 2.4 kg, steel: 7.7 kg) +150 / 200 g of refrigerant (175 g as average) HC refrigerants have important limitations of use if the refrigerant content is above 150g, as much stricter safety conditions have to be met, resulting in additional testing, dimensioning of the system.
WM6: hot-fill	Maximum saving potential without considering system aspects associated to this option: up to -0.42 kWh (-50%) under standard conditions for all programmes with nominal temperature higher than 20°C. -50% of the total energy consumption under optimal real life conditions (-50% for the adapted BC)	Not affected	Not affected	Not affected	+20 € (Second water inlet, valves, hoses, wiring, control)	Not affected	BOM not affected significantly
WM7: Improved drenching systems / improved detergent dissolution	From 0 to 20% for all programmes. An average value of 10% is considered. - 10% of the total energy consumption under real life conditions (the same for the adapted BC).	From 0 to 20% for all programmes. An average value of 10% is considered. - 10% of the total energy consumption under real life conditions (the same for the adapted BC).	Not affected	Not affected	+15 / +20 € (circulation pump, drenching / foam generator system, dissolution chamber, hoses, wiring, control)	Not affected	BOM not affected significantly
WM8: Higher water extraction by spinning (increase of the maximum spin speed from 1,400 rpm to 1,600 rpm)	+0.05 kWh for all programmes except for delicate textiles (+6% under standard conditions, +5% under real life conditions, +5% for the adapted BC) Credit for drying (per cycle) = (50%-45%) x 3.4 kg x 2.26/3.6 kWh/kg x	Not affected	Not affected	Not affected if durability of components is increased	+20 € (stiffer drum, larger bearings, improved balancing system, improved sensors for unbalance)	Not affected	BOM not affected significantly

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	**Water consumption**	**Detergent consumption**	**Lifetime (years)**	**Manufacturing costs**	**Repair and maintenance costs**	**Materials**
	(100%-50%)= 0.05 kWh/cycle (-7% of the Real life BC) Assumptions: - Residual moisture content decrease from 50 to 45%. - 2,260 kJ/kg (latent heat of evaporation for water) - 50% of drying is made on clothes line outdoor						
WM9: Automatic load detection	Half load consumption values are at least 25% lower than full load consumption values. - 7% of the total energy consumption under real life conditions (-3% for the adapted BC).	Half load consumption values are at least 25-30% lower than full load consumption values. - 4% of the total water consumption under real life conditions (-4% for the adapted BC).	Not affected	Not affected	5 € (sensors, software)	Not affected	BOM not affected significantly
WM10: Automatic detergent dosage system	Not affected (impact of pumping negligible)	Not affected	Both overdosing and underdosing will be reduced. On average, up to 30% of detergents can be saved: -15% has been considered	Not affected	25 € (container, pump, sensors)	Not affected	BOM not affected significantly
WM11: Consumer feedback mechanisms about loading (Hp. of full loading)	The assumptions that this option would lead to wash always at full load is made (max theoretical potential). Not affected under standard conditions. Up to +19% of the energy consumption value under real life conditions (+20% for the adapted BC). Since the new average load increases from 3.4 kg to 4.6 kg, number of cycles decrease accordingly, as well as the energy consumption per kg of laundry washed (-13% for the real life BC and -12% for the adapted BC)	The assumptions that this option would lead to wash always at full load is made (max theoretical potential). Not affected under standard conditions. Up to +29% of the energy consumption value under real life conditions (+29% for the adapted BC). Since the new average load increases from 3.4 kg to 4.6 kg, number of cycles decrease accordingly, as well as the water	Not affected	Not affected	5 € (sensors, display)	Not affected	BOM not affected significantly

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	**Water consumption**	**Detergent consumption**	**Lifetime (years)**	**Manufacturing costs**	**Repair and maintenance costs**	**Materials**
		consumption per kg of laundry washed (-5% for the real life BC and -5% for the adapted BC)					
WM12: Increased durability of appliance / components	Up to +0.1 kWh for increased thermal inertia, constant for all programmes. This would mean to increase up to +12% the energy consumption value under real life conditions (+15% for the adapted BC, +12% under standard conditions).	Not affected	Not affected	Doubled	+50 € (BOM increased by 20% to consider stiffer drum, larger bearings, increased material thicknesses, electronic specified for longer stability, etc)	Doubled since the lifetime double	BOM increased by 43% proportionally
WM13 (BNAT): Heat pump technology for the washing function with alternative refrigerant with lower GWP (e.g. propane (R290), isobutene (R600a))	See WM5	Not affected	Not affected	Not affected	See WM5	See WM5	+13 kg (plastics: 2.8 kg, copper: 2.4 kg, steel: 7.7 kg) +85 g of refrigerant However, HC refrigerants have important limitations of use if the refrigerant content is above 150g, as much stricter safety conditions have to be met, resulting in additional testing, dimensioning of the system. According to the European Standard EN 60335-2-24 or draft IEC 60335-2-89, which must be complied with, the refrigerant charge must not exceed 150g. In general the charge of R600a or R290 is approximately 40-50% by weight than that for HFC. Commercially available R600a and R290 must not be used because the fuel grades of these products

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	Water consumption	Detergent consumption	Lifetime (years)	Manufacturing costs	Repair and maintenance costs	Materials
							are of a variable composition. These products may also contain impurities which could significantly reduce the reliability and performance of the system and lead to premature failure. Many commercial compressors for R600a and R290 need a base purity of 97% or better. Impurity limits shall comply with DIN 8960 of 1998 (extended version of ISO 916). All users of refrigerant R600a should refer to the chemical data safety sheets for full information on the safe handling of R600a and R290.
WM14 (BNAT): Heat-fed machines	Maximum saving potential without considering system aspects associated to this option: up to -0.21 kWh (-25%) under standard conditions for all programmes with nominal temperature higher than 20°C. -25% of the total energy consumption under optimal real life conditions (-25% for the	Not affected	Not affected	Not affected	+60 / +100 € (Inlet and outlet for hot fed, valves, heat-exchanger, wiring, control) + 200 € (for external connection to heat-water system)	Not affected	BOM not affected significantly
WM15 (BNAT): Smart-grid ready products	+ 0.05 kWh for additional controls Credits for greener electricity supply (calculated from http://file.scirp.org/Html/5-2210030_29077.htm): - 85% primary energy efficiency, on average, for production and supply of electricity from renewable sources (1.17 MJ of primary energy needed for each MJ of electricity)	Not affected	Not affected	Not affected	+20 € (connectivity)	Not affected	BOM not affected significantly

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	Water consumption	Detergent consumption	Lifetime (years)	Manufacturing costs	Repair and maintenance costs	Materials
	- 40% primary energy efficiency, on average, for production and supply of electricity from other sources (2.5 MJ of primary energy needed for each MJ of electricity) Considering 20% production from renewables, 2.23 MJ of primary energy are considered for each MJ of electricity. Use of energy from renewable would result using 11% less of primary energy. As a simplified assumption, the same correction factor has been applied to other environmental indicators of electricity.						

Table 6.4: Variation of input parameters for single improvement options for WM compared to the Real-life Base Case WM

Improvement option	Energy Cons.	Water Cons.	Detergent Cons.	Prod. costs (€)	Purchase price	Share of repaired machines	Maint. & repair costs over the lifetime (€)	Lifetime (years)	Weight of materials
'Real life' Base Case WM	100%	100%	100%	106	100%	0.3	100%	12.5%	100%
WM1: Increased capacity, unchanged loading	109%	107%	100%	+20	119%	0.3	100%	12.5	121% (increased size)
WM2: PM motor	93%	100%	100%	+10	109%	0.3	100%	12.5	100%
WM3: Extension of std. programme duration (moderate)	96%	100%	100%	+0	100%	0.3	100%	12.5	100%
WM4: Extension of std. programme duration (extreme)	90%	100%	100%	+0	100%	0.3	100%	12.5	100%
WM5: Heat Pump	51%	100%	100%	+150	242%	0.3	100%	12.5	119% (heat pump)
WM6: Hot-fill	50%	100%	100%	+20	119%	0.3	100%	12.5	100%
WM7: Improved drenching	90%	90%	100%	+17.5	117%	0.3	100%	12.5	100%
WM8: Higher spinning extraction	98%	100%	100%	+20	119%	0.3	100%	12.5	100%
WM9: Automatic load detection	86%	96%	100%	+5	105%	0.3	100%	12.5	100%
WM10: Automatic detergent dosage	100%	100%	85%	+25	124%	0.3	100%	12.5	100%
WM11: Consumer feedback on loading, full load	87%	95%	100%	+5	105%	0.3	100%	12.5	100%
WM12: Increased durability	112%	100%	100%	+50	147%	0.6 (since the lifetime double)	200%	25	143% (increased amounts)
WM13: Heat pump (different refrigerant)	51%	100%	100%	+150	242%	0.3	100%	12.5	100%
WM14: Heat-fed	75%	100%	100%	+280	364%	0.3	100%	12.5	100%
WM15: Smart grids	107%	100%	100%	+20	119%	0.3	100%	12.5	100%

6.2.1. Environmental impacts

Life cycle impacts of washing machines implementing single improvement options for WM, expressed per year of use with respect to the Base Case WM (=100%) are shown in Table 6.5 and in Figure 6.1.

Table 6.5: Life cycle impacts of washing machines implementing single improvement options for WM expressed per year of use with respect to the Base Case WM (=100%)

Indicator	WM1	WM2	WM3	WM4	WM5 (R134a)	WM6	WM7	WM8	WM9	WM10	WM11	WM12	WM13 (propane)	WM13 (isobutane)	WM14	WM 15
Total Energy (primary energy)	100%	106%	95%	96%	93%	74%	71%	93%	97%	94%	99%	91%	100%	74%	74%	85%
Electricity (primary energy)	100%	110%	94%	96%	91%	57%	55%	91%	98%	94%	100%	88%	109%	57%	57%	78%
Water (process)	100%	107%	100%	100%	100%	100%	100%	90%	100%	96%	100%	95%	100%	100%	100%	100%
Water (cooling)	100%	118%	98%	99%	98%	96%	88%	98%	100%	98%	100%	97%	81%	96%	96%	94%
Waste, non-haz./ landfill	100%	117%	98%	99%	98%	104%	91%	98%	99%	98%	100%	97%	80%	104%	104%	95%
Waste, hazardous/ incin.	100%	107%	95%	96%	93%	77%	73%	93%	97%	94%	99%	92%	99%	77%	77%	86%
GWP100	100%	107%	95%	96%	93%	93%	73%	93%	97%	95%	99%	92%	98%	76%	76%	86%
Acidification, emissions	100%	109%	96%	97%	94%	88%	76%	94%	98%	95%	99%	93%	94%	88%	88%	88%
VOC	100%	109%	94%	96%	91%	55%	54%	90%	98%	94%	100%	88%	110%	55%	55%	77%
POP	100%	121%	100%	100%	99%	118%	96%	99%	100%	100%	100%	99%	74%	118%	118%	98%
Heavy Metals	100%	124%	100%	101%	100%	106%	98%	100%	101%	101%	101%	100%	71%	106%	106%	99%
PAHs	100%	114%	98%	99%	97%	98%	88%	97%	99%	97%	100%	97%	79%	98%	98%	94%
PM, dust	100%	105%	100%	100%	100%	100%	98%	100%	100%	100%	100%	100%	57%	100%	100%	99%
Heavy Metals	100%	123%	100%	101%	100%	103%	99%	100%	101%	101%	101%	100%	71%	103%	103%	100%
Eutrophication	100%	100%	95%	95%	95%	96%	95%	95%	95%	94%	96%	95%	89%	96%	96%	95%

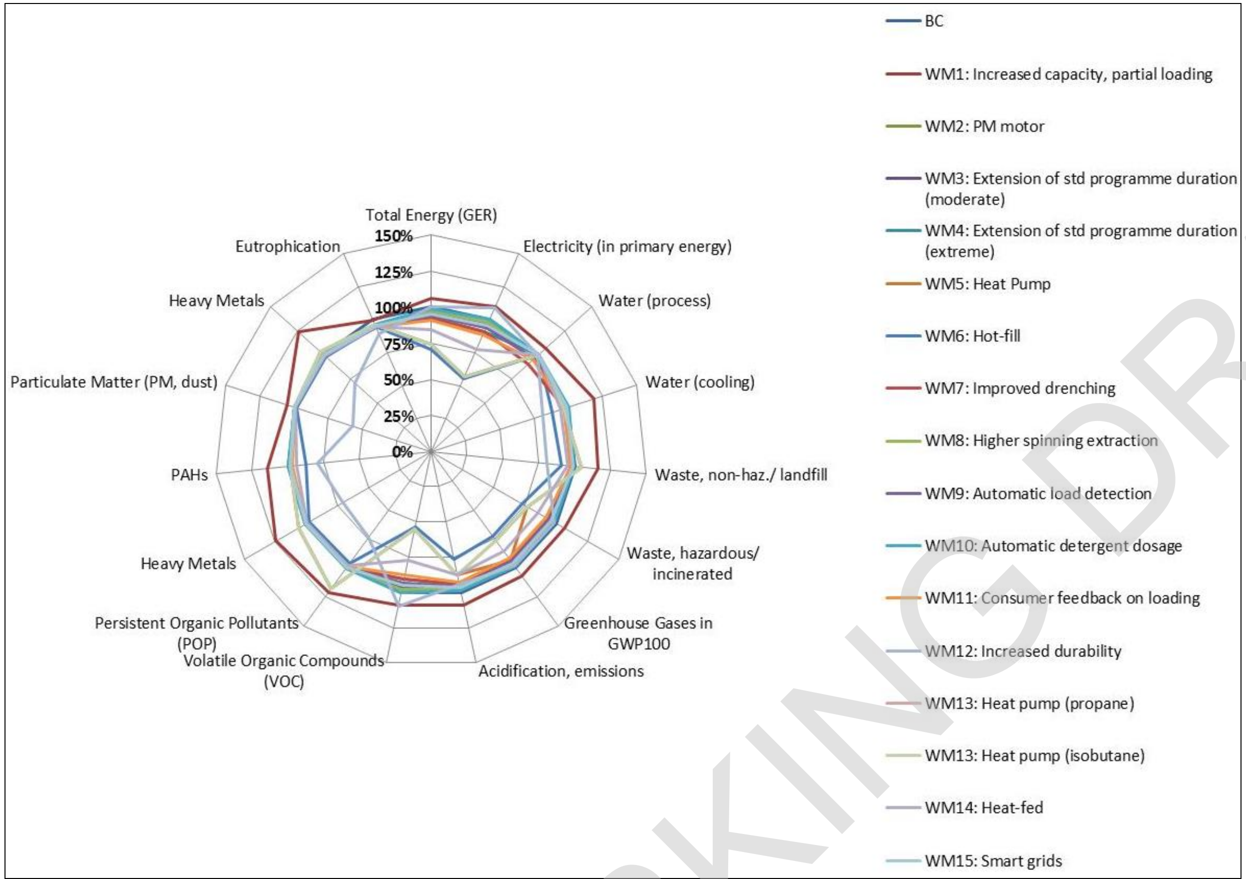

Figure 6.1: Lifecycle impacts of single improvement options for WM expressed per year with respect to the Base Case WM (=100%) – spider diagram

The analysis of Figure 6.1 can lead to the following issues:

- Improvement options are characterised by heterogeneous spectra of environmental profiles.
- With the exception of WM1 (increased capacity, unchanged loading), all other improvement options allow reducing impacts in some categories.
- Maximum reductions range from -10% (water, WM7 – improved drenching) to -46% (VOC, WM6 – hot-fill) depending on the impact category and option considered.

- WM5 and WM13 (Heat Pump) can allow reducing energy demand but present trade-offs for some categories (non-hazardous waste, POP, heavy metals). Trade-offs are registered also for WM12 (increased durability). This is mainly a consequence of the increased demand of materials for such options, partially compensated by the consideration of extended lifetime for WM12

Figure 6.1 reveals also that the environmental profile of some options is favourable for some impact categories, but less favourable for others. Therefore, without aiming at developing some weighting mechanism (which would however present some inherent limitations), it would be difficult to rank options without isolating specific indicators and LCC considerations. Table 6.6 ranks options based on the total demand of primary energy and other selected indicators:

- In terms of primary energy, demand ranges from 71% (WM6: hot-fill) to 105% (WM1: increased capacity with same loading conditions) of that assessed for the Base Case
- A similar ranking is generally observed also for GWP100. The exception is represented by WM5, i.e. the machine implementing a heat-pump that works with a conventional refrigerant (R134a, with a GWP-100 of 1430 kg CO_2-eq/kg), despite having assumed (based on current recycling practice of WM and WD where the share of heat pumps is marginal) that 64% of the whole load of refrigerant is released to the atmosphere. The impact for this category is however lower than for the Base Case.
- The choice of R134a as refrigerant is because of its widespread use for small compressors in household appliances, and excellent technical performance. However, in principle it is possible to construct heat pumps with other refrigerants, as is currently done for several commercial refrigeration applications. The impact for this category could be reduced by changing refrigerant (WM13: propane or isobutene, which have a GWP-100 of 3 kg CO_2-eq/kg). This development already took place in case of tumble dryers, where the first appliances with R290 (propane) as refrigerant are on the market. A challenge that has to be considered is that R290 is a flammable gas. Therefore, due to safety issues the amount of R290 loaded in the circuits may be limited. According to the European Standard EN 60335-2-24 or draft IEC 60335-2-89, which must be complied with, the refrigerant charge must not exceed 150g. In general the charge of R600a or R290 is approximately 40-50% by weight than that for HFC. Commercially available R600a and R290 must not be used because the fuel grades of these products are of a variable composition. These products may also contain impurities which could significantly reduce the reliability and performance of the system and lead to premature failure. Many commercial compressors for R600a and R290 need a high base purity (e.g. 97% or better). Impurity limits shall comply with DIN 8960 of 1998 (extended version of ISO 916). All users of refrigerant R600a should refer to the chemical data safety sheets for full information on the safe handling of R600a and R290.
- Possibilities for water saving appear more limited: -10% for WM7 (improved drenching), -5% for WM11 (consumer feedback on loading, full load), -4% for WM9 (automatic load detection). Water saving is not achieved with the most energy saving options. Water consumption increase by 7% for WM1: increased capacity with same loading conditions).
- The maximum energy saving potential has been estimated for the hot-fill option under the simplified assumption that all heating energy comes for free (solar heating) and without considering additional system aspects (i.e. heating system, alternative supply of energy, water supply network, losses of energy). It is thus to be considered as a maximum theoretical potential achievable with this option. In case of use of hot water from a boiler, similar results as for heat-fed WM would be obtained.

- Energy savings achievable through the extension of the standard cotton programme duration (WM3 and WM4) are limited because considered to apply only to a limited portion of programmes (i.e. the cotton standard programmes). If the frequency of use of standards programmes increases also the savings associated to this option would increase.
- Some unexploited energy saving potential seems associated to motors (WM2), drenching system (WM7), load detection mechanisms (WM9) and loading conditions (WM11 vs. WM1). Energy savings have been estimated to be more limited for higher spinning extraction and automatic detergent dosage
- Smart-grid ready products can lead to an increase of the electricity consumption for control and networked standby, but they could offer some saving potential at system level, depending on the electricity grid mix. The estimation of the overall savings is difficult and very dependent on regional/national conditions of the energy networks.
- WM1 (Increased capacity, unchanged loading) is not providing savings considering the loading conditions that would occur on average in real life. Savings would be achieved for this option only if loading is sufficiently increased, e.g. by coupling this option with WM11 (consumer feedback on loading).
- For the selected indicators, impacts per year of the more durable product are substantially comparable to the Base Case, although these depends on parameters (materials, lifetime, energy efficiency) which can vary broadly depending on product and user behaviour.

Table 6.6: Ranking of single improvement options for WM based on selected environmental indicators

Option	Total Energy (primary energy)	Water (process)	Greenhouse Gases (GWP100)
WM6: Hot-fill	71%	100%	73%
WM5: Heat Pump	74%	100%	93%
WM13: Heat pump (propane)	74%	100%	76%
WM13: Heat pump (isobutane)	74%	100%	76%
WM14: Heat-fed	85%	100%	86%
WM11: Consumer feedback on loading, full load	91%	95%	92%
WM7: Improved drenching	93%	90%	93%
WM4: Extension of std programme duration (extreme)	93%	100%	93%
WM9: Automatic load detection	94%	96%	95%
WM2: PM motor	95%	100%	95%
WM15: Smart grids	95%	100%	96%
WM3: Extension of std. programme duration (moderate)	96%	100%	96%
WM8: Higher spinning extraction	97%	100%	97%

WM10: Automatic detergent dosage	99%	100%	99%
Base Case	100%	100%	100%
WM12: Increased durability	100%	100%	98%
WM1: Increased capacity, unchanged loading	106%	107%	107%

6.2.2. LCC and payback time (PBT) calculation of single improvement options

LCC parameters and calculations for each improvement options are reported in Table 6.7. Based on such parameters, payback times (PBT) have been also quantified according to Eq. 6-1:

Eq. 6-1:

$PBT = - \Delta PC / \Delta OC$

Where,

- ΔPC = difference of total product costs (purchase price + repair and maintenance cost) between improvement option and base case
- ΔOC = difference of annual operating costs between improvement option and base case

The PBT has been calculated only when the ΔOC is negative, that is when the improvement option allows reducing the operating costs. A PBT has not been calculated for the cases in which operating costs increases, based on the assumptions made in the modelling.

In

Table 6.8, options have been ranked based on their PBT.

Table 6.7: LCC and PBT of single improvement options for WM

Option	PP (€)	MRC (€)	Tot. Prod. (€)	ΔOC (€/year)	Lifetime (years)	OC (€)	LCC (€)	LCC (€ norm to 1 year)	PBT (years)
Base Case	412	45	457	115	12.5	1438	1896	152	Ref.
WM1: Increased capacity, partial loading	490	45	535	121	12.5	1509	2044	164	*
WM2: PM motor	451	45	496	113	12.5	1409	1905	152	16.6
WM3: Extension of std. programme duration (moderate)	412	45	457	114	12.5	1422	1879	150	0.0
WM4: Extension of std. programme duration (extreme)	412	45	457	112	12.5	1397	1854	148	0.0
WM5: Heat Pump	996	45	1041	99	12.5	1233	2275	182	35.6
WM6: Hot-fill	490	45	535	98	12.5	1229	1765	141	4.7
WM7: Improved drenching	481	45	526	108	12.5	1350	1875	150	9.6
WM8: Higher spinning extraction	490	45	535	114	12.5	1430	1965	157	116.3
WM9: Automatic load detection	432	45	477	111	12.5	1390	1867	149	5.1
WM10: Automatic detergent dosage	510	45	555	108	12.5	1356	1911	153	14.7
WM11: Consumer feedback on loading	432	45	477	109	12.5	1361	1837	147	3.1
WM12: Increased durability	607	90	697	119	25	2977	3674	147	**
WM13: Heat pump (different refrigerant)	996	45	1041	99	12.5	1233	2275	182	35.6
WM14: Heat-fed	1502	45	1547	107	12.5	1334	2881	230	130.3
WM15: Smart grids	490	45	535	117	12.5	1468	2003	160	*

Note:

**) PBT not calculated because the investment on the technology is never recovered based on the assumptions made. Additional assumptions may reverse this (e.g. if they covers benefits of electricity tariffs for WM15, or savings from increased loading for WM1)*

***) PBT not calculated for 'WM12: increased durability' because not a continuous function (see below)*

Table 6.8: Ranking of single improvement options for WM based on PBT

Option	PBT (years)	Group	Comment
WM4: Extension of std. programme duration (extreme)	0.0	I	No added costs
WM3: Extension of std. programme duration (moderate)	0.0	I	No added costs
WM11: Consumer feedback on loading, full load	3.1	II	Economic investment recovered in few years
WM6: Hot-fill	4.7	II	Economic investment recovered in few years
WM9: Automatic load detection	5.1	II	Economic investment recovered in few years
WM7: Improved drenching	9.6	III	PBT lower than the lifetime of the product but comparable
WM10: Automatic detergent dosage	14.7	IV	PBT higher than the lifetime of the product but comparable
WM2: PM motor	16.6	IV	PBT higher than the lifetime of the product but comparable
WM5: Heat Pump	35.6	V	Long. PBT. Not promising alone, but providing extra savings in combination with other options
WM13: Heat pump (different refrigerant)	35.6	V	Long PBT. Not promising alone, but providing extra savings in combination with other options
WM8: Higher spinning extraction	116.3	V	Long PBT. Not promising alone, but providing extra savings in combination with other options
WM14: Heat-fed	130.3	V	Long PBT, not available on the market
WM15: Smart grids	N.C	VI	Economic investment not recovered without incentives / cheaper tariffs
WM1: Increased capacity, unchanged loading	N.C	VI	Economic investment recoverable only in combination with other options favouring full loading
WM12: Increased durability	N.C.	VII	Attractiveness of this option depends on energy efficiency, product cost, expected lifetime

The PBT calculation allows clustering options in different groups:

1. Improvement options that comes with no added costs (WM4, WM3)
2. Improvement options whose economic investment is recovered in few years (WM11, WM6, WM9)
3. Improvement options whose PBT is either lower (WM7) or higher (WM10, WM2) the estimated lifetime but comparable as order of magnitude
4. Improvement options whose economic investment can be recovered only after long time and that could be more appealing in combination with other options (WM5, WM13, WM8, WM14)
5. Options whose economic investment cannot be recovered without incentives or the consideration of other options/assumptions (e.g. cheaper electricity price for WM15 or increased loading conditions for WM1)

A PBT was not calculated for WM12 (increased durability) since the analysis of this option requires, for a fixed timeframe, the comparison between 2 scenarios, one of which requiring the early replacement of the product.
A simplified LCC comparison has been made between the Base Case, a more durable and expensive product and a cheaper product with shorter lifetime, based on the following simplified assumptions:

- Time horizon for the comparison: 25 years
- Cheap product: half of the product costs and half of the lifetime of the Base Case
- Durable product: product costs of EUR 697 (doubled to EUR 1,394 for sensitivity analysis), double lifetime than the BC (+50% than BC for sensitivity analysis)
- Higher energy efficiency for new products: +8% after 6.25 years, +15% after 12.5 years, +23% after 18.75 years

Results are shown in Figure 6.2, from which it can be observed that:

- Operation costs are similar, the key factors are the purchase price and the time of use of the appliance
- Comparable LCC considering a lifetime of 25 years and a total cost of EUR 697 for the more durable product.
- Similar LCC also before the earlier replacement of the more durable product.
- LCCs always higher when cost of durable product increased to 1,394 EUR

This simplified assessment points out the variability of scenarios associated with the analysis of the product's durability that depends, among the others, on: product costs, time of use and performance of analysed products.

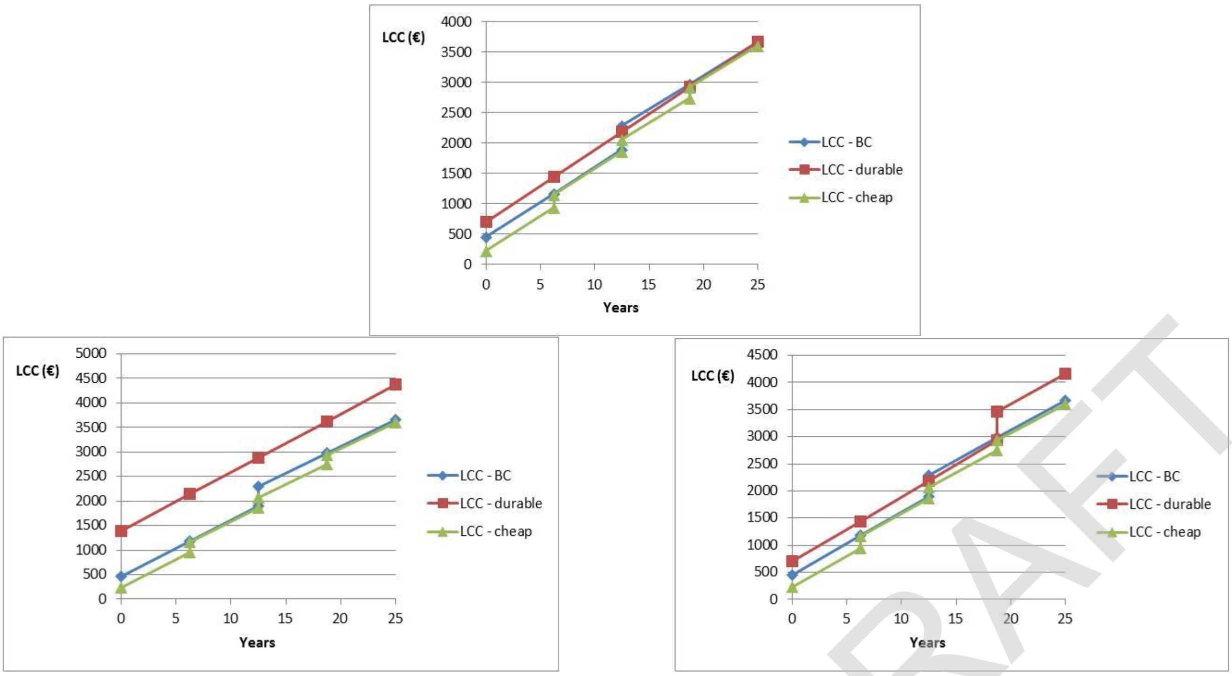

Figure 6.2: Streamlined LCC comparison between washing machines of different durability. Top: Baseline scenario with improved efficiency of new machines; bottom left: doubling the purchase price for the more durable product; bottom right: shortening the lifetime of the more durable product

6.2.3. Selection of improvement options

Figure 6.3 represents the primary energy consumption and the LCC, normalised per year of use, calculated for the single improvement options for WM.

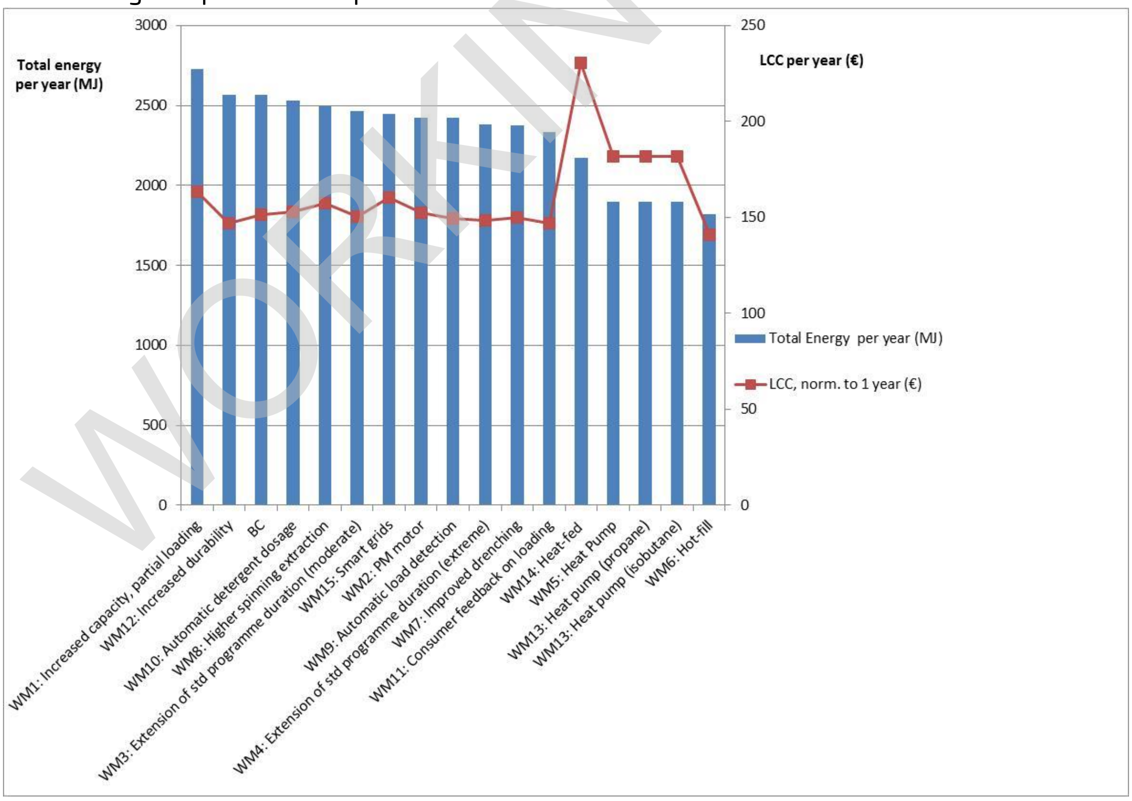

Figure 6.3: Primary energy consumption vs. LCC of single improvement options for WM

WM6 (hot-fill) is both the best available option in terms of energy savings and the option producing the least LCC and is selected for the further analysis of combinations of options. Additional options that appear interesting to analyse are:

- WM3 (Extension of standard programme duration, moderate scenario), WM4 (Extension of standard programme duration, extreme scenario), WM9 (Automatic load detection) and WM11 (Consumer feedback on loading) since they are relatively inexpensive solutions to save energy.
- WM2 (PM motor), WM7 (Improved drenching), WM8 (Higher spinning extraction) and WM10 (Automatic detergent dosage) since it provides additional energy savings with limited investment.
- WM5 (Heat Pump), since it produces significant energy savings (although increasing the LCC).
- WM1 (Increased capacity, unchanged loading), under the condition that the loading is increased.

Some options have been instead preliminarily set aside of further assessment:

- WM12 (Increased durability) since its rigorous analysis would require the detailed analysis of specific scenarios associated to the characteristics and the use of products. Increased durability requires in-depth knowledge of the appliance's material composition, dimensioning of components, likelihood of reparability with age, exact components affected, etc. It is also highly dependent on assumptions made on technology development including efficiency of the appliances that the non-durable machine would be replaced with instead of prolonging its lifetime.
- WM13 (Heat pump - different refrigerant), since some considerations on the type of refrigerant used are already done in this section. Regarding the non-F gas heat pump, it could be also worthy to undertake an investigation on the safety framework and its implications, as there are critical limits for the maximum loading of flammable HC refrigerants in appliances. If the load is exceeded, then the dimensioning of the refrigerant circuit and the whole appliance has to change to withstand e.g. refrigerant explosion tests.
- WM14 (Heat-fed), since representing a niche product that could increase the LCC excessively. For this option, the cost of the appliance's part has been estimated, but the costs of the heat provided (and the installation in the dwelling to deliver that to the machine) should be included too.
- WM15 (Smart-grid ready product), since it depends on the analysis of system aspects that are out of the scope of this study. The potential savings of smart grid operation are in fact dependent on specific boundary conditions of electricity supply.

However, should stakeholders point to specific sources of information that allow in-depth assessment of such options and extracting more robust conclusions, they can be re-considered for further assessment.

QUESTIONS BOX: SELECTION OF SINGLE IMPROVEMENT OPTIONS FOR WM

1. Do you agree with the **selection of single improvement options for WM** on the basis of the assessment performed?
2. Would you have additional information to provide to refine the analysis of **durability aspects**?
3. How the **design of heat pump systems** would be affected in case of using higher amounts / different types of refrigerants (specifically on the maximum loading of flammable HC refrigerants)?
4. Do you consider relevant to deepen the analysis of **heat-fed / smart grid ready machines**?
5. Which **additional refinements** would you consider for the other options?

6.3. Analysis of single improvement options for washer-dryers

Selected improvement options (BAT and BNAT) for WD and estimated variations compared to the BC are listed in Table 6.9. Resulting variation of the Ecoreport tool's input parameters are reported in Table 6.10.

The following options have not been analysed:

- WM13, related to the use of different refrigerants for the heat pump, since already discussed for washing machines.
- WD3 (BNAT), related to the parallel and potential implementation of heat pump technologies for both washing and drying.
- WD4 (BNAT), related to the implementation of energy storage system.
- WD5 (BNAT), related to central/district heating based drying.

QUESTIONS BOX: SINGLE IMPROVEMENT OPTIONS FOR WD

Please check the following Tables 6-9 and 6-10 carefully.

1. Does the **selection of improvement options** (BAT / BNAT) reflect the market developments appropriately? Do you think that any relevant design options should be further added to the analysis? Should some of the chosen improvement options be deleted from the analysis? Please explain your reasons.
2. Can the **assumptions made** (consumption, costs, materials, and lifetime) be considered to reflect appropriately the main changes of improvement options compared to the BC? Is there the need of any MAJOR changes?
3. If known, please provide us with **additional data on market and penetration potential** of single options.

Table 6.9: Selected improvement options (BAT and BNAT) for WD and estimated variations compared to the BC

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	**Water consumption**	**Detergent consumption**	**Lifetime**	**Manufacturing costs**	**Repair and maintenance costs**	**Materials**
WD-WMx: Implementation of improvement options of WM for the washing function	Variations estimated for WM apply to 34% of energy consumption of the BC (washing quota) Exceptions - for higher spin drying extraction, credits are assigned to 63% of the wash cycles resulting in 0.06 kWh/cycle (3% of the BC) - for increased durability and smart grid ready products the variation has been be applied to both washing and drying functions.	Variations estimated for WM apply to 79% of water consumption of the BC (washing quota)	Same as for WM	Same as for WM	Same as for WM	Same as for WM	Same as for WM
WD1: Air condensing system	Not affected	No water consumption in the drying phase, resulting in saving 21% of water compared to the BC	Not affected	Not affected	Up to +10 € (Fan, heat-exchanger)	Not affected	BOM not affected significantly
WD2: Heat-pump for the drying process	- 40 / - 70% of drying energy consumption (55% as average), resulting in saving 36% of the total energy consumed in the BC	No water consumption in the drying phase, resulting in saving 21% of water compared to the BC	Not affected	Not affected	+ 150 € (Heat pump, circulation and drainage pumps, heat exchangers, heat storage material (e.g. phase change material), tank, refrigerant)	Not affected	+13 kg (plastics: 2.8 kg, copper: 2.4 kg, steel: 7.7 kg) +150 / 200 g of refrigerant (175 g as average) HC refrigerants have important limitations of use if the refrigerant content is above 150 g, as much stricter safety conditions have to be met, resulting in additional testing, dimensioning of the system.
WD3 (BNAT): Heat pumps for washing and for drying	???	???	Not affected	Not affected	???	???	???
WD4 (BNAT): Energy storage system	???	???	Not affected	Not affected	???	???	???
WD5 (BNAT): Central/district heating	???	???	Not affected	Not affected	???	???	???

Improvement options (NOTE: new numbering used)	Variations compared to BC (%)						
	Energy consumption	Water consumption	Detergent consumption	Lifetime	Manufacturing costs	Repair and maintenance costs	Materials
based drying							

Table 6.10: Variation of input parameters for single improvement options for WD compared to the Real-life Base Case WD

Improvement option	Energy Cons.	Water Cons.	Detergent Cons.	Prod. costs (€)	Purchase price	Share of repaired machines	Maint. & repair costs over the lifetime (€)	Lifetime (years)	Weight of materials
Base Case WD	100%	100%	100%	212	100%	0.3	100%	12.5	100%
WD-WM1: Increased washing capacity, unchanged loading	103%	106%	100%	+20	109%	0.3	100%	12.5	121% (increased size)
WD-WM2: PM motor	98%	100%	100%	+10	109%	0.3	100%	12.5	100%
WD-WM3: Extension of std. programme duration (moderate)	99%	100%	100%	0	100%	0.3	100%	12.5	100%
WD-WM4: Extension of std. programme duration (extreme)	97%	100%	100%	0	100%	0.3	100%	12.5	100%
WD-WM5: Heat Pump	83%	100%	100%	+150	171%	0.3	100%	12.5	119% (heat pump)
WD-WM6: Hot-fill	83%	100%	100%	+20	109%	0.3	100%	12.5	100%
WD-WM7: Improved drenching	97%	92%	100%	+17.5	108%	0.3	100%	12.5	100%
WD-WM8: Higher spinning extraction	99%	100%	100%	+20	109%	0.3	100%	12.5	100%
WD-WM9: Automatic load detection	98%	97%	100%	+5	102%	0.3	100%	12.5	100%
WD-WM10: Automatic detergent dosage	100%	100%	85%	+25	112%	0.3	100%	12.5	100%
WD-WM11: Consumer feedback on loading, full load	96%	96%	100%	+5	102%	0.3	100%	12.5	100%
WD-WM12: Increased durability	112%	100%	100%	+50	124%	0.6 since lifetime is doubled	200%	25	143% (increased amounts)
WD-WM14: Heat-fed	92%	100%	100%	+280	232%	0.3	100%	12.5	100%
WD-WM15: Smart grids	107%	100%	100%	+20	109%	0.3	100%	12.5	100%
WD1: Air condensing system	100%	79%	100%	+10	105%	0.3	100%	12.5	100%
WD2: Heat Pump – drying	64%	79%	100%	+150	171%	0.3	100%	12.5	119% (heat pump)

6.3.1. Environmental impacts

Life cycle impacts of washer-dryers implementing single improvement options for WM/WD, expressed per year of use with respect to the Base Case WD (=100%), are shown in Table 6.11 and in Figure 6.4.

Table 6.11: Life cycle impacts of washer-dryers implementing single improvement options for WM/WD expressed per year of use with respect to the Base Case WD (=100%)

Indicator	WD1	WD2	WD-WM1	WD-WM2	WD-WM3	WD-WM4	WD-WM5	WD-WM6	WD-WM7	WD-WM8	WD-WM9	WD-WM10	WD-WM11	WD-WM12	WD-WM14	WD-WM15
Total Energy (primary energy)	100%	73%	104%	98%	99%	98%	88%	87%	98%	99%	98%	98%	97%	107%	94%	96%
Electricity (primary energy)	100%	66%	104%	98%	99%	97%	84%	84%	97%	99%	98%	100%	96%	111%	92%	95%
Water (process)	79%	79%	106%	100%	100%	100%	100%	100%	92%	100%	97%	100%	96%	100%	100%	100%
Water (cooling)	100%	92%	113%	99%	100%	99%	101%	92%	99%	100%	99%	100%	98%	90%	96%	98%
Waste, non-haz./ landfill	100%	97%	113%	99%	100%	99%	104%	94%	99%	100%	99%	99%	99%	88%	97%	98%
Waste, hazardous/ incin.	100%	75%	104%	99%	99%	98%	90%	87%	98%	99%	98%	98%	97%	106%	94%	96%
GWP100	100%	83%	104%	99%	99%	98%	98%	87%	98%	99%	98%	98%	97%	105%	94%	96%
Acidification, emissions	100%	81%	106%	99%	99%	98%	94%	88%	98%	99%	99%	98%	97%	103%	94%	97%
VOC	100%	64%	103%	98%	99%	97%	84%	84%	97%	99%	98%	100%	96%	111%	92%	95%
POP	100%	110%	118%	100%	100%	99%	114%	97%	99%	100%	100%	101%	99%	79%	98%	99%
Heavy Metals	100%	101%	121%	100%	100%	100%	104%	97%	99%	100%	100%	102%	99%	74%	99%	99%
PAHs	100%	90%	110%	99%	100%	99%	99%	92%	98%	100%	99%	100%	98%	90%	96%	98%
PM, dust	100%	98%	105%	100%	100%	100%	100%	98%	100%	100%	100%	100%	100%	61%	99%	100%
Heavy Metals	100%	100%	121%	100%	100%	100%	102%	98%	100%	100%	100%	101%	100%	73%	99%	99%
Eutrophication	100%	100%	105%	100%	100%	100%	101%	100%	100%	100%	100%	89%	100%	94%	100%	100%

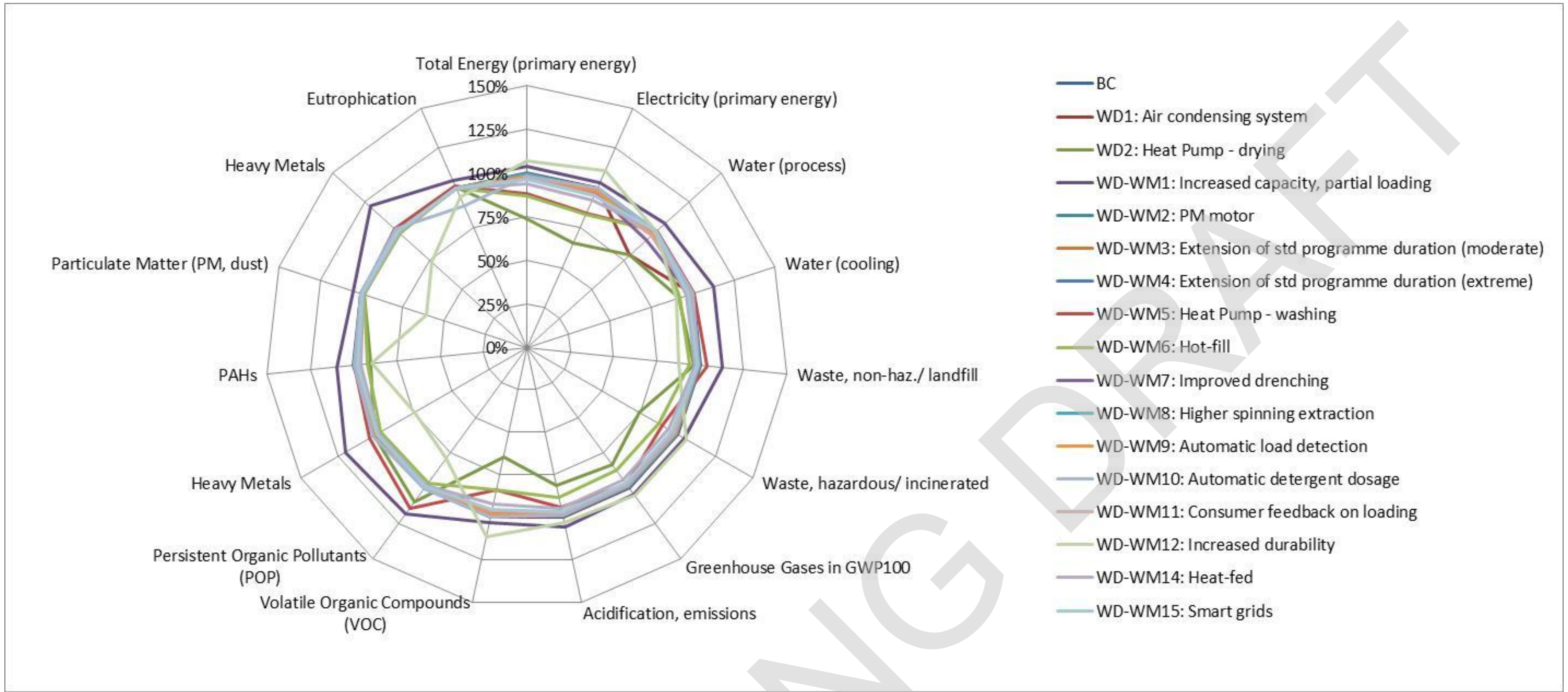

Figure 6.4: Lifecycle impacts of single improvement options for WD expressed per year of use with respect to the Base Case WD (=100%) – spider diagram

The analysis as shown in Figure 6.4 above points out that:

- Improvement options are characterised by heterogeneous spectra of environmental profiles.
- The considerations made for WM can be generally extended also to the washing function of WD. However, for energy issues and impacts related to that, the drying function of a WD has larger impacts than washing.
- With the exception of WD-WM1 (increased washing capacity, unchanged loading), all other improvement options allow reducing impacts in some categories.
- Maximum reductions range from -10% (PAH, WD2 – Heat pump for drying) to -39% (heavy metals to water, WD-WM12 – increased durability) depending on the impact category and option considered.
- WD2 (Heat pump for drying) and WD-WM5 (Heat pump for washing) can allow reducing energy demand but also present trade-offs (WD2 for POP, WD-WM5 for non-hazardous waste, POP, heavy metals and eutrophication). Trade-offs are registered also for WD-WM12 (increased durability). This is mainly a consequence of the increased demand of materials for such options, partially compensated by energy saving for WD2 and WD-WM5 and by the consideration of extended lifetime for WD-WM12

Figure 6.4 reveals also that the environmental profile of some options is favourable for some impact categories, but less favourable for others. Therefore, without aiming at developing some weighting mechanism (which would however present some inherent limitations), it would be difficult to rank options without focusing on specific indicators and LCC considerations.

Table 6.12 ranks options based on the total demand of primary energy and other selected indicators:

- In terms of primary energy, demand ranges from 73% (WD2: heat pump for drying) to 107% (WD-WM12: increased durability) of that assessed for the Base Case
- A similar ranking is generally observed also for GWP100. The exception is represented by WD-WM5, i.e. the machine implementing a heat-pump for washing that works with a conventional refrigerant. However, impact for this category is lower than for the Base Case. The use of alternative refrigerants may add benefits in terms of GWP, as shown for washing machines
- Significant possibilities for water saving rely on different drying systems: -21% through either WD1 (air condensing system for drying) or WD2 (heat pump for drying). Water saving through other options appears more limited: -8% for WD-WM7 (improved drenching), -4% for WD-WM11 (consumer feedback on loading, full load), -3% for WD-WM9 (automatic load detection). With the exception of the drying technologies, water saving is not achieved with the other most interesting energy saving options. Water consumption increase by 6% for WM1: increased washing capacity with same loading conditions)
- Same considerations made for washing machines apply here for hot-fill (WD-WM6), extension of the cotton standard programme duration (WDWM3 and WD-WM4), unexploited energy saving potential seems associated to motors (WD-WM2), drenching system (WD-WM7), load detection mechanisms (WD-WM9), loading conditions (WD-WM11 vs. WD-WM1), higher spinning extraction (WD-WM8) and automatic detergent dosage (WD-WM10). The relative impact of such options in washer-dryers is however lower than for washing machines because of the greater relevance of the drying process.
- Same considerations made for washing machines apply here also for WD-WM15 (smart grids ready products), WD-WM1 (Increased capacity, unchanged loading), WD-WM12 (increased durability).

Table 6.12: Ranking of single improvement options for WD based on selected environmental indicators

Improvement option	Total Energy (primary energy)	Water (process)	Greenhouse Gases in GWP100
BC	100%	100%	100%
WD2: Heat Pump - drying	73%	79%	83%
WD-WM6: Hot-fill	87%	100%	87%
WD-WM5: Heat Pump - washing	88%	100%	98%
WD-WM14: Heat-fed	94%	100%	94%
WD-WM15: Smart grids ready products	96%	100%	96%
WD-WM11: Consumer feedback on loading, full load	97%	96%	97%
WD-WM7: Improved drenching	98%	92%	98%
WD-WM4: Extension of std programme duration (extreme)	98%	100%	98%
WD-WM10: Automatic detergent dosage	98%	100%	98%
WD-WM9: Automatic load detection	98%	97%	98%
WD-WM2: PM motor	98%	100%	99%
WD-WM3: Extension of std. programme duration (moderate)	99%	100%	99%
WD-WM8: Higher spinning extraction	99%	100%	99%
WD1: Air condensing system	100%	79%	100%
WD-WM1: Increased washing capacity, unchanged loading	104%	106%	104%
WD-WM12: Increased durability	107%	100%	105%

6.3.2. LCC and payback time (PBT) of single improvement options

LCC parameters and calculations for each improvement options are reported in Table 6.13. Based on such parameters, payback times (PBT) have been also quantified according to Eq. 6-1.
Options have been ranked based on their PBT in Table 6.14.

Table 6.13: LCC and PBT of single improvement options for WD

Option	PP (€)	MRC (€)	Tot. Prod. (€)	AOC (€/year)	Lifetime (years)	OC (€)	LCC (€)	LCC (€ norm to 1 year)	PBT (years)
Base Case	825	45	870	186	12.5	2330	3200	256	Ref.
WD-WM1: Increased washing capacity, unchanged loading	903	45	948	192	12.5	2399	3347	268	*
WD-WM2: PM motor	864	45	909	184	12.5	2302	3211	257	17.3
WD-WM3: Extension of std programme duration (moderate)	825	45	870	185	12.5	2314	3184	255	0.0
WD-WM4: Extension of std programme duration (extreme)	825	45	870	183	12.5	2290	3160	253	0.0
WD-WM5: Heat Pump - washing	1409	45	1454	171	12.5	2133	3586	287	37.0
WD-WM6: Hot-fill	903	45	948	170	12.5	2129	3077	246	4.8
WD-WM7: Improved drenching	893	45	938	179	12.5	2243	3181	254	9.8
WD-WM8: Higher spinning extraction	903	45	948	185	12.5	2315	3263	261	63.2
WD-WM9: Automatic load detection	844	45	889	183	12.5	2283	3173	254	5.2
WD-WM10: Automatic detergent dosage	922	45	967	180	12.5	2248	3215	257	14.7
WD-WM11: Consumer feedback on loading, full load	844	45	889	180	12.5	2254	3144	251	3.2
WD-WM12: Increased durability	1019	90	1109	198	25	4944	6054	242	**
WD-WM14: Heat-fed	1914	45	1959	178	12.5	2229	4189	335	135.3
WD-WM15: Smart grids	903	45	948	193	12.5	2413	3361	269	*
WD1: Air condensing system	864	45	909	176	12.5	2205	3114	249	3.9
WD2: Heat Pump - drying	1409	45	1454	142	12.5	1779	3232	259	13.2

Note:

**) PBT not calculated. The investment on the technology is never recovered based on the assumptions made. Additional assumptions may reverse this (e.g. if they covers benefits of electricity tariffs for WD-WM15, or savings from increased loading for WD-WM1)*

***) PBT not calculated for 'WD-WM12: increased durability' because not a continuous function (see below)*

Table 6.14: Ranking of single improvement options for WD based on PBT

Option	PBT (years)	Group	Comment
WD-WM3: Extension of std. programme duration (moderate)	0.0	I	No added costs
WD-WM4: Extension of std. programme duration (extreme)	0.0	I	No added costs
WD-WM11: Consumer feedback on loading, full load	3.2	II	Economic investment recovered in few years
WD1: Air condensing system	3.9	II	Economic investment recovered in few years
WD-WM6: Hot-fill	4.8	II	Economic investment recovered in few years
WD-WM9: Automatic load detection	5.2	II	Economic investment recovered in few years
WD-WM7: Improved drenching	9.8	III	PBT lower but comparable to the estimated lifetime of the product
WD2: Heat Pump – drying	13.2	IV	PBT higher but comparable to the estimated lifetime of the product
WD-WM10: Automatic detergent dosage	14.7	IV	PBT higher but comparable to the estimated lifetime of the product
WD-WM2: PM motor	17.3	IV	PBT higher but comparable to the estimated lifetime of the product
WD-WM5: Heat Pump - washing	37.0	V	Long. PBT. Not promising alone, but providing extra savings in combination with other options
WD-WM8: Higher spinning extraction	63.2	V	Long. PBT. Not promising alone, but providing extra savings in combination with other options
WD-WM14: Heat-fed	135.3	V	Long PBT, not available on the market
WD-WM15: Smart grids	NC	VI	Economic investment not recovered without incentives / cheaper tariffs
WD-WM1: Increased washing capacity, unchanged loading	NC	VI	Economic investment recoverable only in combination with other options favouring full loading
WD-WM12: Increased durability	NC	VII	Attractiveness of this option depends on energy efficiency, product cost, expected lifetime

The PBT calculation allows clustering options in different groups:

1. Improvement options that comes with no added costs (WD-WM4, WD-WM3)
2. Improvement options whose economic investment is recovered in few years (WD-WM11, WD1, WD-WM6, WD-WM9)
3. Improvement options whose PBT is either lower (WD-WM7) or higher (WD2, WD-WM10, WD-WM2) the estimated lifetime but comparable as order of magnitude
4. Improvement options whose economic investment can be recovered only after long time and that could be more appealing in combination with other options (WD-WM5, WD-WM8, WD-WM14)
5. Options whose economic investment cannot be recovered without incentives or the consideration of other options/assumptions (e.g. cheaper electricity price for WD-WM15 or increased loading conditions for WD-WM1)

All in all, the same considerations made for WM apply here, with the difference that the alternative condensing systems also play an important role:

- The economic investment for air condensing system recovered in few years

- The economic investment for application of heat pump to the drying process recovered after about 1 lifetime

As for washing machines, a PBT was not calculated for WD-WM12 (increased durability) since the analysis of this option requires, for a fixed timeframe, the comparison between 2 scenarios, one of which requiring the early replacement of the product. A simplified LCC comparison has been made between the Base Case, a more durable and expensive product and a cheaper product with shorter lifetime, based on the following simplified assumptions:

- Time horizon for the comparison: 25 years
- Cheap product: half of the product costs and half of the lifetime of the Base Case
- Durable product: product costs of EUR 1,109 (doubled to EUR 2,219 for sensitivity analysis), double lifetime than the BC (+50% than BC for sensitivity analysis)
- Higher energy efficiency for new products: +8% after 6.25 years, +15% after 12.5 years, +23% after 18.75 years

Results are shown in Figure 6.5, from which the same observations made for washing machines can be drawn.

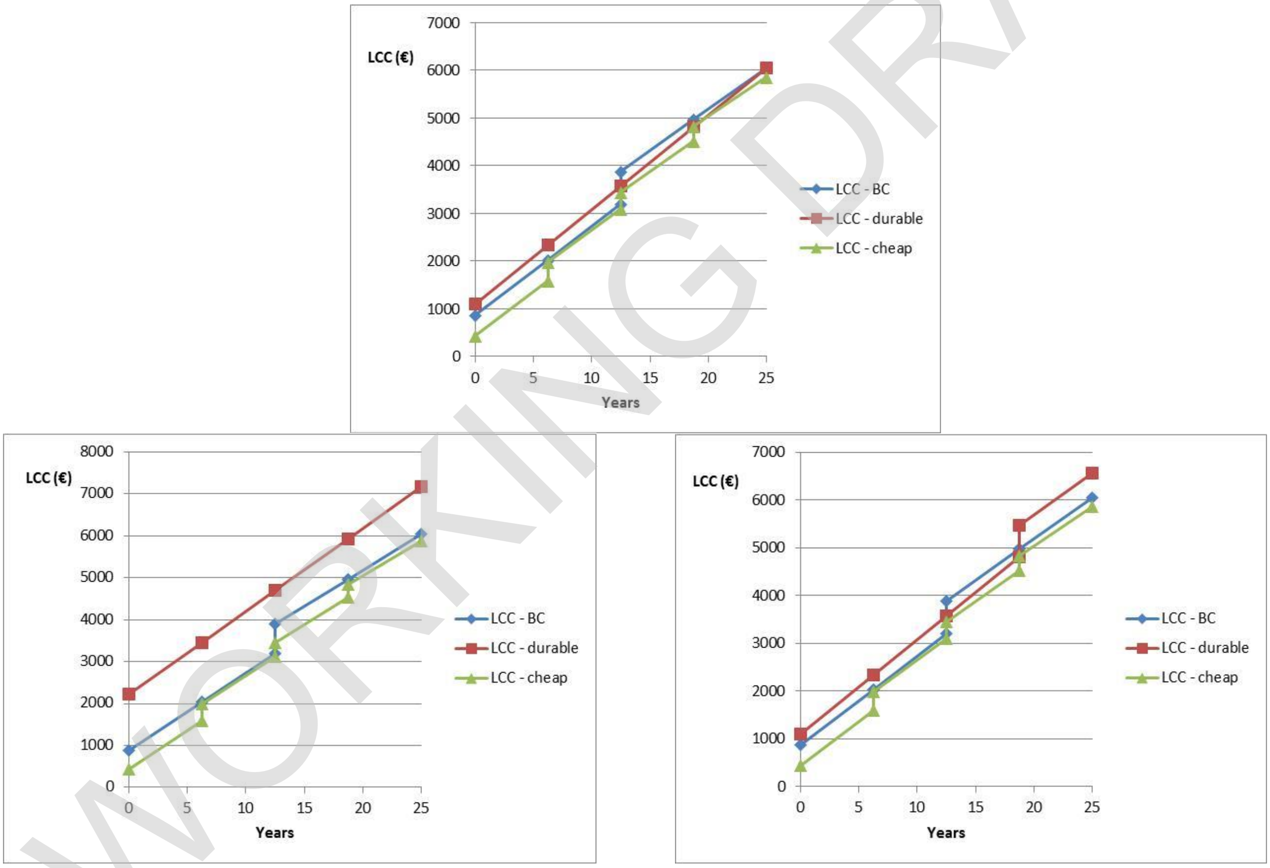

Figure 6.5: Streamlined LCC comparison between washer-dryers of different durability. Top: Baseline scenario with improved efficiency of new machines; bottom left: doubling the purchase price for the more durable product; bottom right: shortening the lifetime of the more durable product

6.3.3. Selection of improvement options

Figure 6.6 represents the primary energy consumption and the LCC, normalised per year of use, calculated for the single improvement options for WD.
WD2 (heat pump for drying) is the best available option in terms of energy savings. The option producing the least LCC is instead WD-WM6 (hot-fill). These are selected for the further analysis of combinations of options. Additional options that appear interesting to analyse are:

- WD1 (air condensing system), WD-WM3 (Extension of standard programme duration, moderate scenario), WD-WM4 (Extension of standard programme duration, extreme scenario), WD-WM9 (Automatic load detection) and WD-WM11 (Consumer feedback on loading) since relatively 'cheap' solutions to save water and/or energy
- WD-WM2 (PM motor), WD-WM7 (Improved drenching), WD-WM8 (Higher spinning extraction) and WD-WM10 (Automatic detergent dosage) since providing additional energy savings with limited investment
- WD-WM5 (Heat Pump), since producing significant energy savings (although less, compared to heat pump application to the drying process)
- WD-WM1 (Increased washing capacity, unchanged loading), under the condition that the loading is increased

Other options (WD-WM12: Increased durability; WM14: Heat-fed; WM15: Smart grids ready product) have been instead preliminarily discarded, in analogy with washing machines.

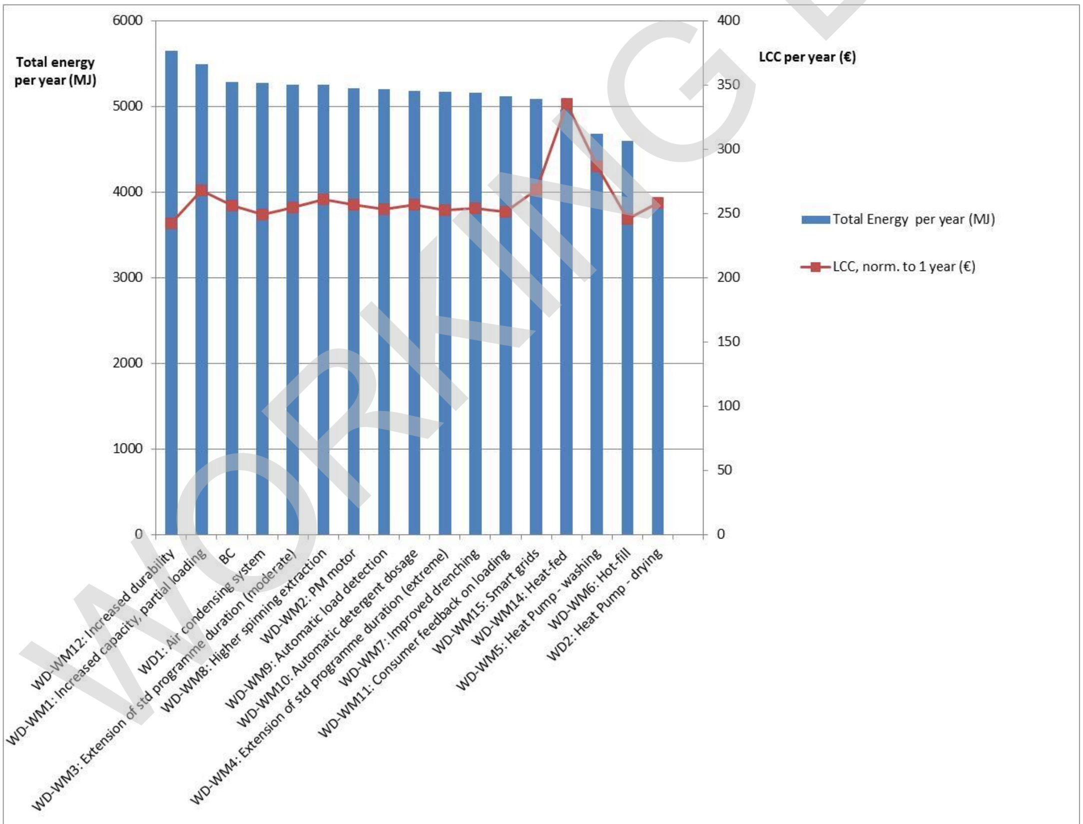

Figure 6.6: Primary energy consumption vs. LCC of single improvement options for WD

QUESTIONS BOX: SELECTION OF SINGLE IMPROVEMENT OPTIONS FOR WD

1. Do you agree with the **selection of single improvement options for WDM** on the basis of the assessment performed?
2. Which **additional options** would you assess/consider?

6.4. Combination of improvement options: Best Available Products (BAPs) for WM

Based on the analysis of the single improvement options, combinations of options forming 'virtual Best Available Products' have been selected and further analysed. Combinations of options selected for washing machines are shown in

Table 6.15 and include:

1. WM-C1 = WM3 + WM9 + WM11 (base case improved implementing improvement options with lower PBTs)
2. WM-C2 = WM3 + WM9 + WM11 + WM6 (base case improved implementing improvement options with lower PBTs and hot-fill)
3. WM-C3 = WM3 + WM9 + WM11 + WM5 (base case improved implementing improvement options with lower PBTs and heat-pump)
4. WM-C4 = WM2 + WM3 + WM7 + WM8 + WM9 +WM10 + WM11 (top product implementing a broad range of improvement options)
5. WM-C5 = WM2 + WM3 + WM7 + WM8 + WM9 +WM10 + WM11 + WM6 (top product implementing a broad range of improvement options including also hot-fill)
6. WM-C6 = WM2 + WM4 + WM7 + WM8 + WM9 +WM10 + WM11 + WM6 (top product implementing a broad range of improvement options including also hot-fill and extreme duration of the standard cotton programmes)
7. WM-C7 = WM2 + WM3 + WM7 + WM8 + WM9 +WM10 + WM11 + WM5 (top product implementing a broad range of improvement options including also heat-pump)
8. WM-C8 = WM3 + WM9 + WM11 + WM1 (base case with increased rated capacity, implementing improvement options with lowest PBTs, increased loading conditions)
9. WM-C9 = WM7 + WM9 + WM10 + WM11 (medium-high product, limited duration of the cotton standard programmes, implementing improvement options with low PBTs BUT not hot-fill nor heat-pump)
10. WM-C10 = WM7 + WM9 + WM10 + WM11 + WM2 + WM8 (medium-high product, limited duration of the cotton standard programmes, implementing a broad range of improvement options BUT not hot-fill nor heat-pump)

QUESTIONS BOX: COMBINATIONS OF IMPROVEMENT OPTIONS FOR WM

Please check the following Tables 6-15 and 6-16 carefully.

1. Do the **selected combinations of improvement options** reflect the market developments appropriately? Do you think that any relevant combinations should be further added to the analysis? Should some of the chosen combinations be deleted from the analysis? Please explain your reasons.
2. Can the **assumptions made** (consumption, costs, materials, and lifetime) be considered to reflect appropriately the main changes of possible design options on the market compared to the BC? Is there the need of any MAJOR changes?

Table 6.15: Combinations of improvement options selected for WM

Improvement option	WM-C1	WM-C2	WM-C3	WM-C4	WM-C5	WM-C6	WM-C7	WM-C8	WM-C9	WM-C10
WM1: Increased capacity (increased loading if coupled with WM11)								X		
WM2: PM motor				X	X	X	X			X
WM3: Extension of std. programme duration (moderate)	X	X	X	X	X		X			
WM4: Extension of std. programme duration (extreme)						X				
WM5: Heat Pump			X				X			
WM6: Hot-fill		X			X	X				
WM7: Improved drenching				X	X	X	X		X	X
WM8: Higher spinning extraction				X	X	X	X			X
WM9: Automatic load detection	X	X	X	X	X	X	X	X	X	X
WM10: Automatic detergent dosage				X	X	X	X		X	X
WM11: Consumer feedback on loading, +50% of loading	X	X	X	X	X	X	X	X	X	X
WM12: Increased durability										
WM13: Heat pump (different refrigerant)										
WM14: Heat-fed										
WM15: Smart grids										

The following modelling assumptions have been made:

1. The savings associated to the selected combinations has been estimated through the adaptation and tuning of the models used for the assessment of base cases and single improvement options
2. The changes in material composition, the additional manufacturing costs and changes in maintenance and repair are assumed to be the sum of the changes of the single design options.
3. It is assumed that the combinations of options do not result in additional changes (e.g. life time).
4. The consumer feedback mechanism (WM11) lead to increase loading by 50% (instead to consider full loading as done previously for the single improvement option). As a consequence, if coupled with such option, partial load consumption values are set at least 12.5% lower than full load consumption values for WM9 (automatic load detection). 25% was formerly considered for the single improvement option WM9 in condition of half loading. The 25% correction factor has been kept for combination WM-C8 (increased rated capacity from 7 to 9 kg, +50% loading, and automatic load detection).

Table 6.16 provides an overview of the variations estimated for the selected combinations of options for WM compared to the BC.

Table 6.16: Variations estimated for the combination options selected for WM compared to the BC

Design Option	Energy Cons.	Water Cons.	Detergent Cons.	Prod. costs (€)	Purchase price	Share of repaired machines	Maint. & repair costs over the lifetime	Lifetime (years)	Weight of materials
Base Case	100%	100%	100%	106	100%	0.3	100%	12.5	100%
WM-C1	80% (76%)	85% (91%)	100%	+10	109%	0.3	100%	12.5	100%
WM-C2	40% (26%)	85% (91%)	100%	+30	109%	0.3	100%	12.5	100%
WM-C3	41% (27%)	85% (91%)	100%	+160	251%	0.3	100%	12.5	119% (heat pump)
WM-C4	65% (57%)	76% (81%)	85%	+82.5	178%	0.3	100%	12.5	100%
WM-C5	32% (7%)	76% (81%)	85%	+102.5	197%	0.3	100%	12.5	100%
WM-C6	30% (1%)	76% (81%)	85%	+102.5	319%	0.3	100%	12.5	100%
WM-C7	33% (8%)	76% (81%)	85%	+232.5	197%	0.3	100%	12.5	119% (heat pump)
WM-C8	74% (85%)	75% (98%)	100%	+30	128%	0.3	100%	12.5	121% (increased size)
WM-C9	74% (70%)	76% (81%)	85%	+52.5	150%	0.3	100%	12.5	100%
WM-C10	67% (61%)	76% (81%)	85%	+82.5	178%	0.3	100%	12.5	100%

Note: within brackets, variations that would have been calculated by adding linearly the contributions of single improvement options

6.4.1. Environmental impacts

Life cycle impacts of selected combinations of improvement options for washing machines, expressed per year of use with respect to the Base Case WM (=100%), are shown in Table 6.17 and in Figure 6.7.

Table 6.17: Life cycle impacts of combinations of improvement options selected for washing machines expressed per year of use with respect to the Base Case WM (=100%)

Indicator	WM-C1	WM-C2	WM-C3	WM-C4	WM-C5	WM-C6	WM-C7	WM-C8	WM-C9	WM-C10
Total Energy (primary energy)	85%	65%	68%	79%	61%	60%	64%	86%	84%	80%
Electricity (primary energy)	78%	46%	47%	68%	38%	36%	40%	77%	76%	70%
Water (process)	91%	85%	85%	76%	76%	76%	76%	75%	76%	76%
Water (cooling)	94%	85%	94%	91%	83%	83%	92%	109%	93%	92%
Waste, non-haz./ landfill	95%	89%	103%	93%	88%	87%	101%	110%	95%	94%
Waste, hazardous/ incinerated	85%	67%	71%	80%	63%	62%	67%	88%	85%	81%
Greenhouse Gases in GWP100	86%	67%	88%	80%	63%	62%	84%	89%	85%	81%
Acidification, emissions	88%	72%	83%	83%	68%	67%	79%	93%	87%	84%
Volatile Organic Compounds (VOC)	79%	44%	45%	67%	36%	35%	38%	75%	75%	69%
Persistent Organic Pollutants (POP)	97%	95%	117%	97%	94%	94%	116%	118%	98%	97%
Heavy Metals	99%	97%	106%	98%	96%	96%	105%	122%	99%	98%
PAHs	97%	85%	96%	91%	83%	82%	94%	105%	93%	91%
Particulate Matter (PM, dust)	99%	98%	99%	99%	98%	98%	99%	104%	99%	99%
Heavy Metals	100%	98%	103%	99%	98%	97%	102%	122%	99%	99%
Eutrophication	94%	95%	96%	96%	95%	95%	97%	99%	96%	96%

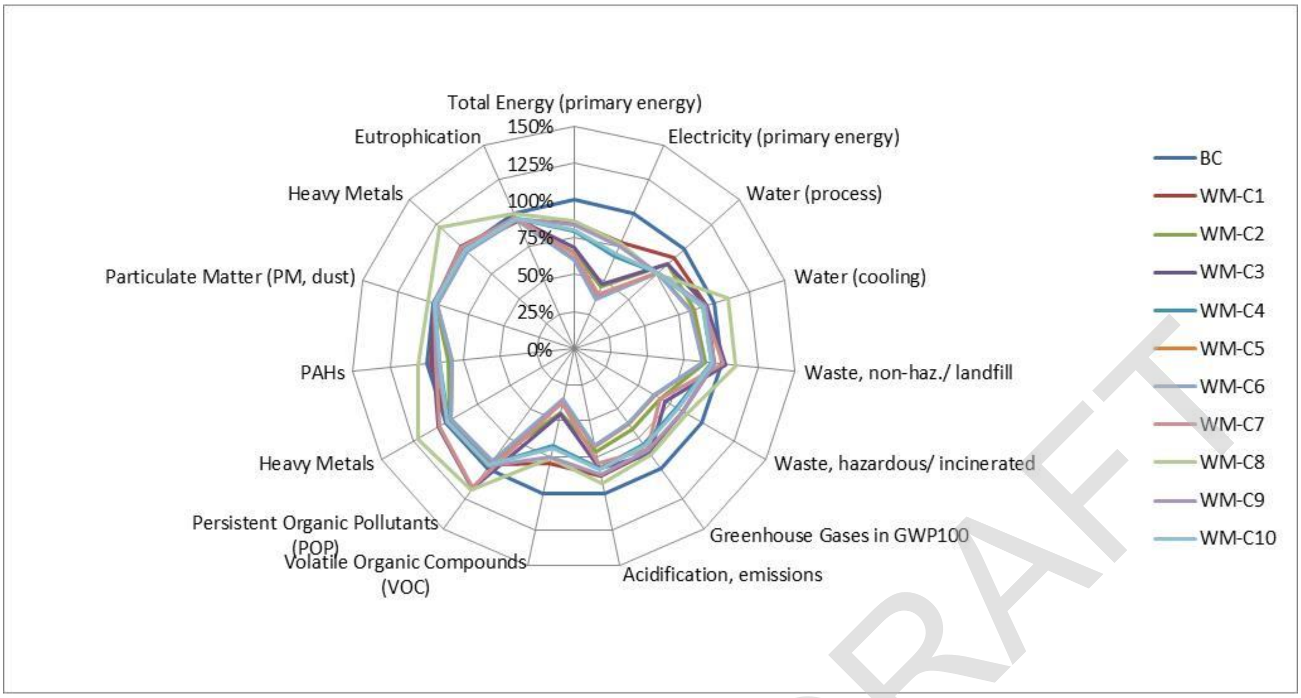

Figure 6.7: Life cycle impacts per year of combinations of improvement options selected for WM with respect to the Base Case WM (=100%) – spider diagram

The analysis in Figure 6.7 above points out that:

- All assessed combinations result to allow energy saving although they are characterised by heterogeneous spectra of environmental profiles
- WM-C5, WM-C7 and WM-C8 can allow reducing energy demand but present trade-offs for some categories (non-hazardous waste, POP, heavy metals). Trade-offs are due to the increased demand of materials for such options (a heat pump system is implemented in WM-C5 and WM-C7; size of the appliance is increased for WM-C8)
- Other combinations allow reducing potential impacts in all environmental categories
- Maximum reductions range from -2% (PM, design options with hot-fill: WM-C2, WM-C5, WM-C6) to -65% (VOC, WM-C6 – top model with hot-fill and extreme extension of the standard cotton programme duration) depending on the impact category and design option considered

Figure 6.7 reveals also that the environmental profile of some options is low on some impact categories, but higher on others. Therefore, without aiming at developing some weighting (which would however present some inherent limitations), it would be difficult to rank design options without analysing individually specific indicators and LCC considerations. Table 6.18 ranks options based on the total demand of primary energy and other selected indicators:

- In terms of primary energy, demand ranges from 60% (WM-C6: top model with hot-fill and extreme extension of the standard cotton programme duration) to 86% (WM-C8: base case with increased capacity and loading conditions) of that assessed for the Base Case
- A similar ranking is generally observed also for GWP100. The exception is represented by WM-C3 and WM-C7, i.e. the machines implementing a heat-pump that works with a conventional refrigerant. However, impact for this category is lower than for the Base Case. The use of alternative refrigerants may add benefits in terms of GWP, as shown in the analysis of single improvement options for washing machines.
- Possibilities for water saving appear more contained than for energy: from -9% for WM-C1 (base case with few 'cheap' improvement options) to -24% for combinations implementing a broad range of improvement options

- High energy savings are generally achievable through the implementation of hot-fill (WM-C6, WM-C5, WM-C2) or heat pumps (WM-C7, WM-C3), which currently represent a niche market. The maximum energy saving potential has been estimated for combination WM-C5 and WM-C6 (top models with hot-fill and moderate/extreme extension of the standard cotton programme duration). In the case of hot-fill, it is assumed that all heating energy comes for free (solar heating) and without considering additional system aspects (i.e. heating system, alternative supply of energy, water supply network, losses of energy). This is thus to be considered as a maximum theoretical potential achievable for this option.
- The extension of the standard cotton programme duration (implemented in all combinations less WM-C9 and WM-C10) can add some additional energy saving but its use in real life conditions would depend on the willingness-to-wait of consumers.
- Significant savings can be achieved also through design options where hot-fill, heat pump, nor extended standard cotton programmes duration are applied: WMC1 (-15% energy, -9% water), WM-C9 (-16% energy, -24% water), WM-C10 (-20% energy, -24% water). Savings are higher when the duration of the standard cotton programmes is included (WM-C4).
- WM-C8 shows the potential benefits that can be achieved by increasing appliance size and loading of the Base Case (-14% energy, -25% water). This is however related to implementation of specific improvement options that can have an influence on the user behaviour (e.g. WM11: consumer feedback on loading).

Table 6.18: Ranking of combinations of improvement options for WM based on selected environmental indicators

Design option	Total Energy (GER)	Water (process)	Greenhouse Gases in GWP100
WM-C6	60%	76%	62%
WM-C5	61%	76%	63%
WM-C7	64%	76%	84%
WM-C2	65%	85%	67%
WM-C3	68%	85%	88%
WM-C4	79%	76%	80%
WM-C10	80%	76%	81%
WM-C9	84%	76%	85%
WM-C1	85%	91%	86%
WM-C8	86%	75%	89%
BC	100%	100%	100%

6.4.2. LCC and payback time (PBT) calculation of combinations of improvement options

LCC parameters and calculations for each design options are reported in Table 6.19. Based on such parameters, payback times (PBT) have been also quantified according to Eq. 6-1.

Table 6.19: LCC and PBT of combinations of improvement options selected for WM

Design Option	PP (€)	MRC (€)	Tot. Prod. (€)	AOC (€/year)	Lifetime (years)	OC (€)	LCC (€)	LCC (€ norm to 1 year)	PBT (years)	Option
BC	412	45	457	115	12.5	1438	1896	152	Ref	Base Case
WM-C1	451	45	496	103	12.5	1284	1781	142	3.2	Base case improved implementing improvement options with lower PBTs
WM-C2	529	45	574	89	12.5	1117	1691	135	4.5	Base case improved implementing improvement options with lower PBTs and hot-fill
WM-C3	1035	45	1080	90	12.5	1121	2201	176	24.5	Base case improved implementing improvement options with lower PBTs and heat-pump
WM-C4	733	45	778	88	12.5	1097	1875	150	11.7	Top product implementing a broad range of improvement options
WM-C5	811	45	856	77	12.5	959	1815	145	10.4	Top product implementing a broad range of improvement options including also hot-fill
WM-C6	811	45	1362	76	12.5	950	1807	145	10.2	Top product implementing a broad range of improvement options including also hot-fill and extreme duration of the standard cotton programmes
WM-C7	1317	45	856	77	12.5	963	2325	186	23.8	Top product implementing a broad range of improvement options including also heat-pump
WM-C8	529	45	574	97	12.5	1212	1786	143	6.5	Base case, increased rated capacity and load, implementing improvement options with lowest PBTs
WM-C9	617	45	662	91	12.5	1134	1796	144	8.4	Medium-high product, limited duration of the cotton standard programmes, implementing improvement options with low PBTs BUT not hot-fill nor heat-pump
WM-C10	733	45	778	88	12.5	1105	1884	151	12.0	Medium-high product, limited duration of the cotton standard programmes, implementing a broad range of improvement options BUT not hot-fill nor heat-pump

The PBT calculation allows clustering design options in different groups:

1. Design options whose economic investment is recovered in less than half of the lifetime, representing basic products with 'cheap' improvement options (WM-C1, WM-C2)
2. Design options whose economic investment is recovered between 0.5 and 1 lifetime, representing the larger machine with increased loading (WM-C8), medium-high products (WM-C9, WM-C10) and top-products with/without hot-fill (WM-C4, WM-C5 WM-C6)

3. Design options whose economic investment is recovered after about 2 lifetimes, representing the larger machine with heat-pump (WM-C3, WM-C7).

6.4.3. BAP and LLCC analysis

Figure 6.8 represents the primary energy consumption and the LCC, normalised per year of use, calculated for the combinations of improvement options selected for WM.
According to the modelling made:

- WM-C6 is the best available design option in terms of energy savings. This is a top model with optimised hot-fill (solar source) and extreme extension of the standard cotton programme duration. However, penetration of this option is limited at the moment. It is additionally not physically possible for all dwellings and requires substantial system adaptation in those where it would be feasible. Additionally, extended cycle times may be not accepted by all consumers.
- The option producing the least LCC is WM-C2, i.e. a basic improved product with hot-fill. The considerations on hot-fill connection outlined above apply for this option.
- In general, savings of energy and money can be achieved through all the design options not implementing a heat pump, no matter the technological complexity of the virtual product (see WM-C1, WM-C9, WM-C10, WM-C4).
- Design options with heat pump allow saving energy but this comes with increased LCC that consumers should be willing-to-accept as well as other drawbacks in terms of mechanical complexity, maintenance and repair, presence of two heating systems (heat pump and electrical resistance), slower warming speed, reduced capacity for washing, and end-of-life considerations.

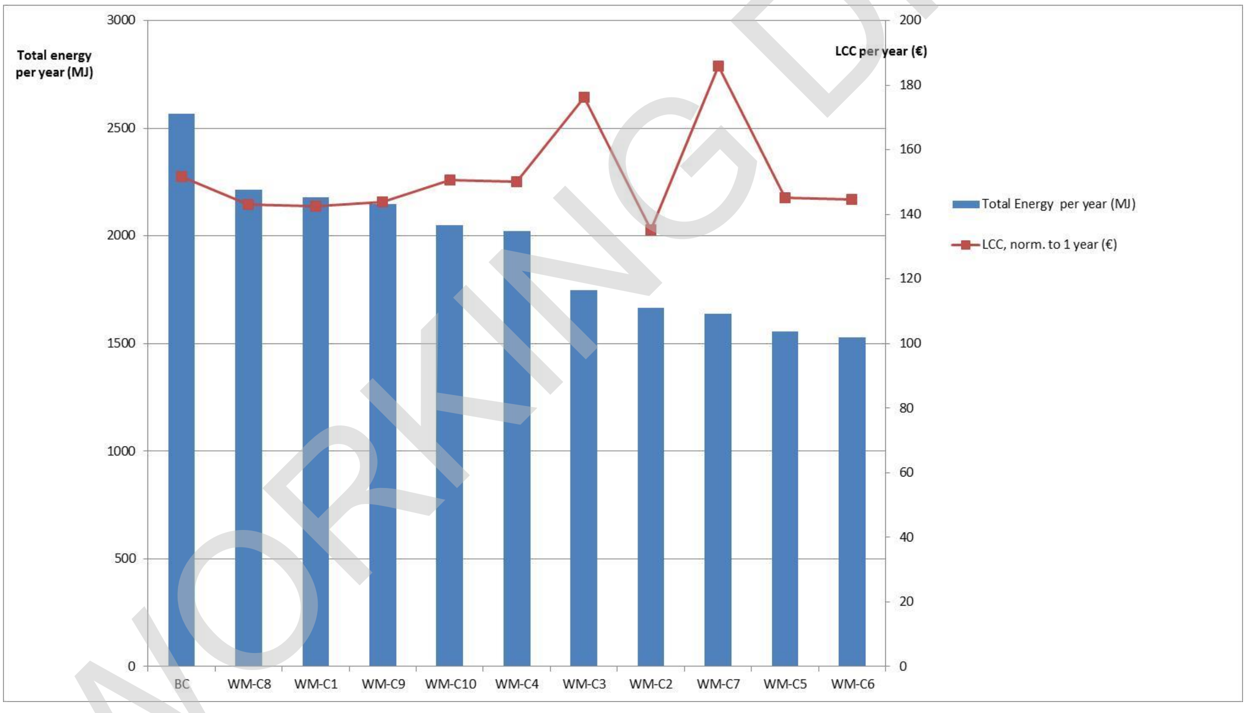

Figure 6.8: Primary energy consumption vs. LCC of combination of improvement options selected for WM

QUESTIONS BOX: ANALYSIS OF COMBINATIONS OF IMPROVEMENT OPTIONS FOR WM

1. Would you generally **agree with the outcomes of the analysis** or do you consider necessary to apply any modelling refinements?

6.5. Combination of improvement options: Best Available Products (BAPs) for WD

Combinations of options selected for washer-dryers are shown in Table 6.20 and include:

1. WD-C1 = WD1 (base case improved implementing air condensing system)
2. WD-C2 = WD2 (base case improved implementing a heat pump for the drying process)
3. WD-C3 = WD1 + WD-WM2 + WD-WM3 + WD-WM7 + WD-WM8 + WD-WM9 + WD-WM10 + WD-WM11 (top product implementing air condensing system and a broad range of improvement options for the washing function BUT not hot-fill nor heat pump – equivalent to WM-C4)
4. WD-C4 = WD1 + WD-WM2 + WD-WM3 + WD-WM7 + WD-WM8 + WD-WM9 + WD-WM10 + WD-WM11 + WD-WM6 (top product implementing air condensing system and a broad range of improvement options for the washing function, including hot-fill – equivalent to WM-C5)
5. WD-C5 = WD1 + WD-WM2 + WD-WM3 + WD-WM7 + WD-WM8 + WD-WM9 + WD-WM10 + WD-WM11 + WD-WM5 (top product implementing air condensing system and a broad range of improvement options for the washing function, including heat pump – equivalent to WM-C7)
6. WD-C6 = WD2 + WD-WM2 + WD-WM3 + WD-WM7 + WD-WM8 + WD-WM9 + WD-WM10 + WD-WM11 (top product implementing heat pump for the drying process and a broad range of improvement options for the washing function BUT not hot-fill nor heat pump – equivalent to WM-C4)
7. WD-C7 = WD2 + WD-WM2 + WD-WM3 + WD-WM7 + WD-WM8 + WD-WM9 + WD-WM10 + WD-WM11 + WD-WM6 (top product implementing heat pump for the drying process and a broad range of improvement options for the washing function, including hot-fill – equivalent to WM-C5)

QUESTIONS BOX: COMBINATIONS OF IMPROVEMENT OPTIONS FOR WD

Please check the following Tables 6-20 and 6-21 carefully.

3. Do the **selected combinations of improvement options** reflect the market developments appropriately? Do you think that any relevant combinations should be further added to the analysis? Should some of the chosen combinations be deleted from the analysis? Please explain your reasons.

4. Can the **assumptions made** (consumption, costs, materials, and lifetime) be considered to reflect appropriately the main changes of possible design options on the market compared to the BC? Is there the need of any MAJOR changes?

Table 6.20: Combinations of improvement options selected for WD

Improvement option	WD-C1	WD-C2	WD-C3	WD-C4	WD-C5	WD-C6	WD-C7
WD-WM1: Increased capacity, partial loading							
WD-WM2: PM motor			X	X	X	X	X
WD-WM3: Extension of std programme duration (moderate)			X	X	X	X	X
WD-WM4: Extension of std programme duration (extreme)							
WD-WM5: Heat Pump – washing					X		
WD-WM6: Hot-fill				X			X
WD-WM7: Improved drenching			X	X	X	X	X
WD-WM8: Higher spinning extraction			X	X	X	X	X
WD-WM9: Automatic load detection			X	X	X	X	X
WD-WM10: Automatic detergent dosage			X	X	X	X	X

WD-WM11: Consumer feedback on loading			X	X	X	X	X
WD-WM12: Increased durability							
WD-WM13: Heat pump (different refrigerant)							
WD-WM14: Heat-fed							
WD-WM15: Smart grids							
WD1: Air condensing system	X		X	X	X		
WD2: Heat Pump – drying		X				X	X

As for washing machines, the following modelling assumptions have been made:

1. The savings associated to the selected combinations has been estimated through the adaptation and tuning of the models used for the assessment of base cases and single improvement options
2. The changes in material composition, the additional manufacturing costs and changes in maintenance and repair are assumed to be the sum of the changes of the single design options.
3. It is assumed that the combinations of options do not result in additional changes (e.g. life time).
4. The consumer feedback mechanism (WD-WM11) lead to increase loading by 50% (instead to consider full loading as done previously for the single improvement option). As a consequence, if coupled with such option, partial load consumption values are set at least 12.5% lower than full load consumption values for WD-WM9 (automatic load detection). 25% was formerly considered for the single improvement option WM9 in condition of half loading.

Table 6.21 provides an overview of the variations estimated for the selected combinations of options for WD compared to the BC.

Table 6.21: Variations estimated for the combination options selected for WD compared to the BC

	Energy Cons.	Water Cons.	Detergent Cons.	Prod. costs (€)	Purchase price	Share of repaired machines	Maint. & repair costs over the lifetime	Lifetime (years)	Weight of materials
BC	100%	100%	100%	212	100%	0.3	100%	12.5	100%
WD-C1	100%	79%	100%	+10	105%	0.3	100%	12.5	100%
WD-C2	64%	79%	100%	+150	171%	0.3	100%	12.5	119% (heat pump)
WD-C3	88%	60%	85%	92.5	144%	0.3	100%	12.5	100%
WD-C4	77%	60%	85%	112.5	153%	0.3	100%	12.5	100%
WD-C5	77%	60%	85%	242.5	214%	0.3	100%	12.5	119% (heat pump)
WD-C6	52%	60%	85%	232.5	210%	0.3	100%	12.5	119% (heat pump)
WD-C7	41%	60%	85%	252.5	219%	0.3	100%	12.5	119% (heat pump)

6.5.1. Environmental impacts

Life cycle impacts of selected combinations of improvement options for washer-dryers, expressed per year of use with respect to the Base Case WD (=100%), are shown in Table 6.22and in Figure 6.7.

Table 6.22: Life cycle impacts of combinations of improvement options selected for washer-dryers expressed per year of use with respect to the Base Case WD (=100%)

	BC	WD-C1	WD-C2	WD-C3	WD-C4	WD-C5	WD-C6	WD-C7
Total Energy (primary energy)	100%	100%	73%	88%	80%	81%	62%	53%
Electricity (primary energy)	100%	100%	66%	88%	77%	78%	54%	43%
Water (process)	100%	79%	79%	60%	60%	60%	60%	60%
Water (cooling)	100%	100%	92%	94%	89%	98%	86%	81%
Waste, non-haz./ landfill	100%	100%	97%	94%	90%	100%	91%	87%
Waste, hazardous/ incinerated	100%	100%	75%	88%	80%	83%	64%	56%
Greenhouse Gases in GWP100	100%	100%	83%	89%	80%	91%	72%	64%
Acidification, emissions	100%	100%	81%	90%	82%	88%	71%	63%
Volatile Organic Compounds (VOC)	100%	100%	64%	88%	77%	77%	53%	42%
Persistent Organic Pollutants (POP)	100%	100%	110%	98%	96%	113%	108%	106%
Heavy Metals	100%	100%	101%	100%	98%	105%	101%	99%
PAHs	100%	100%	90%	94%	88%	96%	84%	79%
Particulate Matter (PM, dust)	100%	100%	98%	99%	98%	99%	97%	96%
Heavy Metals	100%	100%	100%	100%	99%	102%	100%	99%
Eutrophication	100%	100%	100%	88%	88%	90%	89%	89%

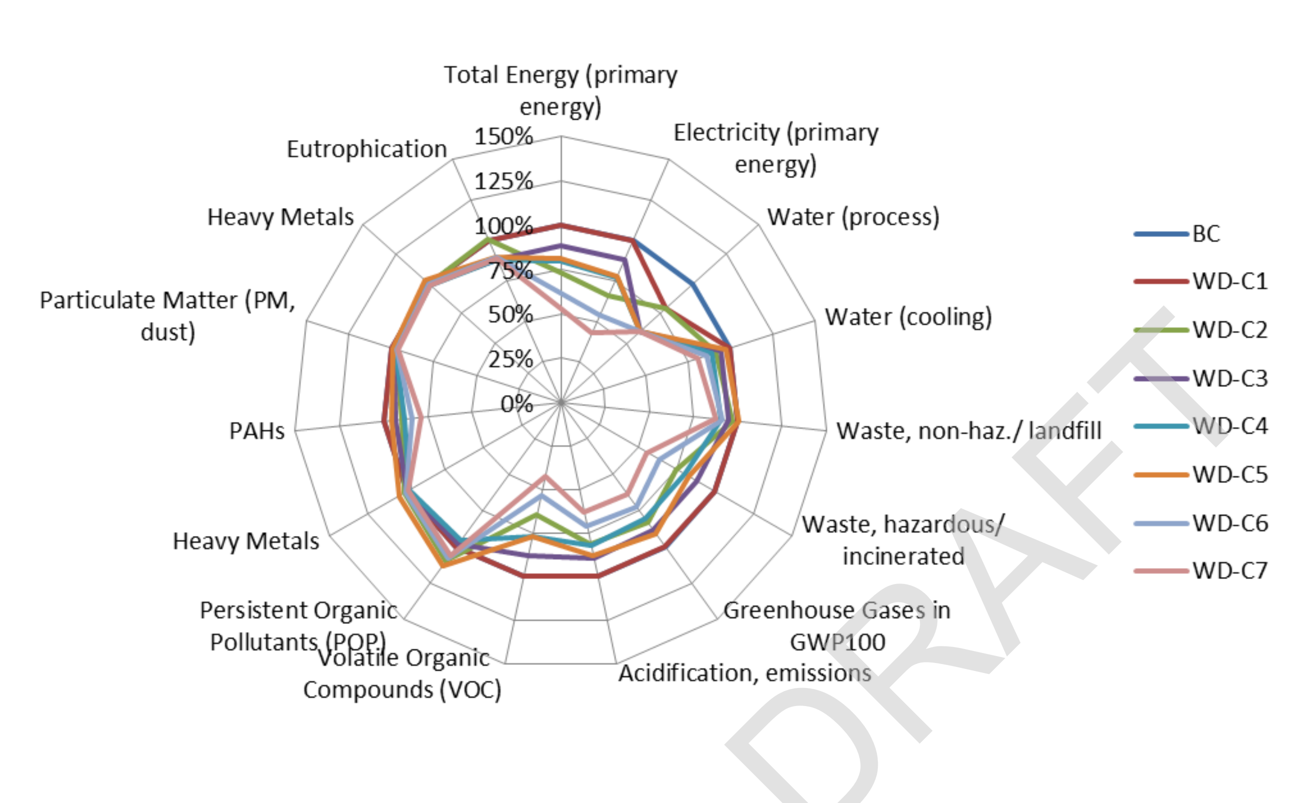

Figure 6.9: Life cycle impacts per year of combinations of improvement options selected for WD with respect to the Base Case WD (=100%) – spider diagram

The analysis in Figure 6.9 above points out that:

- All assessed combinations result to allow energy saving although they are characterised by heterogeneous spectra of environmental profiles
- WD-C2, WD-C5, WD-C6 and WD-C7 can allow reducing energy demand but can present trade-offs for some categories (POP, heavy metals). Trade-offs are due to the increased demand of materials for such options (a heat pump system is implemented in WD-C2, WD-C6 and WD-C7 for the drying process and in WD-C5 for the washing process).
- Other combinations allow reducing potential impacts in all environmental categories
- Maximum reductions range from -1% (heavy metals to water, top products with heat pump for the drying process: WD-C4, WD-C7) to -58% (VOC, WD-C7: top model with heat pump for the drying process) depending on the impact category and design option considered

Figure 6.9 reveals also that the environmental profile of some options is low on some impact categories, but high on others. Therefore, without aiming at developing some weighting mechanism (which would however present some inherent limitations), it would be difficult to rank design options without analysing individually specific indicators and LCC considerations. Table 6.23 ranks options based on the total demand of primary energy and other selected indicators:

- In terms of primary energy, demand ranges from 53% (WD-C7: top model with heat pump for the drying process) to 100% (WD-C1: base case with air condensing system for the drying process) of that assessed for the Base Case
- A similar ranking is generally observed also for GWP100 although design options implementing a heat-pump that works with a conventional refrigerant are penalised for such impact category. However, impact for this category is lower than for the Base Case. The use of alternative refrigerants may add benefits in terms of GWP, as shown in the analysis of single improvement options for washing machines.

- Possibilities for water saving also appear significant for this product since the base case was assumed to use water for the wet-air condensing process: from -21% for WD-C1 and WD-C2 (improvement only in the drying phase) to -40% for other combinations considering improvements in both drying and washing phases
- High energy savings are generally achievable through the implementation of heat-pumps for the drying process (WD-C7, WD-C6, WD-C2), with the maximum energy saving achievable through the use also of a hot-fill connection (WD-C7).
- The air condensing system for the drying process is estimated to allow water saving only. The improvement of the washing phase would bring additional benefits (WD-C3). This would be increased by applying a heat-pump for the washing process (WD-C5) or a hot-fill connection (WD-C4). However, benefits are lower than dose associated to the application of a heat pump for the drying process

Table 6.23: Ranking of combinations of improvement options for WD based on selected environmental indicators

	Total Energy (primary energy)	Water (process)	Greenhouse Gases in GWP100
WD-C7	53%	60%	64%
WD-C6	62%	60%	72%
WD-C2	73%	79%	83%
WD-C4	80%	60%	80%
WD-C5	81%	60%	91%
WD-C3	88%	60%	89%
WD-C1	100%	79%	100%
BC	100%	100%	100%

6.5.2. LCC and payback time (PBT) calculation of combinations of improvement options

LCC parameters and calculations for each improvement options are reported in Table 6.24. Based on such parameters, payback times (PBT) have been also quantified according to Eq. 6-1.

Table 6.24: LCC and PBT of combinations of improvement options selected for WD

Design Option	PP (€)	MRC (€)	Lifetime (years)	ΔOC (€/year)	Tot. Prod. (€)	OC (€)	LCC (€)	LCC (€ norm to 1 year)	PBT (years)	Comment
BC	825	45	12.5	186	870	2330	3200	256	Ref.	Base Case
WD-C1	864	45	12.5	176	909	2205	3114	249	3.9	Base case improved implementing air condensing system
WD-C2	1409	45	12.5	142	1454	1779	3232	259	13.2	Base Case improved product implementing a heat pump for the drying process)
WD-C3	1185	45	12.5	149	1230	1867	3097	248	9.7	top product implementing air condensing system and a broad range of improvement options for the washing function BUT not hot-fill nor heat pump (– equivalent to WM-C4)
WD-C4	1263	45	12.5	139	1308	1737	3045	244	9.2	top product implementing air condensing system and a broad range of improvement options for the washing function, including hot-fill (equivalent to WM-C5)
WD-C5	1769	45	12.5	139	1814	1737	3551	284	19.9	top product implementing air condensing system and a broad range of improvement options for the washing function, including heat pump (equivalent to WM-C7)
WD-C6	1730	45	12.5	115	1775	1441	3216	257	12.7	top product implementing heat pump for the drying process and a broad range of improvement options for the washing function BUT not hot-fill nor heat pump (equivalent to WM-C4)
WD-C7	1807	45	12.5	105	1852	1311	3163	253	12.0	top product implementing heat pump for the drying process and a broad range of improvement options for the washing function, including hot-fill (equivalent to WM-C5)

The PBT calculation allows clustering design options in different groups:

1. Design options whose economic investment is recovered in less than half of the lifetime, representing the base case where the water-based air condensation system is replaced by an air-air system (WDM-C1)

2. Design options whose economic investment is recovered in less than 1 lifetime, representing the base case where the water-based air condensation system is replaced with an air-air system and the washing function improved without using a heat-pump (WD-C3 and WD-C4)
3. Design options whose economic investment is recovered in about 1 lifetime, representing products where a heat-pump is applied for the drying process (WD-C2. WD-C6, WD-C7)
4. Design options whose economic investment is recovered in about 1.5 lifetime, representing the base case where the water-based air condensation system is replaced with an air-air system and the washing function improved also using a heat-pump (WD-C5)

6.5.3. BAP and LLCC analysis

Figure 6.10 represents the primary energy consumption and the LCC, normalised per year of use, calculated for the combinations of improvement options selected for WD.
According to the modelling made:

- WD-C7 is the best available design option in terms of energy savings. This is a top model with heat-pump for the drying process, hot-fill, and other improved washing functions.
- The option producing the least LCC is WD-C4, i.e. a top product equipped with an air condensing system for the drying function and a broad range of improvement options for the washing function, including hot-fill.
- Savings of energy can be achieved through all the design options with the exception of WD-C1, for which the energy consumption does not change compared to the base case. This represents a product in which the water-based air condensation system is replaced by an air-air system.
- LCCs can be generally reduced by use of an air condensing system for the drying process (with or without improving the washing function, see: WD-C1, WD-C3 and WD-C4) and no-heat pump system. LCCs are reduced, in case of insertion of a heat pump system only after improving the washing process (see WD-C2, WD-C6 and WD-C7).
- The use of a heat-pump to the washing process would increase LCCs and allows less energy saving than the application of a heat-pump for the drying process. It would be worth understanding if the parallel implementation of heat pump technologies to both washing and drying processes is an option that could be developed in the future.

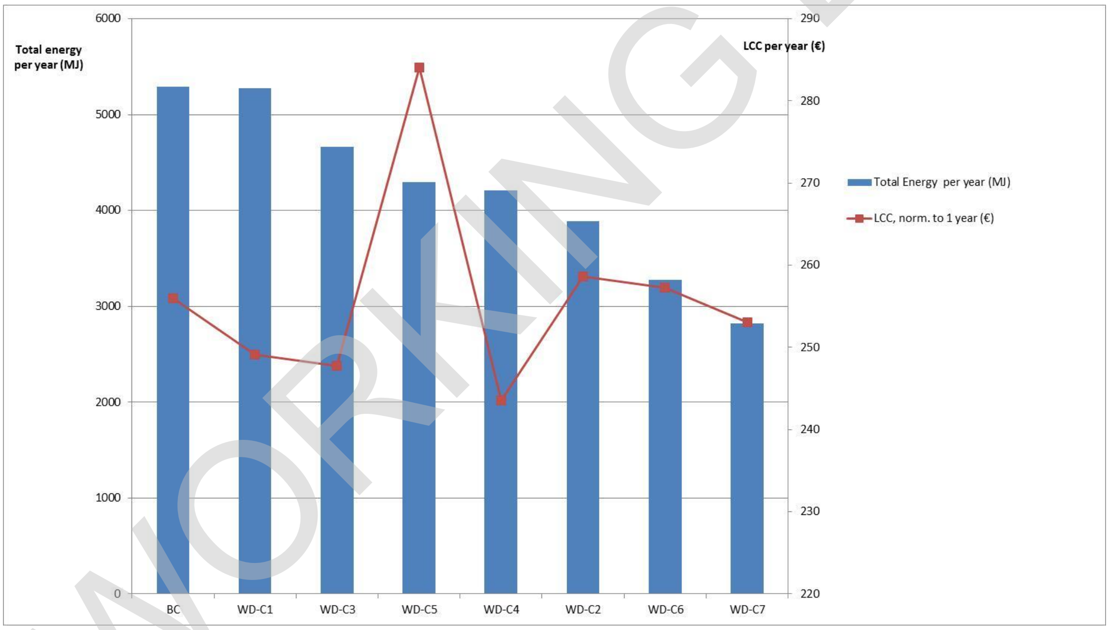

Figure 6.10: Primary energy consumption vs. LCC of combination of improvement options selected for WD

QUESTIONS BOX: ANALYSIS OF COMBINATIONS OF IMPROVEMENT OPTIONS FOR WD
1. Would you generally **agree with the outcomes of the analysis** or do you consider necessary to apply any modelling refinements?

6.6. Indications about saving potentials at EU level

Based on the assessment performed in Tasks 5 and 6 it has been estimated that

- The 'Real life' Base Case WM and the Base Case WD respectively consume ~2500 and ~5300 MJ of primary energy per year of use, accounting for all life-cycle stages.
- The maximum energy saving potential compared to the BC is ~40% for WM (i.e. ~1000 MJ/yr per unit) and ~47% for WD (i.e. 2500 MJ/yr per unit), achievable through a broad mix of technical improvement options, and the use of a solar-driven hot-fill water connection.
- Without considering hot-fill connections, energy saving potentials could be 15-21% for WM (i.e. 380-540 MJ per unit per year) and 12-38% for WD (i.e. 630-2010 MJ per unit per year).
- Consumption of water per year is 13.2 m^3 for the 'Real life' Base Case WM and 12.8 m^3 for the Base Case WD
- Water saving potentials could be 9-24% for WM (i.e. 1.2-3.2 m^3 per unit per year) and 21-40% for WD (i.e. 2.7-5.1 m^3 per unit per year).
- In case of higher frequency of use of standard cotton programmes substituting normal cotton programmes (the 'Adapted' Base Case WM), energy and water saving for WM would be 11% (280 MJ per unit) and 3% (0.4 m^3 per unit) respectively compared to the BC.

WDs thus present relatively larger improvement potentials per product compared to WM. This can be partially explained by the fact that the technical solutions for energy optimisation of a WM have been explored for a longer time than for WD, which is a product exposed to a much smaller market share and development effort. Other reasons rely on the different heat demands of washing and drying processes, which are higher for washer dryers. In addition, it has not been until recent years that the generalisation of large volume WMs that allow continuous wash-and-dry of the average loads in the EU (3.5 kg) have triggered a faster development of WDs. Because of the high energy consumption of the drying phase, this is an obvious part of the cycle for which to explore improvement options. Moreover, the interaction between the washing and the drying phases in a single machine are areas where important developments will be likely seen in the coming years.
First rough indications about the theoretical maximum total savings in the EU can be obtained by scaling-up the saving figures above to the total number of washing machines and washer-dryers installed (197 million of WMs and 0.56 million of WDs):

- 75-106 PJ of primary energy per year for WM, which would increase to 202 PJ considering a solar, loss-free hot-fill connection
- 5-17 PJ of primary energy per year for WD (7-16% of the saving of WM), which would increase to 21 PJ considering the hot-fill connection (11% of the saving of WM)
- 235-626 Mm3 of water per year for WM
- 23-44 Mm3 of water per year for WD (7-10% of the saving of WM)
- 55.6 PJ of primary energy per year and 78 Mm^3 of water per year for WM considering a higher frequency of use of standard cotton programmes.

Considering the overall EU totals, the saving potentials of WD are modest compared to WM, but they could become more significant if the penetration of WD on the market increased.
Compared to the domestic use of water in the EU (about 27000 Mm3 per year), the water saving potential of WM and WD is marginal (0-2%). Most of the water consumed in households is indeed associated to the use of taps and showers.
Compared to the annual energy saving estimated for recent ecodesign measures (http://ec.europa.eu/DocsRoom/documents/5187/attachments/1/translations/en/renditions/native), the energy saving potential for WM and WD may appear significant. However, these figures are first rough estimates of the theoretical maximum life-cycle saving potentials (not only electrical energy use reduction) associated not only to technology development, but also to user behaviour change (e.g. increasing the frequency of use of energy saving programmes and optimising loading conditions).

Table 6.25: Energy saving potential estimated for different product groups

Product group	Estimated savings in terms of primary energy[a] (PJ/yr)	% normalised to total
Electric motors	1215	37%
Domestic Lighting	351	11%
Street & Office Lighting	342	10%
Standby	315	10%
Fans	306	9%
Televisions	252	8%
Circulators	207	6%
Air conditioners and comfort fans	99	3%
External power supplies	81	2%
Simple set top boxes	54	2%
Domestic refrigerators	36	1%
Domestic dishwashers	18	1%
Domestic washing machines	14	0%
Total	3294	

(a) In-house calculation based on the values reported in http://ec.europa.eu/DocsRoom/documents/5187/attachments/1/translations/en/renditions/native (1 PJ of power considered equivalent to 2.5 PJ of primary energy)

7. TASK 7: POLICY ANALYSIS AND SCENARIOS

Building on the information gathered and produced in the previous sections, this task aims at describing potential policy measures which could be proposed for household washing machines and washer-dryers, and assessing their potential impacts against a business-as-usual (BAU) scenario.
In general, these measures relate to generic and specific Ecodesign requirements, the Energy and/or Resource efficiency labelling, standards and measurement methods as well as consumer information and education. Self-regulation or voluntary agreements by industry (as set out in the Ecodesign Directive 2009/125/EC) are not seen as alternative to the existing Ecodesign measures, however might be supportive for example in terms of consumer information campaigns.

7.1. Stakeholder consultation and policy context

7.1.1. Stakeholder consultation

During the preparatory work a continuous stakeholder consultation has taken place. Stakeholders have been contacted bilaterally for information exchange and two technical working group (TWG) meetings are organised. The TWG is composed of experts from Member States' administration, industry, NGOs and academia. The first TWG meeting took place in Seville on 24 June 2015 while a second TWG meeting is organised in Brussels on 18 November 2015.

The first meeting focused on tasks 1-4 of the preparatory study, while the second meeting focuses on tasks 5-7. The project team has visited different manufacturers, test labs, recyclers and a trade fair to investigate the product groups in detail and to stay up to date with the latest developments. Questionnaires have been distributed to the TWG along the process, addressing information and data updates, and gathering opinions on scope, definitions, and energy consumption specificities. An online communication system BATIS has been set-up for easy exchange of documents between registered stakeholders. A website was made available to have the final working documents in the public domain.

More specifically regarding policy options, a comprehensive list of potential policy options including expected benefits and potential disadvantages, challenges and / or drawbacks was developed and circulated to stakeholders for further detailed feedback during summer 2015, cf. Annex 8.3 (washing machines), Annex 8.4 (washer-dryers) and Annex 8.5 (material efficiency options for both WM and WD).
These initially single policy options are now combined to different policy scenarios which are described in more detail in the following sections. A differentiation has been made for policy options related to energy and water consumption on the one hand, and policy options related to end-of-life and durability measures on the other hand.

7.1.2. Current status of household washing machines and washer-dryers in the policy landscape of Ecodesign and Energy labelling

Household washing machines and washer-dryers already have a long history when it comes to the Energy label. The first Energy labels for these product groups were based on the Directive 92/75/EEC (European Council 1992). Since the beginning of 1995, it has been compulsory for electrical appliances to have an Energy Label which helps consumers to choose appliances which conserve energy and the environment.

The energy label for washer-dryers was published in Commission Directive 96/60/EC in 1996 (European Commission 1996), still being valid today. In 2013, around 50% of all washer-dryer models were labelled in Energy Efficiency class A, around 45% in class B (CECED 2014).

For washing machines, Commission Directive 95/12/EC established the first Energy label for household washing machines. The outcome of a revision resulted in Commission Regulation 1061/2010 with requirements reaching into 2016 (European Commission 2010a). Further, for household washing machines (not including washer-dryers), in 2010 also Ecodesign requirements came into effect by

Commission Regulation 1015/2010 (European Commission 2010b). Table 7.1 shows that only three label classes (i.e. A+, A++ and A+++) are allowed on the market for washing machines ≥ 4 kg since December 2013. The label class A could be in theory allowed only for washing machines with rated capacity < 4 kg. However, according to the CECED database, all 36 models of 4 or 4.5 kg on the European market are labelled as A+. In 2014 about 43% of the washing machines that were sold on the European market were A+++ (Michel et al. 2015).

Table 7.1: Overview of the current Ecodesign requirements for household washing machines, which classes are phased out

Class	EEI	Tier Dec 2011	Tier II Dec 2013
A+++	EEI < 46		
A++	46 ≤ EEI < 52		
A+	52 ≤ EEI < 59		
A	59 ≤ EEI < 68		Banned for all machines ≥ 4 kg
B	68 ≤ EEI < 77	Banned for all machines	
C	77 ≤ EEI < 87		
D	EEI ≥ 87		

Altogether, this called for a revision of the energy label classes for washing machines, together with an update of the 1996 Energy label for washer-dryers, especially in view the upcoming revision of the Energy labelling Directive 2010/30/EU.

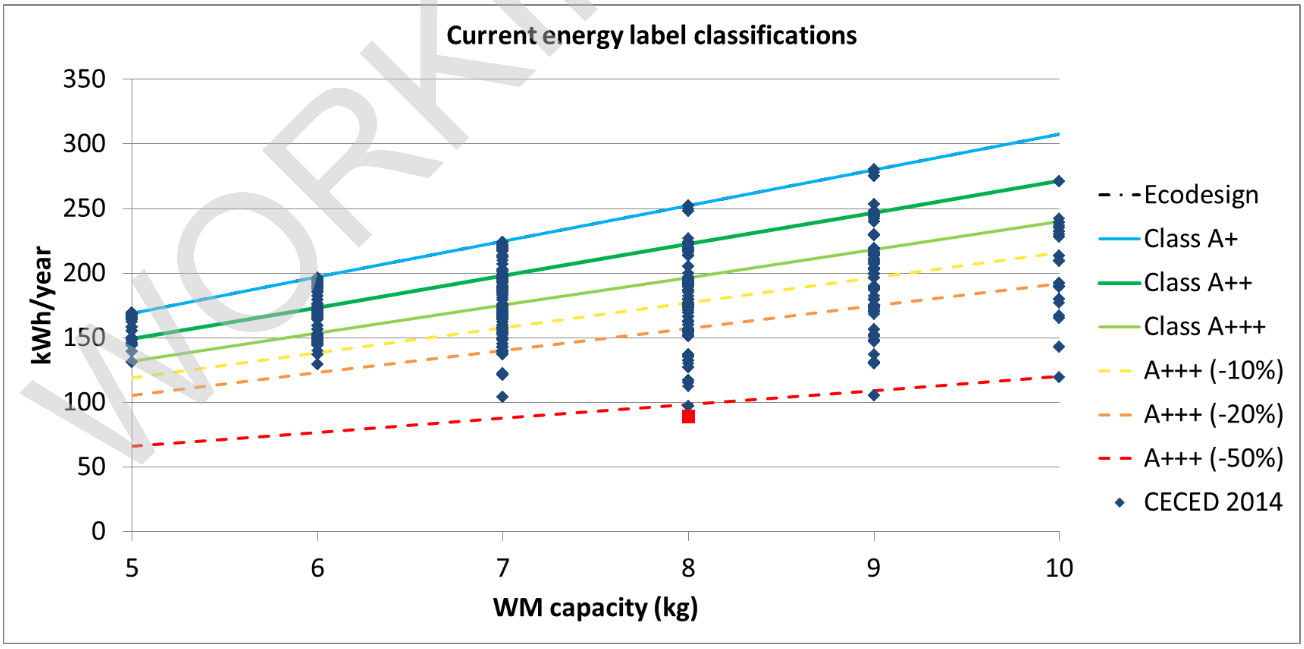

Figure 7.1 Yearly energy consumption of washing machine models on the market in 2014 in function of their rated capacity c (for 5 kg ≤ c ≤ 10 kg) together with the current labelling classes and ecodesign requirement.

A sample of washing machines models sold in the EU in 2014 (CECED database) with a rated capacity ≥ 5 kg is shown in Figure 7.1 together with the current labelling classes and ecodesign requirements. It shows that a large share of WM already far exceeds Energy Efficiency class A+++, especially for appliances with larger rated capacity. On the other hand, the smaller 5 kg machines achieve rarely Energy Efficiency Classes better than A+++.

The market of WM is strongly influenced by the energy label. At first glance, it seems necessary to refresh the scale and set more stringent MEPS. However, it is important to note that a share of the declared performance is achieved by prolonged duration of the standard programmes, a cycle condition that has made consumers not make wide use of these programmes. For instance, the appliance marked red in Figure 7 1, consuming 89 kWh/year, is based on a standard 60°C cotton programme lasting 300 minutes, i.e. five hours. In comparison, a current heat pump washing machine on the market consumes 98 kWh/year.
According to the assessment of Task 6, the possibilities to reduce energy consumption values below A+++ -50% rely on the parallel application of a broad range of improvement options and either an efficient hot-fill connection, or a heat pump. However, both solutions have limitations, as described in Task 6.

7.1.3. Boundary conditions and strategies for the revision

The information gathered in Task 3 and summarized in Task 5 indicates that significant improvement potential for the energy efficiency of household washing machines could be realised if consumers were persuaded to use the most energy-efficient programmes. On top of this, one could add the savings resulting from technical innovation, as described in Task 6:

- Especially for washing machines, the standard cotton 40°/60°C programmes that are used for testing energy performance and subsequent Energy labelling are only used by consumers to a minor extent in practice (17% altogether,5% if considering only the programmes lasting more than 3hrs). Instead, there are other programmes for the same purpose ('normal' cotton 40°/60°C programmes) which are more often used (26% together) but which consume more energy and water than the standard programmes. In some appliances, consumers can also alter the standard cotton 40°/60°C programme by adding options such as 'short'. However, no information is available on how such alterations can influence the energy and water efficiency of this programme.
- The standard cotton 40°/60°C programmes, whose consumption values are displayed on the Energy label and thus influence the purchase decisions of consumers, are designed and configured to improve the energy efficiency, often at the expense of reducing the washing temperature and prolonging the programme duration – characteristics that are not fully convenient to consumers. The user survey presented in Chapter 3 indicates that the reluctance to use long programmes is large beyond 3 hours.
- Washing machines are characterised by offering a broad range of other programmes (further wash temperatures, or for other textiles than cotton) that are not optimised for energy efficiency.
- In general, consumer research shows that the average amount of load under real-life conditions is on average only 3.4 kilogram per cycle for a 7 kg capacity machine, which is far away from full load conditions and also still from the average 5 kg load used for measurement under standard conditions for a 7 kg capacity machine.
- The user survey of 2015 indicates that 90% of respondents expect the label to represent the performance of the WM in all programmes, not only some of them.
- Manufacturers of appliances often mention that technical development of WM is reaching its technical limits. They also acknowledge, however, that there are more improvement possibilities for the drying phase of WD. The preliminary results from Tasks 5 and 6 show that some important energy savings could be achieved by increasing the frequency of use of standard cotton

programmes (max saving: 11% compared to the Real life Base Case WM) and the implementation of technical improvement options together with an increase of the loading (max savings: 15-40% compared to the Real life Base Case WM and 12-47% for the Base Case WD, that however present a much lower volume at EU level).

The revised regulations need therefore to combine the elements above, and exploit both the remaining technical development potential, and user behaviour change opportunity. The proposal shall also ensure that any new targets reflect real-life and likely use of the machines.

Ecodesign and Energy label Regulations need the use of standard testing conditions. This allows creating a level playing field for testing, so the energy efficiency of appliances can be compared, displayed on a label, and used by consumers to support purchase decisions. When the standard is used for the purpose of checking compliance of the ecodesign regulation and classification in labelling, it can be expected that this creates a competition field for manufacturers to develop more energy efficient appliances.

Additional complexity to the above mentioned objectives is added in products that have several operation modes with different energy performance, e.g. washing machines or dishwashers with different programmes. Unlike a TV, the use of energy (but also of detergent, auxiliary chemicals or water) will depend on the programme used. Unfortunately, it is unfeasible for economic reasons to test (and control through market surveillance) the energy efficiency of all programmes. In such cases, a programme which is sufficiently representative of both (1) the use by consumers and (2) the operation of the appliance (in terms of e.g. mechanical stress) is chosen to simplify the testing. Ideally, this representativeness in terms of technology and of use is kept. However, with time competition by manufacturers will tend to develop new means of saving energy, some of which will only be actual if consumers accept them, so the uptake follows at sufficient speed what is offered by manufacturers. The analysis undertaken indicates that the pace of programme development and update by consumers has not been the same for washing machines in the EU.

As with other Ecodesign and Energy label Regulations, the 2010 Regulations on washing machines were defined based on the definition of a specific programme (called standard cotton) to wash normally soiled clothes. The ambition was that in doing so, the largest energy savings would be obtained at EU level. Additionally, if the technology improvements in the appliances affected also the other programmes, this would bring additional savings. However, the research on markets and consumer behaviour undertaken in March-June 2015, as presented in Tasks 2 and 3, has revealed that this objective may not have been fully met. For washing machines (to a much lesser extent to dishwashers), the standard cotton 40°/60°C programmes that are used for testing energy performance and subsequent energy labelling are only used by consumers to a minor extent in practice (17% all together, probably less considering combinations with time-reducing programmes). Instead, there are other programmes for the same purpose ('normal' cotton 40°/60°C programmes) which are more often used (26% all together), but which consume considerably more energy (ca. 60%) and water (ca. 10%) than the standard programmes.

This is to an extent due to the design and configuration of these standard programmes to improve the energy efficiency, at the expense of reducing the washing temperature and prolonging the programme duration – characteristics that are not fully convenient to consumers. Furthermore, washing machines (unlike e.g. dishwashers) are currently characterised by offering a broad range of programmes (other wash temperatures, or for other textiles than cotton), making it less likely that consumers would mainly use the standard programmes.

This has led to a situation where some savings due to technology improvement may have taken place (e.g. more efficient motors) for all programmes of washing machines, but the additional scenario of savings driven by the widespread use of the more efficient test programmes does not correspond to real life programme choice by consumers. In addition, there has been an increase power and of capacity of machines, which only results in lower consumption if the machines are fully loaded, a condition not currently met in households. Thus, the energy and water saving potential for this product group envisaged by the 2010 Ecodesign and Energy label Regulations has only been exploited to a small extent. It may even be possible that the real life energy consumption today is higher as it was in 2010.

The current revision will revisit if this potential associated to user behaviour change is realistic, and if it can be tapped by means of an appropriate design of the ED and EL requirements. This may imply adjusting the tested programme protocol so that it is not only representative of what the appliance can reach technically, but is also representative of real-life use.

Based on the above, two main strategies of policy scenarios are foreseen:

1) The first strategy makes efforts on creating a standard for the most used programmes that delivers a robust comparison basis of energy performance of machines. The expectation is that technology improvements are also noticed in the operation of the other programmes of the machines. In this strategy it is necessary to ensure that the tested programme is somehow representative of consumer use and the machine's technology performance, avoiding potential criticism to the label for providing misleading information. This strategy shall devise mechanisms to avoid that manufacturers design the tested programme using features that are known from user surveys to be unlikely accepted by consumers, or be far from average real use practice, such as longer programmes (>3h), too low temperatures, or programmes for lightly soiled clothes only. This may require setting a number of constraints (e.g. limitation of the maximum programme duration, temperature measurement).

Manufacturers may still offer in their machines other energy saving programmes (e.g. 'super-eco' or 'long-eco' programmes) for the consumers willing to wait longer time. This shall not have obstacles, as is good for saving energy and for the environment. However, one may not need to devise regulatory mechanisms to promote this behavioural change, i.e. this could perhaps be better managed by voluntary and/or communication mechanisms.

2) A second, more ambitious but also more intrusive strategy, is to use the strength of the label as decision making tool for customers, to persuade consumers to change behaviour towards the most energy efficient programmes and practices, which use less energy but may not currently be fully accepted or realistic (e.g. because of long duration programmes, low temperature programmes, and full loading).

The above requires a very careful design of the programmes to avoid consumer rejection, and failure of the role of the label reflecting energy and water use of the machine. If appropriate, it may also require regulatory restrictions to the machine's programme offer (e.g. normal programmes, restriction of other energy saving programmes also called 'eco'), not to undermine the desired persuasion to the low-energy programmes.

Complementary communication efforts are required in both cases, and especially in this second strategy, as it stretches the ambition level to be met by the energy label.

7.2. Policy options for washing machines and the washing function of washer-dryers

A limited number of policy options are presented in this section, in order to trigger a discussion with stakeholders on the potential technical opportunities and barriers that they may present.

Starting from the 'Real-life' Base Case which includes a mix of use of the standard 40/60°C cotton programmes, the normal 40°/60° cotton programmes, but also other significant programmes (e.g. cotton 20°/30°/90°C, quick wash, easy care, or mix programmes), the overall environmental impacts of the average appliance have been determined in section 5. This represents the so called 'Business-as-usual' (BAU) scenario. In this section, three policy alternatives are proposed:

- OLD
- BAU+
- ECO

These are alternatives to the BAU and introduce in different ways the above mentioned constraints with regard to programme time, programme temperature, load, and the resulting washing performance. A summary is provided in section 0.

Scenario 'OLD' responds to the first strategy option outlined above, i.e. developing a robust comparison basis for measuring the energy performance of machines. It shall be avoided that the tested programme use features of uncertain acceptance by consumers (e.g. longer programmes, too low temperatures, programmes for lightly soiled clothes only). In this scenario, it is proposed to leave out of the EL and ED requirements the mechanisms to persuade consumers to change behaviour. These can be addressed via communication campaigns or voluntary instruments.

Scenarios BAU+, and ECO follow the second strategy, in the sense that they further aim to gradually educate users into energy-saving technology options, some of which may imply washing behavioural change.

Depending on the outcome of the discussions, additional policy options might be added.

Complementing the scenarios above, a number of horizontal policy options are outlined to the BAU, see section 7.2.1.6.

7.2.1. Alternative policy scenarios for washing machines and the washing function of washer-dryers

7.2.1.1. Policy scenario 'WM OLD' – most used programmes

This scenario looks back into the standard for measurement used before the last revision of the WM ecodesign/energy label in 2010.

For the calculation of the energy consumption and other performance parameters of household washing machines, the programmes which clean normally soiled cotton laundry at 40°C and 60°C shall be used. These are the two most often used programmes for their daily use when washing cotton load. Additional measures may be taken in relation to the activation of the programmes, so they reproduce real life use also in laboratory testing conditions. 'Eco' programmes with wash cycles at lower temperatures (and with/without programme time extension) are allowed, but these shall not be used for testing for the purpose of the ED and EL regulations.

This approach was applied to the 'old' Energy label for household washing machines in the period 1996-2010.

The following policy sub-options might be combined in this scenario:

WM OLD scenario	Possible sub-options	Expected benefits	Possible drawbacks and risks
TIME	Adding the programme time of the tested cotton programme(s) on the Energy label	Manufacturers may reduce the time of the programmes if they see consumers pay attention to this and respond to the labelling	Uncertainty on the reaction from consumers when time has to be weighed against energy use. If consumers still pay most attention to the energy, shorter programmes may not be offered.
	Cap on the maximum programme time for the tested cotton programmes, e.g. 3 hrs.	Restriction of the playing field to areas that are known to be acceptable for consumers. As a consequence the use of such programmes may increase	Manufacturers reduce their leeway (Sinner circle). Most appliances will cluster on few classes, reducing the influence of the label on purchase
TEMPERATURE	Test cycle for performance measurements for 40/30°C cotton programme (instead of 60/40°C)	Average energy consumption will be reduced	The 40°C cotton programme is the most used temperature
	Adding a requirement for a minimum temperature to be reached, at least in the 60°C cotton programme	Certainty of temperature for the consumers that know its effects (e.g. hygiene, odours) and choose the programme deliberately for this reason. Overall average hygiene of the machine's wet areas improves. Imposing this condition makes the testing be sufficiently demanding on the machine's heating system performance.	If introduced, manufacturers reduce their leeway (Sinner circle). Most appliances will cluster on few classes, reducing the influence of the label on purchase If not introduced, the offer of cotton programmes where the actual temperature is not the declared may continue and further spread. Measurement method for the temperature inside the textile load needs to be defined/adapted from professional WMs. Testing burden increases. Depending on the conditions set,

			energy saving may be limited
LOAD	Test cycles at full, and partial load (e.g. 1/3)	Machines should be subject to a demanding test that rewards those better adapting energy use to different loads, as small loads are typical of real-life user behaviour. Optimization only to half load should not suffice.	Ensure that the testing procedure does not become more complex (e.g. a max amount of laundry equivalent to 5 full load cycles)
PERFORMANCE	>1,03	Continuity	One shall ensure that the measurement of performance on average or on subcycles (e.g. after full load, and after partial load) is designed to avoid playing with average performance, as this may be against the objective of rewarding load adaptation
PROGRAMME RESTRICTION for normally soiled cotton laundry	1) 'eco', 'super saver' (lower temperature, long duration) 2) standard cotton programmes	1) None 2) Avoid programmes names linking to testing	1) There is no reason for restriction in this scenario. If consumers are willing to use them, this should not be hindered. Some rules may be needed for the declarations of 'eco' or 'super saver' that are more efficient than the normal cotton. 2) Enforcement can be challenging

The main benefit of this approach is the better alignment to the most used programmes, i.e. current real-life conditions by consumers for washing cotton load. These programmes are likely not the most efficient ones even if they were optimised to save energy. Other programmes (e.g. more washing and/or energy efficient programmes) can be freely developed for the consumers willing to change their washing behaviour. A concerning issue in this respect is the absence of rules for how manufacturers will promote the programmes that are more efficient than the normal cotton programmes. This freedom may result in confusing information for consumers (e.g. 'super cotton saver - 50% more efficient than the normal cotton of the label'), for which there is no standardised measurement procedure.
This policy scenario would bring some savings compared to the BAU if cotton programmes are further optimised. Technical improvements would expectedly improve the efficiency of the most used programmes.
A potential challenge of this scenario is in terms of communication, as the nominal energy consumption of washing machines would increase.

7.2.1.2. Scenario 'WM BAU+' – refinement of most efficient programmes

In this scenario, the existing approach of the Ecodesign and Energy Label Regulations for household washing machines will be kept, but it is adapted to better reflect and take into account real-life conditions. For the calculation of the energy consumption and other performance parameters of household washing machines, also for the ED and EL regulations, still the two programmes which clean normally soiled cotton laundry at 40°C and 60°C (called 'standard cotton programmes') shall be used. In addition, the machines might offer the ‘normal cotton 40°/60°C' programmes. This scenario is thus specifying two very efficient programmes for Ecodesign and the Energy label, and is guiding consumers to use them.
To reduce the current effects of long programme durations and rather low real wash temperatures of these standard programmes, which make them often highly energy efficient but rather inconvenient to consumers, as well as the typical underloading conditions, the following policy options are proposed for the ‘WM BAU+’ scenario:

WM BAU+ scenario	Possible sub-options	Expected benefits	Possible drawbacks and risks
TIME	Adding the programme time of the standard cotton programme(s) on the Energy label	Manufacturers may reduce the time of the programmes if they see consumers pay attention to this and respond to the labelling	Uncertainty on the reaction from consumers when time has to be weighed against energy use. If consumers still pay most attention

WM BAU+ scenario	Possible sub-options	Expected benefits	Possible drawbacks and risks
			to the energy, shorter programmes may not be offered.
	Cap on the maximum programme time for the tested cotton programmes, e.g. 3 hrs.	Restriction of the playing field to areas that are known to be acceptable for consumers As a consequence the use of such programmes may increase	Manufacturers reduce their leeway (Sinner circle). Most appliances will cluster on few classes, reducing the influence of the label on purchase
TEMPERATURE	Test cycle for performance measurements for 40/30°C cotton programme (instead of 60/40 C)	The average energy consumption would be reduced in the testing protocol and in practice	The 40°C cotton programme is the most used temperature
	Adding a requirement for a minimum temperature to be reached in the 60°C standard cotton programme,because of the implications of hygiene and odour removal of 60°C (not necessary for 40°C)	Certainty of temperature for the consumers that know its effects (e.g. hygiene, odours) and choose the programme deliberately for this reason (especially 60°). Overall average hygiene of the machine wet areas improves. Imposing this condition makes the testing be sufficiently demanding on the machine's heating system performance.	Measurement method for the temperature inside the textile load needs to be defined/adapted from professional WMs. Testing burden increases. Manufacturers reduce their leeway (Sinner circle). Most appliances will cluster on few classes, reducing the influence of the label on purchase Depending on the conditions set, energy saving may be limited.
LOAD	Changing the full/half load test cycles to consider other combinations (e.g. full, 2/3 and/or 1/3 load).	Machines should be subject to a demanding test that rewards those better adapting energy use to different loads, as small loads are typical of real-life user behaviour. Optimization only to half load should not suffice.	Ensure that the testing procedure does not become more complex (e.g. a max amount of laundry equivalent to 5 full load cycles)
PERFORMANCE	>1,03	Continuity	One shall ensure that the measurement of performance on average or on subcycles (e.g. after full load, and after partial load) is designed to avoid playing with average performance, as this may be against the objective of rewarding load adaptation.
PROGRAMME RESTRICTION For normally soiled cotton laundry	1) eco (lower temperature, long duration) 2) normal cotton	1) none 2) restriction of normal cotton programmes would be an extreme measure to promote higher use of standard cotton programmes	1) There is no reason for restriction in this scenario. If consumers are willing to use them, this should not be hindered 2) Enforcement can be challenging. Users may be not satisfied with the temperature reached with the standard cotton programmes if no hygiene programme is offered

The development of 'super eco' programmes that are more energy efficient than the standard programmes but where this is done at the expense of longer time or using lower temperatures would be allowed for consumers willing to wait longer time.

A benefit of this approach is the continuity of the current Ecodesign and Energy label measurement methods, which have only been in place since 2010.

This approach may lead to increased use of the more efficient standard cotton programmes and less of the 'normal' cotton 40°/60°C programmes, which would still coexist. Comprehensive consumer awareness raising (e.g. campaigns) would be needed to explain this.

Communication will be in any case needed to increase the frequency of use of the standard programmes.

Potential challenges and risks: the consumer survey 2015 shows that the standard cotton programmes are hardly used by consumers if they are based on long duration cycles. Consumers also appear to ignore the fact this is one of the key strategies that can allow saving energy. Therefore, this approach could not provide significant energy savings in real-life if the duration is excessively long. On the other hand, if duration is limited, higher consumption values will be declared for ED/EL, compared to current declarations.

7.2.1.3. Policy scenario 'WM ECO' – ideally a combination of most efficient and most used programmes

In this scenario, instead of tuning the standard programmes, these are restructured substantially to reflect real-life conditions.

For the calculation of the energy consumption and other performance parameters of household washing machines, one new programme would be proposed which is able to clean normally soiled cotton laundry that is declared to be washable at 40°C and/or 60°C together in the same cycle. This programme could be called 'ECO programme', with no reference to temperature.

As for the BAU+, this scenario intends to attract users to the most efficient programmes for normally soiled cotton. To reinforce this, it may be potentially required that the machines cannot anymore offer the cotton 40°/60°C programmes.

To not repeat current effects of consumer rejection due to long programme duration the following policy sub-options could be proposed for the 'WM ECO' scenario:

Policy options for WM ECO scenario	**Possible sub-options**	**Expected benefits**	**Possible drawbacks and risks**
TIME	Adding the programme time of the ECO programme on the Energy label	Manufacturers may reduce the time of the programmes if they see consumers pay attention to this and respond to the labelling	Uncertainty on the reaction from consumers when time has to be weighed against energy use. If consumers still pay most attention to the energy, shorter programmes may not be offered.
	Cap on the maximum programme time for the ECO programme, e.g. 3 hrs	Restriction of the playing field to areas that are known to be acceptable for consumers; ≤ 2 hours would be well accepted by consumers. 3 hrs seems to be the limit of acceptance.	Manufacturers reduce their leeway (Sinner circle) to show difference to other manufacturers. Most appliances will cluster on few classes, reducing the influence of the label on purchase
TEMPERATURE	Requirement of a maximum temperature not to be overcome, e.g. 43°C	Avoiding textile damage of 40°C-labelled laundry if the wash temperature is much higher than 40°C	Measurement method for the temperature inside the textile load needs to be defined/adapted from professional WMs. Testing burden increases.
	Adding a requirement for a minimum temperature	Certainty of temperature for the consumers although not strictly necessary since not handling programmes with nominal temperature equal or higher than 60°C (no hygiene issue)	Measurement method inside the textile load needs to be defined. Testing burden increases.
LOAD	Changing the full/half load test cycles to consider other combinations (e.g. full, 2/3 and/or 1/3 load).	Machines should be subject to a demanding test that rewards the ones that better adapt energy use to different loads, as small loads are typical of real-life user behaviour. Optimization only to half load should not suffice. The ambition is to increase the cotton loads in a single programme. Thus, it also makes sense to test full load.	Ensure that the testing procedure does not become more complex (e.g. a max amount of laundry equivalent to 5 full load cycles)
PERFORMANCE	>1,03	Continuity	One shall ensure that the measurement of performance on average or on subcycles (e.g. after full load, and after partial load) is designed to avoid playing with average performance, as this may be against the objective of rewarding load adaptation
PROGRAMME RESTRICTION For normally soiled cotton laundry	1) 'super-eco' or 'long-ECO' (lower temperature, long duration) 2) normal cotton	1) Overuse of the term ECO may be counterproductive; some consumers may identify ECO with long and reject the use of all ECO. The concern	1) more energy saving programmes could be not offered; enforcement can be challenging 2) complaints from consumers,

		is less if the term ECO is not allowed for the long programmes. However, if consumers are willing to use the long programmes, this should not be hindered 2) Extreme measure to promote higher use of eco-programme	enforcement can be challenging

This approach intends to create a programme that fits to the consumer needs, and allows combining 40°C and 60°C cotton loads on higher average loadings, also for loads which are only slightly and not normally soiled (around 70% of the loads). The term 'ECO programme' is already introduced and known from dishwashers, and indicates that this programme is particularly energy-efficient.

Potential drawbacks and risks: it is not foreseeable if this 'ECO programme' would be used more often compared to current standard cotton programmes or other programmes specifically designed for cleaning slightly soiled laundry in short time. Comprehensive consumer awareness raising (e.g. campaigns) would be needed to explain the benefits of this new programme, and persuade consumers to use it.

To reinforce the attractiveness of the programme, the offer of competing programmes may be potentially restricted. For instance, in the extreme case one may restrict the offer of other programmes for normally soiled cotton such as the 'normal cotton 40°/60°C' programmes. In the cases of use of the normal 60°C cotton for hygiene purposes, this may not be accepted by consumers using extensively this programme. However, this could be addressed through communication and the naming of the 60°C cotton programme as e.g. 'Hygiene 60°C'. In this way the 60°C cotton programme users are persuaded to use the ECO programme unless the 60°C is strictly necessary for hygiene reasons.

As for the BAU+ programmes, it shall be discussed if a restriction shall be established additionally to the development of other programmes using the term 'ECO', e.g. that are more energy efficient than the ECO programme but where this is done at the expense of longer time or lower temperature cycles. On the one hand, one shall not restrict the development and use of energy-saving, long programmes if customers accept to use them. On the other hand, overuse of the term ECO may undermine the distinctive value of the ECO programme. Some consumers may identify ECO with long term and refuse to use the ECO programme, especially if alternative cotton 40°/60°C are available.

7.2.1.4. Policy scenario 'WM ECO + ECO short'

This scenario is a variant of the WM ECO scenario, where the restructured testing is complemented with a short cycle for lightly soiled cotton clothes. This can result in the appliances offering an 'ECO short' programme in addition to the 'ECO'.

The user survey 2015 results indicate that approximately 70% of the cotton loads are only lightly soiled. Thus, the washing of those loads with normal cotton programmes or standard cotton programmes would likely consume more energy and water than necessary. There is thus a potential for energy savings if consumers are persuaded to use an 'ECO-short' cycle that is able to clean lightly soiled cotton laundry declared to be washable at 30°C, 40°C and/or 60°C together in the same cycle, ideally with high loads.

The ECO programme would still be the same as on the ECO scenario, and would be the choice for cleaning normally soiled clothes. For lightly soiled clothes, the reduction in performance needs could be potentially used to e.g. reduce further energy and water use compared to the ECO programme, operating a full-load cotton programme for shorter time and/or lower temperature.

The following policy sub-options could be part of the 'WM ECO short' cycle:

Policy options for WM 'ECO+ECO short' scenario	**Possible sub-options**	**Expected benefits**	**Possible drawbacks and risks**
TIME	Cap on the maximum programme time for the ECO short cycle (e.g. 1.5 hours, to be defined after preliminary testing)	Restriction of the playing field to areas that are known to be acceptable for consumers ≤ 1.5 hour would likely be well accepted by consumers. Most short programmes of machines on the	Manufacturers reduce their leeway (Sinner circle) to show difference to other manufacturers. Most appliances will cluster on few classes, reducing the influence of the label on purchase

		market are <40 minutes, but are designed for small loads (<3.5kg) and no more than 40°C.	
TEMPERATURE	Requirement of a maximum temperature not to be trespassed, e.g. 43°C	Avoiding textile damage of 40°-labelled laundry if the wash temperature is much higher than 40°C	This restriction is unlikely needed if one aims to combine 30, 40 and 60°C cotton loads. Measurement method for the temperature inside the textile load needs to be defined/adapted from professional WMs. Testing burden increases.
	Adding a requirement for a minimum temperature	Certainty of temperature for the consumers although not strictly necessary since not handling programmes with nominal temperature equal or higher than 60°C (no hygiene issue)	Increased test burden
LOAD	Changing the full/half load test cycles to consider other combinations (e.g. full, 2/3 and/or 1/3 load) that are more representative of short cycles	Machines should be subject to a demanding test that rewards the ones that better adapt energy use to different loads, as small loads are typical of real-life user behaviour. Optimization only to half load should not suffice. The ambition is to increase the cotton loads in a single programme. Thus, it also makes sense to test full load.	Ensure that the testing procedure does not become more complex
PERFORMANCE	>0.97? (to be discussed after measurement results become available)	This would reflect the fact that a lower washing performance is sufficient for lightly soiled laundry. The ambition is to increase the use of a single programme for different cotton loads	No experience with the washing performance of such new programme
PROGRAMME RESTRICTION for lightly soiled cotton	1) 'super-eco' or 'long-ECO' (lower temperature, long duration) 2) normal cotton	1) Overuse of the term ECO may be counterproductive; some consumers may identify ECO with long and reject the use of all ECO. The concern is less if the term ECO is not allowed for the long programmes. However, if consumers are willing to use the long programmes, this should not be hindered 2) Extreme measure to promote higher use of eco-programme	1) More energy saving programmes could be not offered; Enforcement can be challenging 2) Possible complaints from consumers. Enforcement can be challenging

The ECO short cycle intends to align the standard further to real life demand, as short programmes are frequently used (~15%) by consumers.

Potential drawbacks and risks: It is not foreseeable if the ECO short cycle would replace to any extent existing short programmes. The short programmes use normally less energy, but this is because they are designed to handle small loads (<3.5kg), of lightly soiled clothes, and operate at the lower temperature range (30-40°C). They are not designed to be performant for full loads, which is one of the ambitions for the ECO short cycle. It is also difficult to foresee to what extent consumers would choose the ECO programme or the ECO short programme. However, this is secondary, as both would be energy-saving options compared to current practice.

Comprehensive consumer awareness raising (e.g. campaigns) would be needed to explain the benefits of this new programme.

Alternatively, should the Eco short not being supported, it could be discussed if short programmes should be offered mandatorily.

7.2.1.5. Summary: Comparison of the alternative policy scenarios OLD, BAU+, and ECO/ECO short

Table 7.2 summarizes the essential characteristics and differences of the alternative policy scenarios for the future programme(s) as basis for the energy label and ecodesign requirements.

Table 7.2: Comparison of the alternative policy scenarios BAU+, OLD and ECO/ECO short regarding future programme(s) as basis for the energy label and ecodesign requirements

	OLD	BAU+	ECO	ECO & ECO short
Basis for Ecodesign / Energy Label	Most used programmes for normally soiled cotton	Most efficient programmes (specifically optimized for Ecodesign / Energy label AND user acceptance)	Most efficient programme (specifically optimized for Ecodesign / Energy label AND user acceptance)	Most efficient programmes (specifically optimized for Ecodesign / Energy label AND user acceptance)
Alternative 'normal' programmes allowed for the same purpose?	No	Yes	To be discussed	To be discussed
Alternative 'super ECO' programmes (long duration, low temperature) allowed?	Yes	Yes	To be discussed	To be discussed
Target of the revision	Field for most frequently used programmes in real-life. Stringent definition needed to avoid alternative consumer programmes to be established.	Persuasion of users to choose standard programmes needed.	Persuasion needed to explain benefits of ECO programmes with combined 40°/60°C, washing higher loads.	Persuasion needed to explain benefits of ECO-short programme combining higher loads of lightly soiled 40°/60°C washing.

7.2.1.6. Additional options to the basic policy scenario for washing machines and the washing function of washer-dryers (WM ADD)

In addition to the basic policy scenario (OLD, BAU+, or ECO) and the single options on time, temperature, load and performance already described in section 7.2 above, further policy options (WM ADD) can be applied horizontally. Detailed information on possible benefits and/or potential pros/cons are provided in the Annex, section 8.2. These additional options can be grouped into:

- Generic ecodesign requirements
- Specific ecodesign requirements
- Calculation of the Energy Efficiency Index (EEI)
- Test standards
- Information on the Energy label
- Communication to consumers

For the first five options above, Table 7.3 marks in green the topics where stakeholder feedback tends to agree, whereas yellow marking is used for the topics where diverging opinions have been received from stakeholders. These are still to be further discussed.

Table 7.3: Policy options (WM ADD) additional to the basic policy scenarios to be further discussed

Option	Topic	Policy option
Generic Ecodesign requirements		
Various	Consumer information / education	Various, see section below the table
6a	Standard programme(s)	Default selection when switching on the machine
6b	'	Change the current indicator symbol (arrow)
14c	Increasing drum volume and associated underloading in real-life conditions	Direct consumer feedback on actual loading
18a	Consumer information – improving compliance	Template for information requirements
18b	Consumer information – better access	QR code
18c	"	Information on the appliance's display / control panel
Specific Ecodesign requirements		
9	Quality of rinsing	Minimum requirements on rinsing performance
12c	Remaining moisture content (RMC)	Align different ED/EL requirements on RMC
7b	20°C programme	Minimum washing performance for 20°C
12a	Spin drying efficiency	Minimum requirement on spin drying efficiency
14b	Increasing drum volume and associated underloading in real-life conditions	Specific requirements on half load cycles (relative saving compared to full load and/or info to consumers). Alternatively, consumption values for half/full load could be simply declared without any cap (e.g. in the label, in the product fiche).
15d	Standby consumption	Power cap for delayed start
15f	"	Power cap for other low-power modes
Formula for the calculation of the Energy Efficiency Index (EEI)		
15a	Standby/low power mode consumption	Leave standby out of EEI formula, including smart connectivity (networked standby, network ability) and other low-power modes: - delayed start (also called reactivation function) - left-on mode
13d	Increasing drum volume	Progressive curve/calculation formula
Test standards / performance measurement		
8b	Washing performance	Split / measure washing performance for each cycle in the testing (e.g. half load, full load) and not average, to promote rewarding better load detection.
9	Quality of rinsing	Measurement of rinsing performance
2a	Lower washing temperatures used than declared	Temperature: measurement, declaration and holding
7a	20°C programme	Including 20°C into performance standard tests
14a	Increasing drum volume and associated underloading in real-life conditions	Allow use of sensors
14d	"	Measurement / declaration of fixed amount of loading
14e	"	Increase share of partial loads in performance testing

Option	Topic	Policy option
14f	"	Capacity indication based on volume measurement
Information on the Energy label		
4d	Energy performance	Separate declaration of values for different programmes in the Energy Label instead of average values
8a	Washing performance	Declaration of washing performance on Energy label
16a	Energy label – displaying consumption	Energy values per x number of cycles
16b	"	Energy values per 1 cycle
19	Hot-fill connection	Mandatory consumer information on hot fill option (e.g. symbol coupled with further consumer information under which conditions hot fill is beneficiary

1.1.1.1.3 Options on consumer Information

- Better / mandatory consumer information about the environmental benefits of energy-saving longer programmes (e.g. leaflets, stickers, educational campaigns) which also results in economic benefits for consumers when using primarily the efficient standard cotton programmes (for cotton wash).
- Manufacturer shall inform about the fact that real temperatures might deviate from the declared ones. Education under 'normal' circumstances when only a certain wash performance is necessary lower temperatures being sufficient. Clear indication of which programme(s) is/are designed especially for hygienic needs.
- Develop an agreed list of Best Practice Tips for washing and for drying and include them as, e.g., instruction leaflet / manual in each machine. Example of possible advices:
  - on which programme to use for which types of textiles and soiling; laundry that requires special hygiene conditions;
  - to full load whenever possible; the right use of large capacity machines
  - that programmes at lower temperatures save energy;
  - to adjust detergent dosing with regard to the local water hardness;
  - to use the pre-wash programme only when needed;
  - on the dependencies of spinning and subsequent drying and recommended spin speeds (e.g. 'for tumble-drying / washer dryers please use a higher spin speed', 'for outside line-drying please use a lower spinning speed')
  - on the best environmental practices of drying, depending on the climatic conditions and indoor dwelling climate;
  - on the correct installation in order to minimise the noise emitted;
  - on correct maintenance of the WM/WD;
  - on operations of the machines that are advantageous for hygienic issues and the avoidance of odours of the laundry (e.g. keeping the porthole open to dry out the machine; keeping the dispenser drawer open; ambient conditions of the room, using maintenance cycles at higher temperatures from time to time)
- Introduce a template for the most relevant information requirements of the main programmes of WM/WD (e.g. recommended load, consumption per cycle / per kg of load, consumption at half load, real wash temperature, programme duration, noise.) being easily accessible online before purchase.

- Mandatory consumer information on hot fill option (e.g. symbol on EL for hot fill connection and further consumer information under which conditions hot fill is beneficiary)

7.2.1.7. Discarded policy options

The policy options presented on Table 7.4 have been discarded. The feedback received reflects general opposition or rejection. Detailed descriptions of the options as well as their benefits and disadvantages are provided in the Annex, section 8.2.

Table 7.4: Policy options which have received opposing stakeholder feedback

Option	Topic	Policy option
1c	Long durations of standard cotton programmes	Adjusting measurement standard to avoid excessive programme durations (rearranging soiling strips)
2b	Lower washing temperatures used than declared	Renaming 40°/60°C programme names: indicating the real temperatures used
3b	Double programmes for the same purpose (standard and normal 40°/60°C programmes)	Energy cap of the normal programmes compared to the standard programmes
3c	"	Only one programme for same item/temperature allowed
4b	Taking most used programmes as basis for Ecodesign / Energy label	Adding further washing programmes to the performance measurement
5c	Completely new definition of an ECO programme as basis for Ecodesign / Energy label	Consideration of 30°C as basis
8c	Washing performance	Change test standard to (most used) liquid detergents
10a	Hygiene / avoiding odours	Hygiene requirements (Ecodesign / Energy label)
11	Avoiding textile damage due to very long programme durations	Minimum requirement on Gentleness of action
13a/b	Increasing drum volume	Cap on absolute energy / water consumption
13c	"	Different calculation formulas for small/large appliances
15b	Standby consumption	Keep standby in the formula
15c	"	Include delay start in the formula
15e	"	Bonus on delay start for smart-grid functionality
17b	Detergent consumption / overdosage	Requirement on automatic detergent dosage system
20	Trend towards new kinds of WM (e.g. multidrum)	Adjusting existing measurement standards

QUESTIONS BOX: POLICY OPTIONS FOR WASHING MACHINES

The policy proposals above intend to create a framework of options for discussion with stakeholders. In particular, you would be welcome to

- Identify potential **practical/technical feasibility barriers** for the implementation of the proposals outlined

- Contribute to refine **the new policy scenarios** by proposing any adaptations or alternative policy options that could receive wide acceptance

7.3. Policy options for washer-dryers

7.3.1. Current situation

7.3.1.1. Standard performance measurement of washer-dryers

The existing European Directive on energy labelling of washer-dryers (96/60/EC from 19 September 1996) is based on the use of the washer-dryer to wash and subsequently dry a full load of laundry (as discontinuous processes). This requires more than one subsequent drying cycles, because in current machines the rated washing capacity is higher than the rated drying capacity.
This approach is defined in the basic standard for measuring the energy consumption and performance of washer-dryers (EN 50229) which is to an extent aligned to the measurement standards for washing-machines (EN 60456) and for tumble-dryers (EN61121).

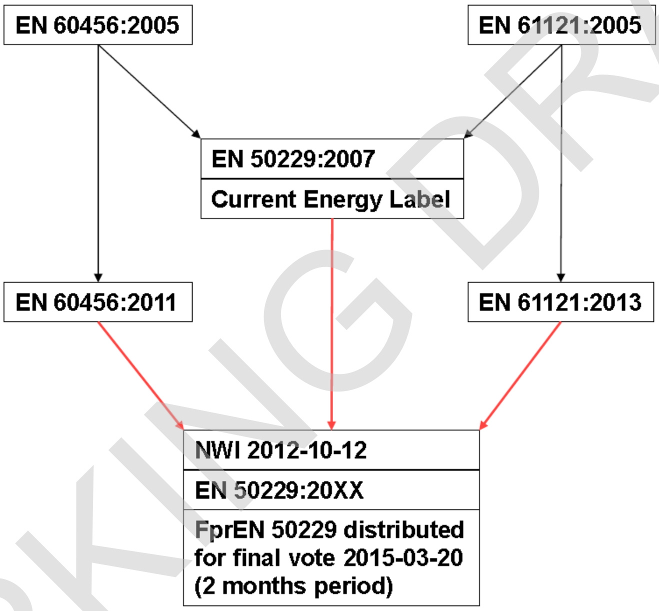

Figure 7.2: Relationship between the washing-machine standard, EN 60456, and the standard for measuring tumble-dryers, EN 61211, with the measurement standard for washer-dryers, EN 50229. Timeline is from top to bottom of the graph. No current relationship exists to IEC 62512, which describes a method for continuous wash and dry.

EN 50229 for WD was first published in 1997, but has been regularly updated to adjust to the modifications of EN 60456 and EN 61121, the European standards for testing washing-machines and tumble-dryers performance, respectively. However, the current WD standard does not follow exactly all the elements of WM and TD standards. For instance, for the washing part it follows the older method of five 60°C full-load washing, whereas washing is currently tested with a 3:2:2 combination of full and half loads at 40°C and 60°C. Also for the drying, half loads are used only.
The latest version of EN 50299 (2007) for WD could be updated to align with recent changes applied to the standards for washing-machines (EN 60456:2011) and for tumble-dryers (EN 61121:2013), as shown in Figure 7.2. The revision of the standard EN 50229:2007 is currently in a formal voting process (draft standard prEN 50229 finalised in March 2015 by CENELEC TC 59X).
The test methods for performance measurement of washer-dryers specified in EN 50229 with regard to the energy labelling of household combined washer-dryers are based on:

- Performance criteria, including energy and water consumption, for the 'Cotton 60°C' wash programme, as specified in EN 60456, at the rated washing capacity, and

- Energy and water consumption of the drying cycle based on the 'Dry cotton programme', as specified in EN 61121, at the rated drying capacity.

As the rated washing capacity is normally higher than the rated drying capacity, the use of this standard requires that the load is divided into two or more parts which, after being washed, are dried individually. Water and energy consumption are calculated by adding up all individual consumption values from the wash cycle and the following drying cycles (2 or more, when the rated washing capacity is more than twice the rated drying capacity).

New designs of washer-dryers allow washing and drying loads of laundry in one continuous cycle (called 'wash&dry'). Following the development of larger WM (and WD) drum volumes (>7kg), the rated capacity of drying in the WD (~3.5kg) is currently exceeding the average wash load in the EU (3.4 kg). The washing and drying functions are used without interruption, load splitting, nor reloading of the parts of the washed load that exceeded the drying capacity. This new feature is what distinguishes a WD from two separate WM and tumble-dryer appliances, and is well accepted and welcome by consumers, especially if space availability is limited. However, this function is so far not considered in the Energy label Directive for washer-dryers, nor is it covered by the current EN 50229.

At international level, the first edition of IEC 62512 'Electric clothes washer-dryers for household use – Methods for measuring the performance' has been prepared specifying the conditions needed to test the combined function of washing and drying in a washer-dryer. The standard defines in detail the procedure of how an interrupted operation cycle (i.e. a complete operation cycle where the operator's action is required to continue the process) and a continuous operation cycle (i.e. a complete operation cycle without interruption of the process or additional action by an operator) of a washer-dryer has to be tested.

7.3.1.2. Results of the consumer survey 2015 on washer-dryers

The consumer survey 2015 on washer-dryers (Stamminger, R. et al. 2015, unpublished) shows that the dominant use of a washer-dryer is as a washing-machine. WD appliances are most used for washing (EU average number of wash cycles per week is 4.6) and to a less extent for drying (EU average number of drying cycles per week is 2.9). From the weekly number of drying cycles, about a half (1.5 cycles/week) are done in a continuous wash&dry cycle, and the other half (1.4 cycles) are drying of a washed load that was previously split.

Consumers are keen to compare the washing and drying performance of WDs with WMs and TDs. Around 78 % of the consumer survey respondents categorise comparability of the Energy label values for a washer-dryer with a washing machine as very important or important. Almost identical results are delivered for the comparability of a washer-dryer Energy label with that of a tumble-dryer.

7.3.1.3. Basic policy scenario for washer-dryers

Based on the current situation and the fact that washer-dryers are used for the functions washing only, drying only, and wash&dry, three basic proposals for policy scenarios for WD were developed and circulated to stakeholders for further detailed feedback during summer 2015 (details including expected benefits and potential disadvantages, challenges and / or drawbacks cf. Annex, section 8.4).

1. Including the WD into the revised ED/EL regulations of WM, as separate section, plus additional requirements for wash&dry.
2. Splitting the WD: including washing function requirements into the revised ED/EL regulations of washing machines; including requirements drying functions into a revision of the ED/EL regulations of tumble dryers
3. Separate / own ED/EL regulation for WD, additional to the existing ED/EL regulations of washing machines and tumble dryers.

Two elements are implicit in this proposal, one is formal, and the other is of content:

a) From a formal/administrative process point of view, dealing with WM and WD together would avoid that the WD revision is set aside and delayed because it would result in much lower potential savings at aggregated EU level, compared to WM
b) From a content point of view, dealing with WM and WD together would facilitate alignment of the common elements (washing cycle), and later reduction of the effort for the testing this washing cycle.
According to stakeholder feedback, the most preferred solution is **including the WD into the revised Ecodesign and Energy label regulations of Washing Machines**. Ideally, requirements for the washing function of the WD would be the same of WM (or similar, where this is not completely feasible).
The second and third policy scenarios were generally not favoured by the answering stakeholders.
Regarding the testing of the drying part of the cycle in WD, additional requirements need to be set. These could be for the *drying only cycle,* for the *continuous (or the 'quasi-continuous'[1]) wash&dry cycle, or for both.*
Based on the comments above, two main building blocks of the policy of WD are foreseen:
For the **washing function** of washer-dryers**:** the same policy and options as for washing machines (cf. sections 7.2 to 7.2.1.6 above) shall apply, to align both product groups as far as possible. This would simplify performance testing and enhanced comparability for consumers in terms of the washing function of WD to WM. Stakeholders seem to generally agree on this proposal.
For the **drying function(s) of washer-dryers**, i.e. for the drying-only function and for the continuous wash&dry function, further policy options have to be discussed, as several options can be envisaged to complement the current policy scenario described above. Detailed information on possible benefits and/or potential drawbacks and risks are provided in the Annex, section 8.4.

7.3.1.4. Additional options to the basic policy scenario for washer-dryers (WD DRY)

Three basic options to test the drying function of the WD can conceptually be proposed:
A) To test exclusively the dry-only function.
B) To test exclusively the continuous wash-and-dry function.
C) To test both options above.
It is important to notice that when referring to the continuous W+D, this may also include a brief interruption (e.g. <2 minutes) that could allow simple operations such as extraction of probes (e.g. for rinsing efficiency testing) or weighting (for spinning efficiency testing), but would have insignificant impact on the overall energy consumption of the wash+dry process (e.g. the machine's temperature loss would be insignificant). In the following, this *quasi-continuous* process is thus considered part of the continuous wash+dry process. The practice of short opening is also commonplace in real life, as consumers would do that to separate delicate clothes that do not withstand drying.
Table 7.5 below summarises the basic pros and cons of the three options. Further details of the options are described in the following sections.

Table 7.5 Pros and cons of options to test the drying function of the WD

	Wash	Dry	PROS	CONS
A) Dry only	As in WM (EN60456 and its updates following the WM revision)	Adapted from TD	- Addresses an important programme used by consumers - Is current standard practice. Further alignment possible to facilitate comparability to TD.	- Dedicated TDs have normally much larger capacity - WD could get poor labels, as the hot spinning or pre-heating of the machine are not part of the TD testing. - The increasingly popular W+D function is not tested

[1] *Quasi-continuous wash&dry cycle is referred to a cycle where the laundry is washed and dried not in a continuous process but as to subsequent operations very close in time (e.g. about 2 minutes).*

B) Continuous Wash+dry	- As in WM (EN60456 and its updates following the WM revision). - If feasible, some of the cycles of the WM testing could continue with drying and thus be used to test the W+D..	A new continuous W+D cycle, to be precisely defined. Inspiration available in IEC 62512, that can be adapted	- Addresses an increasingly popular and distinctive function of WDs, compared to two separate appliances - International alignment. - Option of using some of the wash cycles for both declarations (WM and WD)	- Results not directly comparable to TDs. Calculations are needed to get dry-only estimations comparable with TDs. - Due to the different maximum loading of washing and drying, some of the washing cycles have to be repeated, but may not be of use for measuring washing performance.
C) Both dry-only <u>and</u> continuous W+D	As above (The number of washes may be reduced if both are coordinated, compared to two fully independent tests)	Both above	All of the above	High testing effort and cost

1.1.1.1.4 Policy sub-options for the <u>drying only</u> function of washer-dryers

In principle, Ecodesign and Energy label measures for the drying-only function of washer-dryers could align with those for tumble-dryers (EU 932/2012), for better comparability. As indicated above, consumers requested to answer on this in the consumer survey 2015 on washer-dryers were in favour comparability to the Energy label of tumble-dryers. However, the consumer survey also reveals that in real-life the WD is only in 1/3 of the cycles used for drying only. A few stakeholders suggested not to test the dry-only function (option A above), whereas some others fear that if the drying only function is not tested and declared at all, there would be a risk of misleading information and advertising.

According to stakeholder feedback, testing the single drying function of the washer-dryer in a similar way to tumble-dryers (following EN 61121:2013) has some limitations. Drying in a WD starts normally after the washing, so the WD has already been heated by the washing cycle, or even after a wash+dry cycle (i.e. the WD has already been heated by the drying cycle). However, the testing following EN 61121:2013 would not take this potential energy saving into account. There are also concerns that the water use of WDs is not included in the TD standard and that the condensation technology of TDs and WDs may not be comparable. Stakeholders are also concerned about a possible low classification of WD on the label, compared to TDs, about the need of specific ED limits for WD, and question if the EEI used for TD is applicable at all.

Further, testing drying as in tumble-dryers (EN 61121:2013) would moreover imply to bring the humidity of the clothes loaded to 60% remaining moisture content. This would require some processing, as the usual moisture level after washing in a WD is closer to 45%).

Table 7.6 summarizes the policy sub-options proposed for the drying only function of washer-dryers, and the stakeholder feedback received on possible benefits and challenges or drawbacks.

Table 7.6 Policy sub-options for the drying only function of WD, to be further discussed

Option	Policy sub-option	Expected benefits	Possible challenges / drawbacks
WD 3a	Application of some/all the requirements to the TD regulation: - Availability of a standard cotton programme for drying - Measurement / calculation of the Energy	• General requirements of EN61121 (TDs) can be adapted • Synergies: it is generally good to align with other ED requirements. • The same scale for Energy labelling as for tumble dryers could be used as basis	• Special requirements for WD should be considered. WD less used as a dryer only than as WM only.). • The washer-dryer, when testing the drying function, has already been heated by a previous washing or drying cycle. • The initial moisture content defined in the TD regulation (60%) would have to be

Option	Policy sub-option	Expected benefits	Possible challenges / drawbacks
	Efficiency Index, - Weighted condensation efficiency		adapted to the WD situation (~45%) • The TD regulation does not consider the water consumption as no water is used during the drying phase. • The energy efficiency index from the tumble-dryer regulation cannot be used. • The condensation efficiency cannot be taken from the TD regulation as there are different condensation technologies. • Own Ecodesign limits would have to be defined for WD. If needed, the ED on drying performance might be less strict than for tumble dryers
WD 3b	Align the requirements of the drying function to the (future) approach which is decided to use for the wash-function (currently: 3:2:2 test cycles at 60°C full : 60°C half: 40°C half-load).	• Synergies: it is good to align the drying test to the washing load characteristics.	• The rated capacity of the drying function should be tested and be part of the programme portfolio • Not full alignment is possible since partial load in drying is different than partial load in washing. (because of different rated capacities) • Also the continuous wash&dry cycle should be included in the test programme portfolio

1.1.1.1.5 Policy sub-options for the <u>continuous wash&dry function</u> of washer-dryers

The advantage of a washer-dryer compared to the use of two appliances (WM+TD) is the possibility of washing <u>and</u> drying clothes in one go.

Currently, the testing of the washing and drying of the clothes is done separately, following Directive 96/60/EC and EN 50229:2015 on WDs. This means that currently the wash load needs to be taken out after each of the wash cycles where the drying capacity is exceeded, and split in two (or more) partial loads, which are then dried and the remaining separated and kept. Once the washes and dryings are completed, the drying of the remainings takes place.

The process where the wash load is not removed and split after the wash cycle and immediately dried, preferably in a continuous process which does not foresee the intervention of the user, is not tested.

.Table 7.7 summarizes the policy options proposed for the continuous wash&dry function of washer-dryers including stakeholder feedback on possible benefits and challenges or drawbacks.

Table 7.7 Policy sub-options for the continuous wash&dry function of WD, to be further discussed

Option	Policy sub-option	Stakeholder feedback
WD 4a	Business as usual; keep the existing measurement method and A-to-E Label classes, but adjusting them to the current consumption levels	• This option was not backed at all by stakeholders.
WD 4b	Define a new measurement method for testing the most used programmes for the continuous wash&dry cycle (different temperatures, full/partial load, taking the average of a certain number of cycles in the end)	• This proposal was welcomed by stakeholders, who expect alignment of requirements and measurements for WM and WD as much as possible, so that the extra cost for testing the WD is kept down.
WD 4c	Define a most efficient standard/eco programme for the wash/dry function of WD which can wash and dry normally soiled cotton labelled textiles (alignment with BAU+, ECO, OLD scenarios needed)	• If such an approach would be introduced for WM, stakeholders would agree to align the approach for WD accordingly

7.3.1.5. Additional issues to discuss for washer-dryers (WD ADD)

In a second step, depending on the Ecodesign and Energy labelling measures proposed for the drying only cycle and/or for the continuous wash&dry cycle, the following issues should be discussed for washer-dryers (WD ADD). These include aspects related to:

- Generic and specific ecodesign requirements,
- Formula for the calculation of the Energy Efficiency Index EEI,
- Modifications of the current test standard and/or
- Information to show on the Energy label.

A list of policy options to be further discussed is presented in Table 7.8. Further discussion with stakeholders is needed to point out the comprehensiveness of the options presented and associated pros and cons.

Table 7.8: Possible additional policy options for washer-dryers (WD ADD), to be further discussed

Topic	Policy option
Generic Ecodesign requirements	
Standard programme(s)	Definition, including decision about the name or indicator symbol (arrow)
Increasing drum volume associated to underloading in real-life conditions	Direct consumer feedback on actual loading
Consumer information (education, improving compliance, better access)	For example • Various information requirements on the standard programmes, benefits of energy-saving (longer) programmes and best practice tipps) • Template for information requirements • QR code • Information on the appliance display
Wash&dry cycle	Mandatory presence of this cycle in all machines on the market
Specific Ecodesign requirements	
Washing performance	Minimum requirements for the wash&dry function (e.g. same requirements as for the washing performance of WM?)
Energy consumption	For example • Maximum total energy consumption allowed (cap) • Requirements on a certain minimum Energy Efficiency Index to be reached for the drying and/or W+D functions, possibly in different tiers
Water consumption	For example: maximum total water consumption (cap)
Spin drying efficiency / Remaining moisture content (RMC)	For example • Minimum requirement on spin drying efficiency of the washing process • Minimum requirement on RMC at the end of the washing process
Increasing drum volume associated to underloading in real-life conditions	Specific requirements on half load cycles (relative saving compared to full load and/or info to consumers) with special focus of a definition of 'half load' with regard to the rated capacity of washing and drying.
Formula for the calculation of the Energy Efficiency Index (EEI)	
General formula	Programme choice, number of test cycles etc. aligned to real life and based on measurement standard
EEI classes	Different EEI classes (A-G scale) to be determined for the Energy label

Topic	Policy option
Standby/low power mode consumption	To be aligned to the approach decided for washing machines. Current proposal: leave all low-power modes out of EEI formula (including smart connectivity, delayed start, left-on mode)
Increasing drum volume	For example progressive curve/calculation formula
Test standards / performance measurement	
Basis for a future test standard	Choice for example • Aligning to IEC 62512
Test cycle	Various parameters are to be decided and defined for the overall test cycle: • Continuous drying cycle vs. interrupted operation • Full vs partial load treatments • Choice of programmes for drying (e.g. the 'most used': cupboard dry and/or iron dry) • Definition of time needed to reach the final moisture content for the time controlled cycles • Definition of the performance of wash&dry cycles • Number of test runs
Drying performance	Measure drying performance for each cycle in the testing (e.g. half load, full load) and not average, to promote rewarding better load detection
Energy performance	Separate declaration of values for different programmes
Increasing drum volume associated to underloading in real-life conditions	For example • Allow use of sensors • Measurement / declaration of fixed amount of loading • Increase share of partial loads in performance testing
Information on the Energy label	
Type of Energy label	Sub-options: • One label scale for the washing function plus additional information on the drying / wash+dry function • Different label scales for the washing function and for the drying / wash+dry function (combined label as already applied e.g. for air conditioners).
Type of information to be declared on the label	For example: rated capacity, information on wash&dry cycle, average total energy consumption, energy label class, average total water consumption, average total time, specific total energy consumption, noise washing, noise spinning and noise drying
Reference of declared performance values	Per cycle / per x number of cycles

QUESTIONS BOX: POLICY OPTIONS FOR WASHER-DRYERS

The policy proposals above intend to create a framework of options for discussion with stakeholders. In particular, you would be welcome to

- Identify potential **practical/technical feasibility barriers** for the implementation of the proposals outlined
- Contribute to refine **the new policy scenarios** by proposing any adaptations or alternative policy options that could receive wide acceptance

7.4. Policy options related to material efficiency and end-of-life of washing machines and washer-dryers

Research of previous tasks 1 to 4 with regard to material efficiency and end-of-life management of washing machines and washer-dryers can be summarized as follows:

- In general, there is an increasing need for finding feasible, operational measures for implementing resource efficiency aspects into product policies, as reflected in a number of European Union strategic policy documents, including the revision of the ED and EL directives, and the drafts of the Action Plan on the Circular Economy.
- There is an increasing number of examples of integration of resource efficiency matters (such as durability and facilitating end-of-life management of products) into specific product policy instruments like mandatory Ecodesign Regulations or voluntary ecolabels.
- There seems to be still a gap between the already implemented requirements/criteria in product policies, and the ongoing research in this field, which highlights the potential beneficial impacts of increased product-related resource efficiency.
- There is absence of sufficient standards which are applicable for testing and measuring resource-related criteria, including procedures for verification and market surveillance. Currently, a number of standards are somehow related to material efficiency (e.g. safety standards for durability, standards for recycling in end-of-life management), but they are primarily developed for other purposes (product safety, management at recycling operations) and are not directly addressing resource efficiency in the design phase.
- The European Commission addressed in January 2015 a standardization request M/529 to the European standardization organisations (ESOs) with regard to ecodesign requirements on material efficiency aspects (recyclability, recoverability and reusability indexes, durability, reversible disassembly and end of life extraction time). The request, however, was rejected by the ESOs and is still under development.
- The average technical product lifetime of washing machines and washer-dryers (i.e. first useful service life of a machine replaced due to a defect) of 12.5 years slightly decreased compared to approximately 15 years in former years. However, WM and WD are still relatively long-lasting products compared to other EEE.
- There are statistical indications that the proportion of washing machines which have to be replaced earlier than the expected average lifetime, especially within the first 5 years, due to a defect has increased.
- Reasons for breakdowns cannot be assigned to certain components in WM/WDs. The causes of breakdowns are rather manifold, and can affect the motor, electronics, shock absorbers, heating elements, drainage pumps, or door hinges.
- Although a defect is still the main cause for the replacement of WM, consumer research in Germany (Prakash et al. 2015) revealed that more than 10% of the replaced large household appliances were still functional and were replaced due to the desire of the consumer for a better device.
- Repairability of washing machines seems to become more difficult for reuse and repair centres due to lack of access and costs of spare parts, lack of access to service manuals, software and hardware, as well as due to product design which hinders disassembly of the appliances for repair.
- Also for users, it seems that the repair of a WM/WD has become with time less attractive due to the relatively high costs of repair (between EUR 100-300 depending on the defective component),

compared to decreasing prices for the purchase of a new appliance (~EUR 415 for a WM, ~EUR 830 for a WD).

- Regarding EoL-management, for both WM and WD, there are currently well established recycling processes in place in accredited WEEE installations. Appliances (especially WDs) with heat pumps have to be processed separately for depollution (extraction and incineration) of the F-gas refrigerants. Permanent magnet motors in WM/WD have been highlighted as relevant subject of manual disassembly to recover rare earth and copper content. However, recent stakeholder feedback indicates that newer permanent magnet motors do not contain rare earths and copper is replaced by aluminium, both because of lower cost and equal performance of the alternative.
- The collection rate of waste WM/WD through the accredited WEEE collection systems, mostly in connection with producer responsibility systems, is in some Member States (e.g. IT, ES, PT, GR) only around 1/3 of the appliances sold on the market being treated in accredited installations.. In other Member States, this share is ca. 2/3. On both cases, large flows are apparently not treated following WEEE prescriptions. Pathways of appliances not collected and registered in official statistics might be prolonged storage in households, recycling within the EU but in non-accredited installations that do not report to official Member State statistics, or export as used EEE or end-of-life equipment to non-European destinations. The revised WEEE Directive has set specific measures to try to address these enforcement issues. The upcoming Action Plan on a Circular Economy may likely address how to improve producer responsibility systems, by imposing minimum operation rules (e.g. transparency of fees and costs, no-profitability) and proposing fees to manufacturers based on the recyclability of their appliances (for which clear definitions and measurement of recyclability will be needed).

Against this background, a list of different potential policy options on material efficiency and EoL-management of household WM/WD has been laid out, including a draft of expected benefits and potential disadvantages, challenges and / or drawbacks. This was circulated to stakeholders for further detailed feedback during summer 2015 (cf. Annex 8.5 for details). The options were split into two main sections concerning durability (including reparability) of products, i.e. measures addressing the prolongation of product lifetime on the one hand, and End-of-life management of WM/WD on the other hand.

7.4.1.1. Durability and reparability

Most of the technical potential for improving the energy efficiency of household washing machines and washer-dryers has been already exploited. In the context of Ecodesign, durability and repairability measures might thus become more relevant. Durability can be understood as an extension of the lifetime of the machine under the same performance conditions. Such an extension of lifetime can be established either by increasing the original lifetime of the product or by extending the use phase of products, e.g. through repair activities. Lifetime and durability tests are still to be defined and for the time being, they are not standardised.
The following causes decreasing the durability of products or the use time by consumers have been identified:

- **Unsatisfactory mechanical robustness or durability** of certain components and/or the whole appliance, which lead to early failure rates.
- **Wrong user behaviour** leading to defects of appliances (e.g. incorrect use, insufficient maintenance)
- **Fewer repairs**: In case of a defect, appliances are increasingly discarded although a repair might have increased the lifetime; reasons might be e.g. intrinsic product design impeding repairs, missing and/or no access to spare parts, high costs for repairs compared to purchase of a new product etc.
- **Early replacement** of appliances **due to changes in consumer preferences and needs** (e.g. larger or newer products, modern design, ...)

The stakeholder feedback received to the list of options on durability and reparability reflects disagreement between environmental / consumer NGOs, Member States representatives and industry. The general need is seen for requirements on improving durability, such as information about the expected operational lifetime of the products, or design for upgrades and repairs, but the lack of practicability of these approaches is often mentioned as obstacle, due to missing definitions or measurement standards.
The policy options presented in Table 7.9 were seen as least feasible according to stakeholder feedback.
On the other hand, there is a set of policy options that have been more welcome by stakeholders, mainly on reparability of products, and are presented in Table 7.10. These will be followed-up for discussion.

Table 7.9 Policy options on improving durability seen as least feasible by stakeholders

Option	Policy option	Reasons for discomfort with the option
1a	Requirement on performing durability tests of certain components which are known to be prone for early failures	• No clear evidence which components usually fail more often; effective measures would have to be set to all main components (definition of 'main'?) • Definitions of components difficult due to different designs – a too wide definition would make consistency checks complicated; a too narrow definition would be easy to circumvent • Durable components do not lead to durable products automatically • High effort / costs for testing, also for market surveillance • No standard / test available; existing safety standards cannot be taken to measure durability • Durability / availability of after sales service is seen as market differentiation / competition issue
1b	Requirements on minimum operational lifetime of certain components which are known to be prone to early failures	• No clear evidence which components usually fail more often; • Durable components do not lead to durable products automatically • High effort / costs for testing, also for market surveillance; long-time needed for tests or accelerated tests • No standard / test available; no definition of 'operational lifetime' against different usage patterns in EU
1c	Consumer information about the operational lifetime of certain components, e.g. motor	• No definition / measurement standard available to underpin this information • Does not hinder breakdown of machines • Might misguide consumers as e.g. the lifetime of a single component cannot be taken as indication for the overall quality of the product
2a	Requirement on performing durability tests of the whole product (e.g. endurance tests, tests under extreme conditions)	• Cf. arguments under option 1a, although this option is partly favoured over option 1a • Non-compliant 1-year lifetime test would only be able to force products out from the market 1 year after entry
2b	Requirements on minimum operational lifetime of the whole appliance (e.g. machines to run a certain minimum number of cycles)	• Cf. arguments under option 1b • For long living products such as WM/WD a minimum operational lifetime must be quite high to be meaningful. Even if it would be set at 50% of the Average Expected Product Lifetime (AEPL), it is more crucial that it can be repaired if it fails after the minimum operational lifetime has expired.
3b	Compulsory direct feedback on necessary maintenance intervals via the machine's display	• Increasing appliance costs, especially for low-price machines without display so far • Impact not clear, i.e. if consumers really change their maintenance behaviour
3c	Consumer information about the environmental (and economic) benefits of prolonged product use	• Long lasting WM/WD are usually rather not replaced due to fashion and design • Better proper information on disposal and more efficient WEEE collection / recycling • Educational effects might be limited • Work with second hand market might be more effective
4d	Information requirements on repairability (e.g. repair label); indicating if the machine can be repaired or not; indicating which components are not repairable	• Self-declared claims are prone to market distortion • Requires a comprehensive standard such as ONR 192102 • No certainty that repairs will be done by consumers in the end (e.g. depending on the costs for repairs compared to the purchase price for a new product) • Repairability and after-sales services are market differentiation / competition issues
4e	Consumer information about access to professional repairs	• Common practice of most (all?) manufacturers, although a standard format might help enforcement of such requirements • Such requirements should not be set on a product by product case • Repairability and after-sales services are market differentiation / competition issues
4j	Mandatory consumer information about commercial guarantees, i.e. the number of years the producer guarantees the full functioning of	• Cf. arguments under option 4i

Option	Policy option	Reasons for discomfort with the option
	the appliance for free and without passing the burden of proof to the consumer	

Table 7.10 Policy options on improving durability to be followed-up

Option	Policy option	Benefits	Challenges / drawbacks
2c	**Consumer information about the expected operational lifetime** of the whole product (e.g. label, manual)	• When buying new appliances, consumers are not informed about the lifetime expectancy of the product, if used and maintained properly. With such information, consumers are enabled to reward manufacturers who produce long-lasting and/or repairable goods.	• No existing definition / standard • High risk of market distortion if claims are not backed up by harmonised testing procedures and market surveillance
3a	General **consumer information about correct use and maintenance** of appliances	• Although often being available, this information should additionally been promoted • Use of further dissemination possibilities, e.g. NGOs and test institutes	• A standard format could help enforcement of such requirements • Rather for consumer information campaigns than for Ecodesign / Energy label regulations
4a	Design for upgrades and repairs: **components** being prone to early failures **should not be designed in a manner prohibiting repairs** (e.g. high integration of different components)	• Seen as very important by some stakeholders	• No clear evidence which components usually fail more often • Precise specifications of how this design might look like are missing
4b	Design for upgrades and repairs: **components** being prone to early failures should be **easily accessible and exchangeable** by the use of universal tools	• Seen as very important by some stakeholders • Already applied by some manufacturers	• Cf. arguments under option 4a • Early failures are covered by the warranty and defects liability regulation
4c	Appliance **internal failure diagnosis systems** to report error specific messages to the user	• Already applied by some manufacturers • Particular relevant for electronic control systems which may make identification of defects difficult for repairers	• External diagnostic tools should also be made available to independent repair operators to make them understand the error codes
4f	Information about the availability (and price) of **spare parts** (current practice: from 0 to 10-15 years after production)	• Seen as very important by some stakeholders • Already applied by some manufacturers • Cf. French law with regard to a legal requirement on information about the time for which spare parts will be available	• Risk of market distortion if claims are not backed up by harmonised testing procedures and market surveillance • Other legislation (e.g. REACH, RoHS, Ecodesign on certain components being integrated in appliances such as motors or fans) might ex post restrict the availability of spare parts
4g	Guarantee of public availability of **spare parts** for a certain period following the end of the production of the model; ensure original and backwardly compatible spare parts	• Seen as very important by some stakeholders • Already applied by some manufacturers	• No clear evidence which components usually fail more often • A guarantee bears the risk of changes in the policy framework (cf. 4f) and an oversupply of spare parts that become WEEE at a later point in time • Detailed research on costs and effects of this option needed • Verification is difficult as this requirement is targeted to the future and not when the product is placed on the market
4h	Repair manual: **clear disassembly and repair instructions** to enable non-destructive disassembly of product	• Seen as very important and prerequisite for repairability by some stakeholders • Repair manuals are already in place for approved service providers which undergo specific in-house training / qualification	• Having access to electronic repair software might be even more relevant to repairers as WM/WD become electronically more complex • Public availability of repair manuals bears the risk of abuse causing liability issues or

Option	Policy option	Benefits	Challenges / drawbacks
	for the purpose of replacing key components or parts for upgrades or repairs. Information publicly available or by entering the products unique serial number on a webpage to facilitate **access for recognized / independent repair centres**. A diagram of the inside of the housing showing the location of the components available online for at least 5 years	programmes	damage to consumers • Making repair manuals available to repairers but not making them publicly available would be very difficult to implement legally: one would need to define 'repair cafe', they would need to register etc. • Repairability and after-sales services are market differentiation / competition issues
4i	Commercial warranty providing a minimum of 3 years warranty effective from the purchase of the product during which manufacturers shall ensure the goods are in conformity with the contract of sale (without passing the burden of proof to the consumer). It includes service agreement with a pick-up and return option.	• This requirement would have the advantage that the manufacturer guarantees the proper functioning of the product e.g. for a certain number of cycles or years (whichever occurs first), i.e. that the manufacturer has to prove misuse by the consumer, and not the other way around that the consumer has to prove that the failure was due to a manufacturing fault). This approach might facilitate reducing early failures. An extended guarantee would also mean that manufacturers will pay attention to the availability of spare parts. • The guarantee should include a take back requirement by the manufacturer, so that it can be properly recycled or components be reused if the product cannot be repaired.	• A commercial warranty by its definition cannot be a legal obligation as it is undertaken by the trader / producer in addition to his legal obligation relating to the guarantee of conformity. • Ecodesign is not the appropriate framework to extend guarantees • The effect might be limited given the calculated technical lifetime of 12.5 years for WM/WD

Regarding the options 4g and 4h on availability of spare parts and access to repair information, a stakeholder has proposed an adapted approach based on a simple classification of 'basic repairability grades':

a) No repair service by the manufacturer or authorized repair companies and no availability of spare parts for at least 10 years or no repair manual publicly available

   → The product information sheet and the information on the website of the manufacturer shall contain a warning on that.

b) Repair service by the manufacturer or authorized repair companies for at least 10 years (could be variable per product, e.g. differ for WM/WD) after production:

   → This information shall be on the product information sheet and the website of the manufacturer.

c) Availability of spare parts for at least 10 years (variable) and repair manuals made publicly available by the manufacturer:

   → This information shall be on the product information sheet and the website of the manufacturer.

In this way, for a given product the manufacturer has a choice to:

a) Do nothing (when the product is too cheap to afford this),

b) Keep the repair service in its own hands (repair manual need not be available publicly) or

c) Have spare parts available and make the repair manual public.

A combination of the latter two options would also be possible.

On the drawback side, it is easy to see that no matter how simple the system is designed with additional colours (e.g. red/yellow/green), it will work for well-established manufacturers (which normally keep an eye on each other's declarations), but will not be on the way for illegal commercialisation or import of products, or wrongdoing regarding the labelling. The weak point of these proposals is thus the extent to which swift market surveillance can hinder e.g. that smaller parties of WMs declared as very repairable ('grade c') have no actual system for spare part provision, repair, etc.

7.4.1.2. Recyclability

Specific requirements in the product design could be put forward that would enhance the effectiveness of End-of-Life efforts by facilitating

- **Proper collection** and treatment of appliances after use; or
- **Recycling of specific materials,** and thus enabling recyclers to comply with the WEEE Directive.

As for the proposed measures on durability and reparability, the proposed policy options on recyclability have received opposing stakeholder feedback from environmental / consumer NGOs, Member States representatives and industry.

The general need is seen for requirements on improving recyclability, such as design for recovery and recycling or information for recyclers on disassembly of important components, but the operational feasibility of the proposals is often mentioned as obstacle.

Some of the reasons brought forward are that the proposed action is interesting from a theoretical point of view, but are superfluous to recyclers, which use recycling practices or technologies where the proposals are inapplicable and therefore of no real benefit, or are only valid for economic boundary conditions (e.g. certain price ranges for metals) that are not always met, as the international markets for metals are highly volatile.

Stakeholders are in general not in favour of a requirement for the minimum content of recycled material (indicating the share of recyclable materials a product is composed of). They argue that most metals are indeed stemming from a mix of virgin and recycled origin. For plastics, it is difficult to use recycled technical plastics, as it is not certain that they will meet e.g. non-flammability requirements. In other cases, the use of plastics with recycled content would increase the dimensions of components to deliver the same mechanical properties (not always possible for space reasons), or are not available in a given colour (e.g. white) that is needed for aesthetic reasons. Stakeholders also do not support the use of a 'recyclability index', expressing how much material of the product could theoretically be recycled, since there is no widely accepted standard methodology so far available to measure it. Apparently, manufacturers claim that criteria in this area would not be a major selling point. Some of the policy options proposed focus on easy manual dismantling of certain components of the machine, as from a theoretical point of view the separation of certain components would lead to higher quality and yield of the recyclate streams, and higher prices for it. This is proposed in contrast to a procedure of shredding followed by mechanical sorting. In this line, the following initiatives have been tabled in some studies:

- Design for recovery and recycling which allows **better / easier access** to dismantle WEEE relevant components (because of hazardousness), or components containing valuable resources. Concerning hazardous components, these should be easy to identify and remove, so the prescriptions of proper treatment of WEEE are met. For WM/WDs, the components of concern are printed circuit boards, displays, and F-gases in heat pumps. The proposed measures for manual dismantling for the purpose of higher yield of e.g. rare earths or copper in permanent magnet motors are, as discussed above, not sufficiently considering the speed of composition changes of components, and the market forces that currently steer the technology choice in WEEE installations.
- Clear **marking** of special components facilitating recyclers to identify them easily and treat them separately, e.g.
  - WM/WD equipped with heat pumps. These labelling requirements are meanwhile covered by the amended F-Gas Regulation 517/2014.
  - Materials containing hazardous substances (e.g. displays, flame-retardant containing plastics such as PCBs).
- Information to recyclers (**exploded diagram of the product,** labelling the targeted components, documentation of the sequence of dismantling operations needed to access them).

The requirements above refer usually to the composition of appliances currently on the market and to appear for EoL 12.5 years from now, but refer to the present recycling techniques, which are mainly based

on shredding. It is argued that the technology of recycling is developing very slowly. However, given that washing machines and washer-dryers have an average lifetime of 12.5 years, it is difficult to judge how the future recycling techniques will have evolved when e.g. more appliances with WEEE-relevant displays (above a certain size) come to the end of their lives. Recycling business models vary: some recyclers work on high flows, and generate large volumes of not very pure fractions of e.g. copper, steel, aluminium, or plastics, while others treating specific appliances individually, e.g. manually, and obtain higher material yields from which they obtain a compensatory profit. One-fits-all recipes have to be considered cautiously, as recyclers with business models based on high flows would probably not benefit from requirements of manual dismantling of specific components of the machine. Thus the effect on the real-life recycling praxis is still not clear. Components are also different in different appliances: For example, Printed Circuit Boards of domestic appliances are not comparable to those of Information and Communication Technologies, as the former have a lower content of copper and precious metals. This makes measures in this field less effective than some studies may suggest.
In conclusion, in order to be widely accepted and implemented, the proposals will need measurement and verification standards, and incorporate profound knowledge of the market mechanisms that drive recycling.

QUESTIONS BOX: POLICY OPTIONS FOR MATERIAL EFFICIENCY AND END OF LIFE

The policy proposals above intend to create a framework of options for discussion with stakeholders. In particular, you would be welcome to

- Identify potential **practical/technical feasibility barriers** for the implementation of the proposals outlined
- Contribute to **refine the new policy scenarios** by proposing any adaptations or alternative policy options that could receive wide acceptance

7.5. Missing elements for the completion of Task 7

After the 2nd TWGM, the following sections will be included to complete Task 7 of the MEErP study:

1. Selection of policy measures for further analysis,
2. Assessment of policy scenarios
3. Recommendations to policy makers

8. ANNEXES

8.1. Input data ErP-Ecoreport tool – Base Case for Washing machines

Table 8.1: WM Inputs 'Materials extraction and production'

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
1	Stainless steel	17984	3-Ferro	26 -Stainless 18/8 coil	Yes
2	Steel sheet	7898	3-Ferro	22 -St sheet galv.	Yes
3	Cast iron	1779	3-Ferro	24 -Cast iron	Yes
4	Steel	866	3-Ferro	23 -St tube/profile	Yes
5	Aluminium	2347	4-Non-ferro	28 -Al diecast	Yes
6	Copper	1356	4-Non-ferro	29 -Cu winding wire	Yes
7	Copper wire (cable tree)	379	4-Non-ferro	30 -Cu wire	Yes
8	PP	2000	1-BlkPlastics	4 -PP	Yes
9	ABS	1740	1-BlkPlastics	11 -ABS	Yes
10	Elastomer EPDM	1468	1-BlkPlastics	1 -LDPE	Yes
11	Insulation (cable tree)	95	1-BlkPlastics	8 -PVC	yes
12	PET	22	1-BlkPlastics	10 -PET	yes
13	PE foil	15	1-BlkPlastics	1 -LDPE	Yes
14	Glass fibre filler for tub	6138	2-TecPlastics	19 -E-glass fibre	No
15	POM	126	2-TecPlastics	14 -PMMA	Yes
16	Talkum	121	2-TecPlastics	18 -Talcum filler	No
17	PMMA	46	2-TecPlastics	14 -PMMA	Yes
18	PA	24	2-TecPlastics	12 -PA 6	Yes
19	PUR	1	2-TecPlastics	16 -Rigid PUR	Yes
20	Circuit board	225	6-Electronics	98 -controller board	Yes
21	Concrete Weights	20186	7-Misc.	59 -Concrete	Yes
22	Glass	1870	7-Misc.	55 -Glass for lamps	Yes

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
23	**Packaging**				
24	Wood, Coated	2000	7-Misc.	57 -Cardboard	Yes
25	Packaging EPS	510	1-BlkPlastics	6 -EPS	Yes
26	Paper, Carton Packaging	210	7-Misc.	57 -Cardboard	Yes
27	Plastic foil PE	130	1-BlkPlastics	1 -LDPE	Yes
28	Paper	66	8-Extra	100-Office paper (from recycled paper)	Yes
	TOTAL	69603			

Table 8.2: WM Inputs 'Manufacturing and distribution'

Pos Nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	**OEM Plastics Manufacturing** (fixed)	12438		21
202	**Foundries Fe/Cu/Zn** (fixed)	1779		35
203	**Foundries Al/Mg** (fixed)	2347		36
204	**Sheetmetal Manufacturing** (fixed)	25882		37
205	**PWB Manufacturing** (fixed)	0		54
206	**Other materials** (Manufacturing already included)	27158		
207	**Sheetmetal Scrap** **(Please adjust percentage only)**	3106	5%	38

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	60
209	**Is it an installed appliance (e.g. boiler)?**		NO	61
				63
210	**Volume of packaged final product in m³**	**in m3**	0,45	64

				65

Table 8.3 WM Inputs 'Use phase'

Pos nr	USE PHASE direct ErP impact Description		unit	Subtotals
226	ErP Product (service) Life in years	12,5	years	
	Electricity			
227	On-mode: Consumption per hour, cycle, setting, etc.	0,713	kWh	163,46
228	On-mode: No. of hours, cycles, settings, etc. / year	220	cycles	
229	Standby-mode: Consumption per hour	0	kWh	0
230	Standby-mode: No. of hours / year	0	#	
231	Off-mode: Consumption per hour	0	kWh	0
232	Off-mode: No. of hours / year	0	#	
	TOTAL over ErP Product Life	1,96	MWh (=000 kWh)	66
	Heat			
233	Avg. Heat Power Output	0	kW	
234	No. of hours / year	0	hrs.	
235	Type and efficiency (Click & select)			86-not applicable
	TOTAL over ErP Product Life	0,00	GJ	
	Consumables (excl, spare parts)			material
236	Water	9,438	m³/year	84-Water per m3
237	Auxilliary material 1 (Click & select)	16,5	kg/ year	121-Detergent - Washing machine
238	Auxilliary material 2 (Click & select)	0	kg/ year	86 -None
239	Auxilliary material 3 (Click & select)	0	kg/ year	86 -None
240	Refrigerant refill (Click & select type, even if there is no refill)	0	kg/ year	3-R404a; HFC blend; 3920
	Maintenance, Repairs, Service			
241	No. of km over Product-Life	50	km / Product Life	87

242	**Spare parts** **(fixed, 1% of product materials & manuf.)**	696 g	1%

Table 8.4: WM Inputs 'Disposal and recycling'

Pos nr	DISPOSAL & RECYCLING Description				
253	product (stock) life L, in years	**12,5**			
		current	L years ago	period growth PG in %	CAGR in %/a
254	unit sales in million units/year	16,600	**11,600**	43,1%	2,9%
255	product & aux. mass over service life, in g/unit	276550	276550	0,0%	0,0%
256	total mass sold, in t (1000 kg)	4590,722183	3207,974537	43,1%	2,9%

Pos nr	Per fraction (post-consumer)	1 Bulk Plastics	2 TecPlastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7a Misc., excluding refrigant & Hg	7b refrigerant	7c Hg (mercury), **in mg/unit**	8 Extra	9 Auxiliaries	***TOTAL (CARG avg.)***
263	EoL mass fraction to re-use, in %						**1%**			1%		**0%**	*0,2%*
264	EoL mass fraction to (materials) recycling, in %	29%	**29%**		94%		**50%**	**10%**	**0%**	**39%**	**60%**	**0%**	*9,7%*
265	EoL mass fraction to (heat) recovery, in %	15%	**15%**		0%		**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	*0,8%*
266	EoL mass fraction to non-recov. incineration, in %	22%	**22%**		0%		**30%**	**0%**	**35%**	**5%**	**10%**	**0%**	*1,1%*
267	EoL mass fraction to landfill/missing/fugitive, in %	33%	**33%**		5%		**19%**	**88%**	**64%**	**55%**	**29%**	**100%**	*88,2%*
268	TOTAL	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100,0%*
269	EoL recyclability****, (click& select: 'best', '>avg', 'avg' (basecase); '< avg'.; 'worst')	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	***avg***
		0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	

Table 8.5: WM Inputs for EU-Totals and LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	**12.5**	years
B	Annual sales	17	mln. Units/year
C	EU Stock	197	mln. Units
D	Product price	€ 413.00	Euro/unit
E	Installation/acquisition costs (if any)	€ 0.00	Euro/ unit
F	Fuel rate (gas, oil, wood)	€ 0.00	Euro/GJ
G	Electricity rate	€ 0.21	Euro/kWh
H	Water rate	€ 3.98	Euro/m3
I	Aux. 1: Detergent - Washing machine	€ 2.67	Euro/kg
J	Aux. 2 :None	€ 0.00	Euro/kg
K	Aux. 3: None	€ 0.00	Euro/kg
L	Repair & maintenance costs	€ 45.00	Euro/ unit
M	Discount rate (interest minus inflation)	4%	%
N	Escalation rate (project annual growth of running costs)	4%	%
O	Present Worth Factor (PWF) (calculated automatically)	12.50	(years)
P	Ratio efficiency STOCK: efficiency NEW, in Use Phase	0.89	

8.2. Input data ErP Ecoreport tool – Base Case for washer-dryers

Table 8.6: WD Inputs 'Materials extraction and production'

Pos Nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
1	Stainless steel	19369	3-Ferro	26 -Stainless 18/8 coil	Yes
2	Steel sheet	8506	3-Ferro	22 -St sheet galv.	Yes
3	Cast iron	1916	3-Ferro	24 -Cast iron	Yes
4	Steel	933	3-Ferro	23 -St tube/profile	Yes
5	Aluminium	2527	4-Non-ferro	28 -Al diecast	Yes
6	Copper	1460	4-Non-ferro	29 -Cu winding wire	Yes
7	Copper wire (cable tree)	409	4-Non-ferro	30 -Cu wire	Yes
8	PP	2155	1-BlkPlastics	4 -PP	Yes
9	ABS	1874	1-BlkPlastics	11 -ABS	Yes
10	Elastomer EPDM	1581	1-BlkPlastics	1 -LDPE	Yes
11	Insulation (cable tree)	102	1-BlkPlastics	8 -PVC	yes
12	PET	24	1-BlkPlastics	10 -PET	yes
13	PE foil	16	1-BlkPlastics	1 -LDPE	Yes
14	Glass fibre filler for tub	6611	2-TecPlastics	19 -E-glass fibre	No
15	POM	136	2-TecPlastics	14 -PMMA	Yes
16	Talkum	131	2-TecPlastics	18 -Talcum filler	No
17	PMMA	49	2-TecPlastics	14 -PMMA	Yes
18	PA	26	2-TecPlastics	12 -PA 6	Yes
19	PUR	1	2-TecPlastics	16 -Rigid PUR	Yes
20	Circuit board	225	6-Electronics	98 -controller board	Yes
21	Concrete Weights	20186	7-Misc.	59 -Concrete	Yes
22	Glass	1870	7-Misc.	55 -Glass for lamps	Yes

Pos Nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
23	**Packaging**				
24	Wood, Coated	2000	7-Misc.	57 -Cardboard	Yes
25	Packaging EPS	510	1-BlkPlastics	6 -EPS	Yes
26	Paper, Carton Packaging	210	7-Misc.	57 -Cardboard	Yes
27	Plastic foil PE	130	1-BlkPlastics	1 -LDPE	Yes
28	Paper	66	8-Extra	100-Office paper (from recycled paper)	Yes
	TOTAL	73023			

Table 8.7: WD Inputs 'Manufacturing and distribution'

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	**OEM Plastics Manufacturing** (fixed)	13347		21
202	**Foundries Fe/Cu/Zn** (fixed)	1916		35
203	**Foundries Al/Mg** (fixed)	2527		36
204	**Sheetmetal Manufacturing** (fixed)	27875		37
205	**PWB Manufacturing** (fixed)	0		54
206	**Other materials** (Manufacturing already included)	27358		
207	**Sheetmetal Scrap** (Please adjust percentage only)	1394	5%	38

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	60
209	**Is it an installed appliance (e.g. boiler)?**		NO	61
				63
210	**Volume of packaged final product in m³**	in m3	0,45	64

				65

Table 8.8 WD Inputs 'Use phase'

Pos nr	USE PHASE direct ErP impact Description		unit		Subtotals
226	**ErP Product (service) Life in years**	**12,5**	years		
	Electricity				
227	**On-mode: Consumption per hour, cycle, setting, etc.**	2,07	kWh	455,4	
228	**On-mode: No. of hours, cycles, settings, etc. / year**	220	cycles		
229	**Standby-mode: Consumption per hour**	0	kWh	0	
230	**Standby-mode: No. of hours / year**	0	#		
231	**Off-mode: Consumption per hour**	0	kWh	0	
232	**Off-mode: No. of hours / year**	0	#		
	TOTAL over ErP Product Life	**5,69**	**MWh (=000 kWh)**		66
	Heat				
233	**Avg. Heat Power Output**	0	kW		
234	**No. of hours / year**	0	hrs.		
235	**Type and efficiency (Click & select)**			86-not applicable	
	TOTAL over ErP Product Life	**0,00**	**GJ**		
	Consumables (excl, spare parts)			**material**	
236	**Water**	11,968	m^3/year	**84-Water per m3**	
237	**Auxilliary material 1 (Click & select)**	16,5	kg/ year	**121-Detergent - Washing machine**	
238	**Auxilliary material 2 (Click & select)**	0	kg/ year	**86 -None**	
239	**Auxilliary material 3 (Click & select)**	0	kg/ year	**86 -None**	
240	**Refrigerant refill (Click & select type, even if there is no refill)**	0	kg/ year	**3-R404a; HFC blend; 3920**	
	Maintenance, Repairs, Service				
241	**No. of km over Product-Life**	50	km / Product Life		87

242	**Spare parts** (fixed, 1% of product materials & manuf.)	730 g	1%

Table 8.9: WD Inputs 'Disposal and recycling'

Pos nr	DISPOSAL & RECYCLING Description				
253	product (stock) life L, in years	**12,5**	Please edit values with red font		
		current	L years ago	period growth PG in %	CAGR in %/a
254	unit sales in million units/year	1,000	**0,699**	43,1%	2,9%
255	product & aux. mass over service life, in g/unit	280003	280003	0,0%	0,0%
256	total mass sold, in t (1000 kg)	280,0034512	195,6650623	43,1%	2,9%

Pos nr	Per fraction (post-consumer)	1 Bulk Plastics	2 TecPlastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7a Misc., excluding refrigant & Hg	7b refrigerant	7c Hg (mercury), **in mg/unit**	8 Extra	9 Auxiliaries	***TOTAL (CARG avg.)***
263	EoL mass fraction to re-use, in %						**1%**			1%		**0%**	*0,2%*
264	EoL mass fraction to (materials) recycling, in %	29%	**29%**	94%			**50%**	**10%**	**0%**	**39%**	**60%**	**0%**	*9,8%*
265	EoL mass fraction to (heat) recovery, in %	15%	**15%**	0%			**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	*0,8%*
266	EoL mass fraction to non-recov. incineration, in %	22%	**22%**	0%			**30%**	**0%**	**35%**	**5%**	**10%**	**0%**	*1,1%*
267	EoL mass fraction to landfill/missing/fugitive, in %	33%	**33%**	5%			**19%**	**88%**	**64%**	**55%**	**29%**	**100%**	*88,1%*
268	TOTAL	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100,0%*
269	EoL recyclability****, (click& select: 'best', '>avg', 'avg' (basecase); '< avg'.; 'worst')	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	***avg***
		0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	

Table 8.10: WD Inputs for EU-Totals and LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	**12,5**	years
B	Annual sales	1	mln. Units/year
C	EU Stock	8,56	mln. Units
D	Product price	€ 826,00	Euro/unit
E	Installation/acquisition costs (if any)	€ 0,00	Euro/ unit
F	Fuel rate (gas, oil, wood)	€ 0,00	Euro/GJ
G	Electricity rate	€ 0,21	Euro/kWh
H	Water rate	€ 3,98	Euro/m3
I	Aux. 1: Detergent - Washing machine	€ 2,67	Euro/kg
J	Aux. 2 :None	€ 0,00	Euro/kg
K	Aux. 3: None	€ 0,00	Euro/kg
L	Repair & maintenance costs	€ 45,00	Euro/ unit
M	Discount rate (interest minus inflation)	4%	%
N	Escalation rate (project annual growth of running costs)	4%	%
O	Present Worth Factor (PWF) (calculated automatically)	12,50	(years)
P	Ratio efficiency STOCK: efficiency NEW, in Use Phase	0,85	

8.3. Full list of possible policy options for household washing machines

The following Table 8.11 provides a full list of possible policy options for household washing machines preliminarily discussed with stakeholders in the course of study. The policy instruments addressed are the Energy label (EL), generic and/or specific Ecodesign-measures (ED), standards and measurement methods (SM), as well as consumer information (CI) measures. Please note that these policy options for washing machines (WM) might also be of relevance for the washing function of washer dryers (WD).

Table 8.11: Full list of possible policy options for household washing machines

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
1a	The consumer survey reveals that the most efficient 'standard cotton 40°/60° programmes' are not used so much in real life, there are other most used programmes (mainly quick wash/short, normal 40°/60° and synthetic/easy care). One reason for this might be that the standard cotton programmes are often optimised by **increased programme duration** which is not convenient for consumers. Also, consumers don't believe that washing programmes with long cycles are energy saving (cf. 2015 survey results)	Cap for maximum **programme duration** of the standard cotton programmes (e.g. 2-4 hours? during the stakeholder meeting 2 hours were suggested, 4 hours would allow better differentiation between appliances on the market - stakeholders' views are welcome)	ED	Unrealistic cycle times will be avoided. Better acceptance: Consumers might use the standard cotton programmes more often if the cap is rather short and convenient (e.g. 2 hours). On the other hand, a more flexible cap (e.g. 3 hours) would leave enough freedom for manufacturers for differentiation. The increase of energy consumption if the programme duration is shortened (see drawbacks), however, should not have an effect under real life conditions as at the moment the (very efficient) standard cotton programmes are hardly used. It can also be an incentive for manufacturers to find other possibilities to reduce the energy consumption than just increasing the duration. Despite a cap, manufacturers still can offer longer and thus more energy saving programmes (as an extra/competitive feature). However this should not be the 'standard programme' as people are not willing to use it as 'standard' if it is too long. Therefore the standard-programme should somehow be regulated (time cap, temperature prescription, duration on label,…). Damages of laundry might decrease (cf. option 11)	If the cap of the programme duration is too strict, machines might not differ any more in their energy consumption (especially in combination with fixed temperature). Energy consumption in the standard cotton programmes would increase or maximum loading capacity will decrease. Consumers which would generally accept longer programme times would not find programmes which are really saving a lot of energy. Other short programmes will be preferred further on. New innovation / developments are possibly prevented (e.g. efficient small heat pumps need longer programme durations until they reach their stationary operating mode). The accuracy of measuring the rinsing performance has to be increased to avoid workarounds circumvention (the effect could be a shortening of rinsing cycles by increasing the washing time to reach the same washing performance at shorter cycle times, i.e. worse rinsing performance or higher water consumption).

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
1b	cf. 1a	**Information about the maximum (average) programme duration of standard cotton programmes** on the Energy Label (for example, for tumble dryers the duration of the longest label programme is indicated)	CI / EL	Consumers might use the standard cotton programmes more often; better consumer information before a purchase decision; consumers might choose WM/WD with shorter cycle times which might lead to an overall market shift / competition towards machines with shorter cycle times (even more than a cap) and thus stimulating manufacturers to reduce the time, driven by competition, i.e. with other innovations to reach better Energy efficiency classes Already in place in the Energy label for tumble dryers	Overload of label information; with this explicit information, consumers might choose machines with shorter programme durations resulting in higher energy consumption. There is a need to be further discussed, i.e. how to come up with a relevant information about the cycle time (average time, time per treatment, time for full-load, time for half-load,...). The accuracy of measuring the rinsing performance has to be increased to avoid workarounds circumvention (the effect could be a reduction of rinsing cycles to reach shorter cycle times, i.e. worse rinsing performance or higher water consumption).
1c	cf. 1a	**Adjust measurement standard so that long programme times** do no longer add benefit to reach the required average washing performance > 1,03 (may be done for instance by rearranging the test strips into separate evaluation of the five soilings)	SM	Reduction of the benefit of long runtimes in the standard measurement might lead to a reduced programme time for standard cotton programmes of today; further also better consideration of the real household soilings.	No clear evidence of this effect. Still the standard cotton programmes might not be used sufficiently in real life.
1d	cf. 1a	Better / mandatory **consumer information about the environmental benefits of a longer programme duration** in terms of energy savings (e.g. leaflets, stickers, educational campaigns, ...) which also results in economic benefits for consumers when using primarily the efficient standard cotton programmes (for cotton wash).	ED/CI	Consumers might use the standard cotton programmes more often (i.e. overcome the misperception of consumers that longer programmes consume more energy)	Consumer information is difficult to be regulated by Ecodesign measurements (cf. ATLETE II results for washing machines with regard to (non-) compliance of consumer information measurements)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
2a	Standard cotton programmes are often optimised by **decreasing the wash temperature compared to the declared ones**; consumers might rather choose the 'normal' 40°/60° programmes.	**Prescribing the declared temperatures to be reached** at least for the standard cotton 60° programme for a certain time, e.g. 10 minutes. In general, the temperature prescription should not be limited to the standard programme(s) only (even though it is likely that the machines reach the declared temperatures in other than the standard programmes anyway). The same approach as decided for WM should be applied to WD	SM	Consumers might use the standard programmes more often when they can rely on the indicated temperatures. Consumer transparency: credibility and comparability increases; especially in households where besides the washing performance also hygienic aspects are relevant more often, people rely on the fact that the temperature of the 60°C programme is reached (i.e. hygiene might be improved). This is supposed to be necessary for e.g. the proper elimination of mites, lice/lice eggs, nematodes/nematode eggs.	From a functional point of view the required washing performance level is reached by these (lower temperature) programmes as well. Machines might not differ any more in their energy consumption (especially in case of combination with a cap of the programme duration). The energy consumption of the standard cotton 40°/60° programmes would generally increase although hygienic issues requiring 60°C for a certain time might occur rather seldomly. Temperature measurement needs to be done inside the load to ensure the real temperature is measured. However, so far no standard test method exists to measure the temperature insight the drum/load of household WM/WD, but only for the temperature of the water supply (proposals are under discussion in standardization working groups). For professional machines a measurement method has already been developed. This could be a basis for the development of a measurement method for household appliances. However, precision of data loggers has to be taken into account. In general, rather than putting constraints for the washing temperature (measurement), the use of lower temperatures to decrease the energy consumption should be promoted.
2b	cf. 2a	**Renaming of the standard cotton 40°/60° programmes** by indicating the 'true' temperatures which are maximum reached.	ED	Better transparency to consumers.	Shift in consumer thinking (definite temperatures) needed; the reduction level of temperatures might be rather different for different manufacturers / machines; also alignment to textile labelling (indicating the maximum possible temperatures the laundry may be treated), as the initial definition of washing temperature was related to the capability of washing clothes without damaging them and following the recommendation of the clothes label not to the real washing temperature.
2c	cf. 2a	Better **consumer information:** Manufacturer shall inform about the fact that real temperatures might deviate from the declared ones. Education that under 'normal' circumstances when only a certain wash performance is necessary, lower temperatures are sufficient.	ED/CI	Consumers might use the standard programmes more often	Consumer information is difficult to be regulated by Ecodesign measurements (cf. ATLETE II results for washing machines with regard to (non-) compliance of consumer information measurements

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
		Clear indication which programme(s) is/are applicable especially for hygienic needs.			
3a	The consumer survey reveals that the **most efficient 'standard cotton 40°/60° programmes' are not the most used ones** in real life; these are rather the normal 40°/60° and 30° cotton, quick wash/short, and synthetic/easy care programmes. Also, there is a tendency towards use of lower temperature programmes.	Define / **keep the '<u>most efficient</u>' programme(s) as ED/EL programme(s)** (business-as-usual). **Re-name it ECO** for WM/WD (as already common for dishwashers).	ED / EL / SM / CI	Clearer identification of the energy saving programme(s) for consumers; the term ECO is already introduced and common for DW.	This option is less representative for real-life usage (other programmes are per se more often used), thus the effect on real-life usage could still be minor (only ecological oriented consumers, not mainstream) due to long programme durations etc.
3b	cf. 3a	Additional requirement to avoid circumvention: **Other programmes for the same washing item & temperature** (i.e. 'normal' 40°/60° cotton programmes) **shall use not more than 20% more energy** than the standard programmes	ED / EL	Cap on energy consumption of other often used programmes	Must be verified and would thus add costs
3c	cf. 3a	Additional requirement to avoid circumvention: Prescribing that WM/WD **offer only one programme** for the same washing item & temperature	ED	Avoids the current washing machine situation where the main programmes are duplicated to reach better energy label classes	Prevents product innovation / market variety / consumer choices

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
4a	cf. 3a	Define the **'most used' programme(s) as standard programme(s)** (not the 'most efficient' ones): Taking those programmes which are recommended by the manufacturer for the wash of normally soiled cotton articles at 40°/60°C, i.e. **todays 'normal' 40°/60° cotton programmes without setting further requirements on programme duration or temperature** (cf. options 1 and 2). (=> taking those programmes which consumer already today use/want) Keep the name 'standard programme', not using the term ECO as it might not be the most efficient programme of the machine.	ED / EL / SM / CI	Better alignment to real-life conditions: The normal cotton programmes are still the most used washing programmes for 40° and 60° washes. The real life programmes for these articles would be used for declaration, i.e. skipping the approach of developing special programmes only for the energy label.	The 'most used programme' is different for each consumer. Consumer behaviour changes frequently due to public discussions/issues, i.e. variance and heterogeneous consumer groups. Programme application also varies for particular washing machines. Consumer choice of most used programmes might change in near future: the 2015 consumer survey shows the use of washing machines currently IN STOCK, which is presumably different to how people would use a NEW machine (e.g. washing machines in stock not necessarily have the arrow to indicate the standard programmes, also a 20°C programme was mandatory only from 2014 onwards, etc.). Energy consumption on the label will be much higher as today. However, under real life conditions the consumption will not change only by increasing the declared consumption. Consumers use these programmes already today without their energy efficiency being regulated. There may be programmes which allow saving energy, but consumers may not be sufficiently informed or motivated to use them. Manufacturers may declare new programmes which the consumer may prefer to use, like 'Cotton 60°C short'
4b	cf. 3a	**Include further wash programmes** (e.g. short/quick wash or delicate/synthetics) into the current test procedure and calculation formulae for energy and water consumption of the standard programmes.	ED / EL / SM	Better alignment to real-life conditions according to the spread of most used programmes; realizing further improvement potentials of Ecodesign/Energy labelling measures (e.g. incentive to improve the other - often used - programmes as well)	Increasing testing effort. The resulting energy/water consumption declared on the label would be an average of even more tested programmes thus diluting the 'real' consumption values of the single programmes

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
4c	cf. 4a	**Change the programme selection for test cycles** (e.g. from 3:2:2 test cycles at 60°C full : 60°C half : 40°C half to 3:2:2 test cycles at 40°C full : 40°C half : 30°C half or, alternatively, adding further 30°C test cycles to the current 40°C and 60°C cycles). For WD, the same approach as decided for WM should be applied.	ED / EL / SM	According to the 2015 consumer survey, 40°C programmes are mostly used, 30°C nearly the same as 60°C programmes; i.e. better alignment to real-life user behaviour. In general, high temperature cycles should be dedicated to special purposes only.	The total average energy consumption indicated would be lower just by changing the calculation formula, not by improving the machines. The temperature and thus consumption differences between 40°/30°C are rather small. 60°C is the most energy consuming programme and still used by consumers, e.g. for disinfection of machine and/or textiles. This programme might then not be energy optimised any more if taken out of the calculation, but it is still used to a certain extent (7% standard 60°C cotton, 11% normal 60°C cotton). 40°C is suitable for many cotton and cotton blend items, but bleaching with today's detergents still demands for higher temperatures, best around 60°C. Further alternative options do not seem to be justified: 40°/20°C would leave out the most energy consuming programme as well; 60°/30° would leave out the most used 40° programme.
4d		Each **separate declaration of the energy consumption of the 60° standard cotton programme and the 40° standard cotton programme** instead of an average weighted mix on the Energy label	ED / EL / CI	More transparency to consumers with regard to real consumption values of the programmes at a first glance (EL, not only in the manual); ideally further shift towards use of lower temperature programmes; each programme might be optimized individually, not only the weighted average	The uncertainty of measured values might increase due to less number of test cycles per programme (compared to todays 7 total cycles); or higher test burden for manufacturers / market surveillance authorities due to increasing number of test cycles needed for each of the programmes.
5a	cf. 4a	<u>**Completely new definition of an ECO programme**</u>: Define an Eco programme for WM and the washing function of WD which can wash normally soiled cotton labelled textiles for 40°C and 60°C *together*. No limit on time, but indication of programme time on the label. Offering a cleaning level of a 60°C programme and therefore replacing it. The maximum temperature (measured in the load) shall be 43°C to ensure that 'cotton 40°C' labelled textiles can be washed (this is the maximum temperature a textile labelled for 40°C should be washed).	ED / EL / SM / CI	Provides a clear option to the consumer to choose an energy saving programme. Real life saving as - it allows the use of the higher capacities, i.e. better utilizing the drum loads by combining separate loads which can be washed at 40°C or 60°C; - the wash temperature is lower than 60°C (60°C can be avoided); - by indication of the programme time on the label unrealistic cycle times will be avoided, i.e. consumers might use this programme more often - better identification for consumers: under the assumption that the consumers are willing to wash as environmental friendly as possible it makes sense to name it 'eco' to quickly identify the most efficient programme	New thinking of consumers is necessary. Temperature range for Textile Care Labels (40°C, 60°C) which can be washed in this programme needs to be communicated. The change in philosophy for the programme name might not be understood by consumers. To address hygienic issues it still would be necessary to guarantee that the declared temperature of other programmes, e.g. 60°C cotton is really reached. So consumers would be able to choose between (1) wash most environmental friendly or (2) (in certain circumstances) wash hygienic and be sure to eliminate pathogenic germs and/or parasites. Precise rinsing performance measurement needed to avoid circumventions.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
		Call (only) this programme 'ECO' for indication of ecological benefits. Test procedure: e.g. 3 x full load + 4 times half load in Eco cycle (instead of 'half' load, a fixed low load could be possible, e.g. 4 kg). This measure should be accompanied with intensive consumer information / education of the feasibility and ecological benefits of mixing cotton clothes together, the meaning of the maximum temperature etc.			
5b	cf. 4a	**<u>Completely new definition of an ECO SHORT programme</u>**: Define an Eco programme for WM and the washing function of WD which can wash all **lightly soiled** cotton labelled textiles for 40°C and 60°C *together,* **programme duration <1h** The maximum temperature (measured in the load) shall be 43°C to ensure that 'cotton 40°C' labelled textiles can be washed (this is the maximum temperature a textile labelled for 40°C should be washed). Call (only) this programme 'ECO SHORT' for indication of ecological benefits. Test procedure: e.g. 3 x full load + 4 times half load in Eco cycle (instead of 'half' load, a fixed low load could be possible, e.g. 4 kg). This measure should be accompanied with intensive consumer information / education of the feasibility and ecological benefits of	ED / EL / SM / CI	cf. 5a	cf. 5a Consumers may still choose other programmes, especially for non-cotton items

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
		mixing cotton clothes together, the meaning of the maximum temperature etc.			
5c	cf. 4a	Alternative option: taking into account the **cotton programme for normal soiled textiles labelled 30°C** (that is suitable also for textiles with higher temperatures) with **different load sizes** (for example: full load, 70% load and 30% load), in order to align testing to the most used programmes by consumer and consumer habits as shown in market research done by AISE and Bonn University	ED / EL / SM / CI	Better alignment to real-life conditions: This programme is claimed to be used frequently as shown in the studies. Detergent products for lower temperatures are available. The energy reduction might be higher in the EU (provided that consumers really use this lower temperature programme compared to todays 40°C/60°C programmes). The single test programme will enhance the alignment with the washer dryer testing and will simplify the overall testing procedure.	cf. 5a Consumers may choose other programmes, especially for non-cotton items

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
6a	The **most efficient** standard cotton 40°/60°C **programmes** are **often not easy to find** between the lots of programme choices	**Default setting of the future 'standard programme**' for household WM/WD equipped with automatic programme selection or any function for automatically selecting a washing programme or maintaining the selection of a programme	ED	Consumers might use the standard programmes more often	Since Jan 2014 implemented for DW; so far no evaluation on impact of this measure. For WM/WD more difficult as far more textile types / wash programmes exist (also for WM currently not one single standard programme, but 60°C/40°C). Making mandatory to have a standard programme as default setting would cause inconvenience to consumers as they would have to change programme every time they would use the appliance for other purposes than washing cotton textiles, i.e. consumers might try to overrule this setting easily. Some WM/WD still have mechanical programme selection. Having a standard programme as default setting would be easier for machines with electronic displays/selection while it would add design burdens for appliances with mechanical programme selection. Such requirement would also limit temperature selection. For WD, the drying cycle cannot be default.
6b	cf. 6a The most efficient programmes are today indicated by the arrow on the control panel. Based on consumer feedback, the symbol is not really understood by customers and can therefore hardly contribute to identify the most energy saving program.	**Change the current indicator symbol** (arrow, 'standard cotton…') for the standard programmes, e.g. into 'Eco' as already applied for DW Alternative: 'Energy saving programme'	ED	Consumers might find and use the standard programmes more often. Other signs/terms like 'eco' are better known from the campaign of the washing temperature reduction from 90°C to 60°C in the 1990's. The formerly used eco concept might be applicable for the future also, thanks to its link with environmental (ecological) aspects. This is supported by the Dishwasher regulation, which is using Eco and not the arrow.	Changing the control panels would imply large extra costs for the industry. Not all washing machines have control panels with text language to display 'ECO', there are models only with symbols. Manuals would also have to be adapted as it would require new explanations to be found. Finally, applying this proposal would confuse consumers who are now getting used to the current symbol. Changing it again would require starting new education campaigns. The term 'ECO' would only make sense if the standard programmes are the most efficient ones (cf. options 3 and 5 versus option 4) The currently required arrow solution might be kept / allowed additionally to avoid rework of control panels.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
7a	According to the 2015 consumer survey, only 4% of consumers use the **mandatory 20°C programmes**; one reason might be consumers suspecting lower wash performance	Inclusion of measurement of **wash performance level of 20°C** wash programmes in performance standard and information about wash performance level of 20° wash programme (e.g. booklet, label)	SM / CI / (EL)	Consumers might trust and use the low temperature programmes more often. At the moment, it is only an alibi requirement being fullfilled formally but not used in the practice. Some of these cycles are short, others long, some refresh, others are performance cycles, so communicating clearly on what consumers can expect with the 20°C cycle will be crucial.	In general, consumers should not expect the same washing performance as for 60°C programmes; cold washing - even with high cycle durations - can only partly fulfill expected washing results such as removing stains, dirt, germs etc. An inclusion of 20°C wash performance into the overall wash performance of the WM/WD would decrease the possibility to differentiate between machines. The results of the 2015 consumer survey shows the use of washing machines currently IN STOCK, which is presumably different to how people would use a NEW machine (e.g. a 20°C programme was mandatory only from 2014 onwards, i.e. it might be that the machines of the consumers participating in the survey did not have a 20°C programme at all etc.). Increased test burdens.
7b	cf. 7a	Require minimum **wash performance level for 20°C** wash programme	ED	Consumers might trust and use the low temperature programmes more often	cf. 7a Specific low temperature detergents which might enable a better wash performance at 20°C are not included in the performance standard measurement; however: specific low temperature detergents might not use special ingredients at all (only marketing). Avoid circumvention of using detergents with chemicals more harmful than common detergents.
8a	Consumers often do not know that a certain minimum **washing performance for the standard programmes** is mandatory and might mistrust the performance especially when getting knowledge about longer times and lower temperatures in these programmes. Tests found that longer lasting programmes deliver better washing results.	**Declaration of the average washing performance (mandatory A class) for the standard cotton programmes** provided on the label again. Proposal: a classification of the washing performance / efficiency should be reintroduced only as a fixed mark on the label	CI / EL	Confirmation of good washing performance in standard programmes might lead to consumers choosing these programmes more often despite knowledge about longer duration / lower temperatures	Overload of label information

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
8b	cf. 8a	**Require that the washing performance of A is reached in the different programmes tested** (60°C full/haf and 40°C half).	ED / CI (/EL)	Better consumer transparency; the overall washing performance might improve	Uncertainty of verification might become higher as fewer number of wash cycles contribute to the measurement of each the single programmes (2 or 3 instead of 7). Level of performance needs to be determined for each programme (currently, the washing performance 1.03 must be met on average only; the reference for each programme (or a future standard programme) may not obligatory be the required performance of the standard 60° cotton programme for all tested programmes).
8c	Both liquid detergent and powder detergents exist on the market (with a majority of liquid detergent being used, and those not containing an active oxygen bleach system to date)	Use of a modern **reference detergent** for the performance cycle matching the reality of the market use (and thus, notably **liquid**)	SM	Better alignment to real-life conditions	Cost and availability of standard detergents ensuring repeatability and reproducibility of tests.
9	The **quality of rinsing of residues of detergents** is important for consumers, especially for those being sensitive due to allergies. Certain requirements (e.g. caps on water consumption or on programme duration) might worsen the rinsing quality as for example the number of rinsing cycles might be reduced to save water and/or programme time. Consumer tests (e.g. OCU 03/2015) report about unsatisfactory rinsing performance in the tested appliances.	Introduce **rinsing performance** for WM/WD (possibly minimum requirement, e.g. at least 2 rinsing cycles; indication on EL), continuing the work to ensure the robustness of the rinsing standard for WM. The rinsing performance should not be classified only on the EL, but have a required minimum performance.	SM / ED / EL	Consumers get a guarantee of a certain minimum rinsing performance in the standard programmes, i.e. energy efficiency gains are not realized at the expense of rinsing performance. The so called 'LAS' standard method currently under development by CENELEC SWG 1.8 and IEC WG20 is most likely also applicable for washer-dryers, whereas the currently known alkalinity method would not be applicable for WD.	So far, no measurement standard exists (because of reproducibility reasons). Additional testing effort for manufacturers and also market surveillance authorities. Possibilities of circumvention can be achieved for instance through a wash cycle with bad rinsing which would leave detergent in the load and would thus increase the performances of the next cycle thanks to the accumulated detergent.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
10a	Complaints about **odours of laundry**, e.g. caused by frequent washing cycles at lower temperatures with liquid detergents	Introduce **hygiene performance** for washing machines (possibly minimum requirement, indication on EL; for consumer information requirements cf. also option 17a)	SM / ED / EL / CI	Important information for (sensitive) consumers; might reduce ecological 'rebound effects' that consumers start choosing additional or stronger detergents, additional rinsing cycles or similar to prevent those odours	High test effort (microbiological analysis) and less experiences, there is up to now no international standard, the repeatability and reproducibility of draft methods (PAS) would have to be checked. The germ reduction potential of washing machines is already generally high (no need for quantified evaluations). There are washing cycles availabe up to 90°C. For washer-dryers, there is also additional germ killing during drying because of high temperatures.
10b	cf. 10a	**Consumer information about best practice / possibilities to avoid odours** of the laundry (using cycles at higher temperatures from time to time)	CI	cf. 10a	Consumer information is difficult to be regulated by Ecodesign measurements (cf. ATLETE II results for washing machines with regard to (non-) compliance of consumer information measurements
11	Especially during very long cycle times (e.g. 6 hours), the mechanical action (drum repeatedly turning around) might lead to increased **damage of textiles** (resource efficiency)	Introduce a '**Gentleness of Action**' for WM/WD measure to avoid too much damage of the textiles. Set a limit value	ED / EL / SM	would reduce the possible programme time	There is no clear evidence that programme length is causing damages. Textile is damaged not only by mechanical action but also by temperature and chemistry, longer cycles at lower temperature are not necessarily worse than shorter cycles at higher temperature with high detergent concentration. Cotton is a fabric that can be treated with more mechanics than other fibres. Drum washing machines are already very gentle in comparison to tub washing machines (Asian style or US-style). Additional testing cost if one more test watch is needed. Several methods exist to measure textile damages during the washing process at international level which, however, have to be updated and included in the 6th edition of the IEC 60456; repeatability / reproducibility are low. All manufacturers are using these methods and are already taking care of mechanical actions and textiles protection, and machines are generally designed to take care of textiles. Thus, there might be no added value of having requirements on textile damages.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
12a	The spin drying efficiency (remaining moisture content RMC) not only depends on the maximum spin speed (rpm), but also on the drum size (larger drums cause higher centrifugal forces at same spin speeds compared to lower drums). The spin drying performance is an important information to consumers for the subsequent drying process.	Introduction of a minimum requirement for **spin drying efficiency** (remaining moisture content RMC) of the standard programme(s), e.g. class A.	ED / EL / CI	The better the laundry is spun, the less water it contains and the faster goes drying - in case of a tumble dryer being used, well spun laundry is a measure to reduce the energy demand of the subsequent drying process considerably (and in general, a strong trend to tumble drying can be observed).	According to a OCU consumer test report of March 2015, models with 1,000 and 1,200 rpm eliminate half the humidity from the clothes and machines with 1,400 rpm eliminate 60% of this humidity; however, these additional rpm might not be particularly useful (if not further drying the clothes in a very humid place), but contribute to more wrinkling of the laundry. Spin drying efficiency is closely connected to the mechanical dimensioning of the appliances and offers a possibility of differentiation between types and models. A strict requirement would limit such differentiations. Still, most of the laundry is dried in the outside air / on a line, and high spin speeds are only recommended when using a tumble/washer dryer
12b	cf. 12a	**Mandatory consumer information on spin speed** depending on the subsequent drying process, e.g. within the fiche: 'For tumble-drying / washer dryers please use a higher spin speed; for outside line-drying please use a lower spinning speed.	ED / CI	cf. 12a	cf. 12a
12c	The requirements for remaining moisture content measurement are different for the ecodesign and labelling requirements. For labelling, the value of remaining moisture content is evaluated for a weighted mix of the standard cotton programmes, analogue to the procedure for the calculation of the energy consumption. For the product fiche, values have to be documented (and verified) for the 'standard 60 °C cotton programme' at full load or the 'standard 40 °C cotton	Aligning ED / EL requirements to the same basis	ED / EL	Better consistency	None

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	programme' at partial load, whichever is the greater. Conversely in ecodesign the testing shall be done for every main washing programme at full or partial load, or both.				
13a	**Trend towards increasing drum volumes vs. non-increasing size of households/loads**: The overall trend to higher capacities might offset (at least partly) the efficiency gains due to their better efficiency classes as the absolute energy consumption of larger machines might be similar compared to that of smaller ones. In addition, the situation could be worse under real life conditions as the real life loading is expected to be rather lower and different from the declared rated capacity measured under standard conditions. Also, for programmes and loads other to standard conditions, large (and hence 'efficient') WM/WD can even lead to energy wastage: if they do not adapt water and energy consumption to the effective load, for all programmes and loads, more energy is used by larger machines.	**Cap for absolute energy consumption** independent of the rated capacity	ED	More smaller machines with less absolute consumption in real life; no thrive for bigger machines just to reach a better Energy label class	No clear evidence of this effect and hard to justify any change

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
13b	cf. 13a	**Cap for absolute water consumption** independent of the rated capacity (in the current formulae, there is a dependency of the rated capacity)	ED	Higher presence on the market of smaller machines with lower absolute consumption values in real life.	Further reducing the water consumption might lead to worse rinsing performance (only a minimum washing performance is mandatory), cf. also option 9 on rinsing performance. Less water consumption is important, in particular in some countries, but as there is no requirement on rinsing performance, it may imply worse rinsing performance. This can lead to increased consumption if consumers use an extra rinse or smaller loads, and to more allergies / hypersensitivities (especially in cold climates with low indoor relative humidity in winter). Thus, a cap on the water consumption should only be done together with a minimum requirement on rinsing performance.
13c	cf. 13a	**Different calculation formulae** for smaller and larger machines, being stricter for machines with a larger rated capacity	ED / EL	Higher presence on the market of smaller machines with lower absolute consumption values in real life. Avoiding the today's effect of the linear efficiency approach that good efficiency classes can be reached more easily by increasing the capacity than by efficiency improvements that lower the machine's energy consumption.	No clear evidence of this effect
13d	cf. 13a	**Progressive (bended) curves** / calculation of EEI, i.e. stricter for machines with a larger rated capacity	ED / EL	cf. 13c	cf. 13c
14a	The 'standard load' being the basis for the rated capacity of the machine is difficult to reach under real life conditions (other / different kinds of laundry). Under standard test conditions, sensors (adapting energy & water consumption better to the real life conditions) have to be switched off.	Allow **sensor use in the measured standard programmes**.	ED / SM	Real life has normally less load. Machines equipped with intelligent sensors should be able to adapt the programme accordingly and realize savings.	Sensors are not measured in the standard programme performance test so far, i.e. no effect on EEI; the current evaluation method using average values calculated out of results from full and half load is not suitable to show the load adaptation function provided by sensors. To have an effect, different treatments with different load amounts must be evaluated separately. Sensor use is difficult to measure (reproducibility). Price of low cost machines might increase if sensors (with a certain quality) become mandatory. Having partial loads included in the test procedure might also give a wrong signal to consumers as it may encourage them even more to use their appliances half loaded.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
14b	cf. 14a	Based on load detection / sensor use in measurement of standard programmes: **Specific requirements on energy and water consumption for half-load** of the standard programmes compared to full load (e.g. the consumption in half-load has to be at least xy% lower than full-loaded). Alternatively: **Consumer information (e.g. saving percentage)** of half-load consumption (label, fiche, ...), i.e. overcome the misperception that there is a 'linear' reduction of water/energy when using 'half load'.	ED / EL / CI	Real life has normally less load compared to the standard load. Machines equipped with intelligent sensors should be able to adapt the programme accordingly and realize savings. Minimum requirements would lead to a minimum performance of the quality of load sensors. Consumer information will receive the message to wash full loads if possible	cf. 14a Today, half load consumption values are not visible to consumers due to the average value. Difficult to achieve due to necessary basic consumption with any load independent from load size. Prescription of savings could lead to higher energy consumptions with full loads to fulfill such regulations.
14c	cf. 14a	Direct **feedback on actual load** to consumers **via display**	ED / CI	Possibility to influence consumer behaviour / increase real-life loading	Not all appliances are equipped with a display so far; communication of such information can only be done with special displays (control panel with text language, TFT e.g.). Such indications would be subject to certain tolerances which would make to only rough estimations; the more accurate it is required to measure, the more costly would be the technology to measure. Significant raise of the appliance prices expected, especially on low range models; would not help improving resource efficiency (more materials needed for display); impact is not clear (if consumers are really changing their behaviour).
14d	cf. 14a	Measurement and declaration of energy consumption (and water) at a **fixed amount of load, e.g. 3, 3.5 or 4 kg laundry**, or introduction of a 'small-load' (2 kg or less). At least instead of 'half load' - the terminus might be replaced e.g. by 'average load'; could also be taken for all cycles (assuming that real-life 'full load' is also only filled with maximum 4 kg laundry compared to the	ED / SM / EL	Better alignment to real-life conditions - currently, the tests are based on half-load which, for very big appliances (e.g. 13 kg machines), is still far above from the known 'average' load figure of 3.5 kg. This may help to stop the trend of increasing sales of large capacity machines which are apparently more efficient at full load conditions only. It might offer an incentive to optimise machines for small loads from an energy perspective. Number of test cycles might be reduced if *all* standard programmes are measured at 4 kg instead of spread between full/half load.	No clear evidence of this effect. Loading would be underestimated if users were able to actually fill half of the rated capacity. Today, half load consumption values are not visible to consumers due to the average value.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
		standard load)			
14e	cf. 14a	**Increase the share of partial load in the EEI calculations and differentiate by declared nominal loads**: e.g. to prescribe 2 quarter loads (25%) instead of 1 half load with machines from a particular nominal load (e.g. >8kg). 2 full loads (nominal loads) should however remain to prevent unrealistic declarations	ED / EL / SM	Partial loads would have higher influence in the EEI calculation for ED/EL for machines with higher loads. Better alignment to real-life conditions - currently, the tests are based on half-load which, for very big appliances (e.g. 13 kg machines), is still far above from the known 'average' load figure of 3.5 kg. This may help to stop the trend of increasing sales of large capacity machines which are apparently more efficient at full load conditions only. It might offer an incentive to optimise machines for small loads from an energy perspective.	No clear evidence of this effect. Today, half load consumption values are not visible to consumers due to the average value.
14f	There exist no normative demands on how to define and declare the capacity of a WM/WD. Thus, a mechanically similar model can be sold with different capacities (however, the electronics and programmes would be adjusted to account for the different maximum load sizes).	Require a **standard measurement of the volume** as described in the existing standard IEC 60456 and to define a clear formula with a conversion factor from volume into capacity (load in kg)	SM	The capacity has direct influence on the Energy Efficiency Index EEI. A standard definition of the capacity helps to avoid declaring same machines just with higher rated capacities to gain a better Energy label class.	US legislation refers to the drum volume. On the one hand, reference to volume makes requirements independent of the textile type. On the other hand, it is more difficult to address issues like half-load, or the dependency of wetting (and water consumption), spinning and drying on the textile type. However, the drum volume is not the only element determining the capacity. Other components of WM/WD have to be suitable for the capacity claimed. Application of different technologies and intelligent treatment techniques allow the treatment of different load amounts which can be significantly higher than the calculated capacity based on the drum volume. Thus, interlinking certain drum volumes by a conversion factor to a fixed load capacity of the machine is not reasonable.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
15a	**Standby consumption** is covered by Ecodesign regulations 1275/2008 and 801/2013 on standby/networked standby anyway; low contribution to total energy consumption; according to 2015 consumer survey, most consumers 73% always switch off their appliance immediately or after unloading; for additional 13% the appliance switches itself off.	**Leave standby**-values totally out of the calculation formulae	ED / EL / SM	Simplifies the measurement which saves costs for manufacturers and market surveillance authorities. The regulated modes can be eliminated from the EL evaluation as they will not contribute to the differentiation of machines on the market. Better alignment to real-life usage, as the current calculation procedure in the regulation assumes that in 50% of the cycles the consumer does not switch off its appliance.	The energy consumption of the standby modes might be enough - at the annual level - to pass from one energy efficiency class to another (if not taken into account any more)
15b	cf. 15a	**Business as usual: Keep standby-values** within the calculation formulae for the total annual energy consumption	ED / EL / SM	The energy consumption of the standby modes might be enough - at the annual level - to pass from one energy efficiency class to another (if not taken into account any more)	Test burdens
15c	**Delay start** is not covered by Standby-regulation as it is not an 'unlimited' mode; delay start might become more relevant in the context of smart appliances / smart-grid-ready appliances	Include **delay start mode** into standby measurement / calculation of machine's total energy consumption	ED / EL / SM	Might avoid delay start modes with high wattages. Assuming 8 hours delay for each cycle with 5 or 10 W could contribute to a relevant extent to the total annual energy consumption. If taken into account, the energy consumption of the delay start mode might be enough - at the annual level - to pass from one energy efficiency class to another	This mode is assumed to have only minor contribution to the overall energy consumption of the machine. May lead to a less acceptance of delay start-mode. Higher test burden (for manufacturers and market surveillance authorities) if measurement in an extra test cycle would be needed. Definition of a standard delay time may be challenging.
15d	cf. 15c	**Set MEPS / power cap for delay start mode** as it is the case for standby mode, e.g. a maximum of 2W.	ED	Avoids delay start modes with high wattages. Assuming 8 hours delay for each cycle with 5 or 10 W could contribute to a relevant extent to the total annual energy consumption.	This mode is assumed to have only minor contribution to the overall energy consumption of the machine. May lead to a less acceptance of delay start-mode. Higher test burden if measurement in an extra test cycle would be needed. Ideally, this mode would also be covered by the horizontal Ecodesign regulation(s) on standby (1275/2010 and 801/2013)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
15e	cf. 15c	Provide **'bonus / allowances' on delay start consumption** for WM/WD with smart-grid functionality (at least for a certain time of market introduction)	ED / EL / SM	Smart-grid ready appliances are an important instrument within the total energy transition system and thus should be favoured; too strict limit values might hinder product innovations	No standards / no real smart grids available yet. Demand-response ability does not make the appliance more efficient. Allowances for certain functions should be avoided as far as possible within Ecodesign; also, using the EU Energy label for promoting these functions of smart appliances would not be compatible with the primarily role of the label (information tool for consumers on energy efficiency and selected other aspects which have a direct impact on operating costs such as water consumption, or which are relevant because of convenience issues, such as noise level). Networked standby should ideally be covered by the horizontal Ecodesign regulation on standby/networked standby; new product innovations should comply ideally with existing energy efficiency targets.
15f	cf. 15a/15c	**Set MEPS / power cap for any other standby-modes** of WM/WD (e.g. max. 2 W) in case they are not covered by existing Ecodesign regulations 1275/2008 and 801/2013 so far, e.g. in the context of smart-grid functionality	ED	The introduction of smart-grid appliances (or other functionalities) should not lead to an overall increase of the energy consumption only due to the supply of this functionality	Smart-grid ready appliances are an important instrument within the total energy transition system and thus should be favoured; too strict limit values might hinder product innovations. Ideally, these modes would also be covered by the horizontal Ecodesign regulation(s) on standby (1275/2010 and 801/2013)
16a	The 2015 consumer survey reveals that the EU **average number of use cycles for WM (229) is still near to the current 220 cycles/year; for WD it is slightly higher (240 cycles/year);** in general, these are only average and theoretical numbers for relative comparison of machines	Keep **number of annual wash cycles** (220) for WM as they are; for the washing function of WD, the number of annual wash cycles should be aligned to this for better comparison. Alternatively: take 230 cycles for both WM/WD. For WD, additionally 104 drying cycles might be used to express the yearly consumption by the drying function (to be further analysed based on the results of the 2015 user survey).	ED / EL	Continuity (as it is only an average value for comparison of different machines); better understandable in terms of annual savings	The EU average number of wash-cycles slightly decreased to 4.4 cycles per week. High variance for individual users. For smaller or larger households these average numbers still do not represent their individual behaviour (cf. 2015 Consumer survey results)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
16b	cf. 16a	Indication of total energy consumption **per cycle**, not annual average consumption. Alternative: to keep some differences visible, it could be declared per 100 cycles The same approach as decided for WM should be applied to WD.	ED / EL	Better understandable and scalable for consumers. The choice of the Latin expression 'kilowatt hours per annum' alleviates the burden of expressing 'yearly' in all the languages of the single market. In a survey 2012/2013 of 1,006 German consumers, more than 70% did not understand correctly (or did not understand at all) the meaning of 'per annum' on the energy label. In the 2015 consumer survey, the option of providing the consumption value 'per cycle' was reached an importance of around 60%, whereas the option 'per annum' reached an importance of around 40%. 'Per cycle' communicates more clearly that the energy consumed depends on usage.	The consumption values (kWh and l) are already at a very low level; differences between machines (decimal places) might become insignificant for consumers whereas yearly consumption values deliver greater numbers, where differences between appliances become more obvious and easier to quantify by users (in favour of energy efficient appliances). Coherence with the energy labels of other products would be omitted as for all other products the consumption is indicated per year. For washing machines this will be the consumption of a hypothetical wash cycle if the value still is derived as average from the measurement of 60°C full, 60°C partial load and 40°C partial load. Thus it would not correspond to the consumption values of a certain programme as given in the booklet which might make it more difficult for consumers to understand.
17a	Consumers do not use the appliance in its best way (programme choice, loading, detergent dosage,...)	Develop an agreed **list of Best Practice Tips for washing and for drying** and include them as, e.g., instruction leaflet / manual in each machine. Example of possible advices: - on which cycle to use for which load; loads that require special hygiene conditions; - to full load whenever possible; the right use of large capacity machines - that programmes at lower temperatures save energy; - to adjust detergent dosing with regard to the local water hardness; - to use the pre-wash programme only when needed; - on the dependencies of spinning and subsequent drying; - on the most ecological ways of drying depending on the surroundings; - on the correct installation in order to minimise the noise emitted;	CI	If branded by EU it will give some confidence in the best way of using the machine; improved consumer behaviour, thus realising further efficiency potentials	Additional costs, also for compliance check (cf. ATLETE II results for washing machines); overload of information might lead to no effect in the end.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
		- on correct maintenance of the WM/WD; - on treatment advantageous for hygienic issues (such as keeping the porthole open to dry out the machine; keeping the dispenser drawer open; ambient conditions of the room etc.)			
17b	cf. 17a with regard to detergent dosage (soiling of laundry is often overestimated)	Mandatory requirement on machines being equipped with an **automatic detergent dosage system**	ED / SM	Might lead to relevant real-life savings of resources such as detergents, waste water due to better alignment of detergent consumption to the real-life conditions / programmes chosen.	Increase of appliance costs of approximately 200 Euro; i.e. long pay-back periods for consumers; only usable with fluid detergents, i.e. bleaching agents (ingredients of solid heavy-duty detergents) have to be additionally dosed manually if necessary. In the current standard test method no variation of the kind and amount of detergents is not a variable, i.e. the use of the automatic detergent dosage would not lead to an effect under current standard methods.
18a	In general, consumer information requirements are difficult to be regulated by Ecodesign measurements (cf. ATLETE II results for washing machines with regard to (non-) compliance of consumer information measurements)	Introduce a **template for the most relevant information** requirements of the main programmes of WM/WD (e.g. recommended load, consumption per cycle / per kg of load, consumption at half load, real wash temperature, programme duration, noise…) being easily accessible online before purchase.	ED/CI	Easier to fill out, easier to check compliance; facilitates better comparability between programmes and/or appliances for consumers	Not all the consumers would consider the same pieces of information as relevant. There are (too) many possible combinations of programmes and options able to reference them in a cost effective manner (e.g. more than 400 up to 1,000 for premium WM). A clear indication of 'main programmes' is necessary. If more performance data of additional programmes are provided, they may need to be verified, thus more testing would be necessary. A way is needed to ask for declaration without verification of the values.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
18b	cf. 18a	Use of a **QR code** to provide consumer information	ED/CI	Modern form of consumer information, more flexible; might address younger consumers better	Not all consumers have access to this information tool (QR-code reader necessary)
18c	cf. 18a	Compulsory **information via the display** of the appliance when the programme is chosen	ED/CI	Modern form of consumer information, direct feedback and influence possibilities	cf. 14c
19	Several WM/WD do have a possibility to connect the machine directly to the hot water tap; in practice, this option is rather seldom used	Mandatory consumer information on **hot fill option** (e.g. symbol on EL for hot fill connection; further consumer information under which conditions hot fill is beneficiary)	CI / EL	For WM/WD, a direct connection to the hot water tap could be beneficiary in terms of overall electricity savings; with better consumer information, this option might be used more often as consumers might not be aware of this electricity saving option.	Overload of (label) information might lead to no effect in the end; might still be difficult to understand and implemented by consumers. For washing machines, an overall trend to lower washing temperatures is already in place, i.e. hot fill might not be so effective; also rinsing with hot water would result in wastage of energy. For some washing needs (e.g. avoiding denaturation of proteins or avoiding damages of textiles) the use of hot water can be counterproductive (e.g.blood can be fixed to textiles at higher temperatures); also the temperature at the tap should not exceed 60°C to ensure full protection of the functioning of the appliance; additional safety devices need to be installed to ensure this limit. Benefits will be realized depending on the type of heating system in the house (e.g. renewable sources, natural gas) and the length of the pipe, e.g. hot fillings linked to improper hot water systems (e.g. a circulator) can increase the energy consumption. For those consumers explicitly looking for those types of appliances, the information of hot water supply is already available in the manual at the point of sale.
20	Trend towards new kinds of washing machines	Adjust existing standard measurement method or define a new one for **innovative types of machines**, e.g. multi-drum WM	SM	Avoiding a regulatory loophole	Additional test work for (currently only) niche products

8.4. Full list of possible policy options for household washer-dryers

The following Table 8.12 provides a full list of possible policy options for household washer-dryers preliminarily discussed with stakeholders in the course of study.. The policy instruments addressed are the Energy label (EL), generic and/or specific Ecodesign-measures (ED), standards and measurement methods (SM), as well as consumer information (CI) measures. Please note that policy options for washing machines (WM) (cf. Section 8.2) might also be of relevance for the washing function of washer dryers (WD).

Table 8.12: Full list of possible policy options for household washer-dryers (washing function and drying function)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
Washing function of Washer-dryers (WD)					
1	Washing only function as one part of regulation for WD	Apply the requirement for the new EL and ED for the washing only function	ED / EL / SM / CI	According to the 2015 consumer survey, WD are mostly used as WM. All washing performance tests according to EN60456 can be applied for washer dryers without exception	Should be done to align regulations.
2	Approaches for WM NOT applicable to the washing function of washer-dryers	*For the other policy options listed for washing machines (cf. Annex I, options 1-20), stakeholders were asked to check which can NOT be applicable for the washing function of washer-dryers*			
Drying function of Washer-dryers (WD)					
3a	Drying only function: No existing ecodesign requirements / labelling	Application of the requirements to the TD regulation: - Availability of a standard cotton programme for drying - Measurement / calculation of the Energy Efficiency Index, - Weighted condensation efficiency	ED / EL / SM / CI	Easy to adapt; better comparison with TD. All drying performance tests according to EN61121 can be applied for washer dryers with the special condition that the initial moisture content for the drying needs to be defined based on washing tests in related programmes (cotton, easy care)	Adaptations may be needed. Condensation efficiency cannot be measured. Current minimum requirements on Energy Efficiency of TD might be challenging for WD.
3b	cf 3a For tumble dryers, in regulations 932/2012 and 392/2012 the measurement and calculation of the Energy Efficiency Index is based on the weighted average of 3 full-load and 4 half-load cycles of one standard cotton	Align the requirements of the drying function to the (future) approach which is decided to use for the wash-function (currently: 3:2:2 test cycles at 60°C full : 60°C half : 40°C half-load, cf. option 4c on the sheet WM (WASH)).	ED / EL / SM / CI	Better alignment to the approach decided to use for the washing function and possibly to actual conditions of use	

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	programme. In the annual energy consumption, also the standby modes are included.				
3c	cf. 3a	Alternative adaptation of requirements for the drying process from TD regulation	ED / EL / SM / CI	Possibly reflecting better the characteristics of WD	Values to be defined ad-hoc, no direct comparison with TD
3d	cf 3a According to the 2015 consumer survey, the drying-only function of WD is not used frequently	No requirements at all for the drying only function		The use of this function does not seem relevant; its regulation would create burdens without providing additional benefits compared to those that can be achieved through regulating the wash & dry function	Missed regulation of such function
4a	Wash&dry function According to the 2015 consumer survey, WD are mainly used as WM, with a broad spectrum of wash programmes used, but also to wash&dry textiles (mainly in a continuous wash&dry cycle); The Energy label Directive 96/60/EC is based on a standard 60°C cotton cycle; the wash&dry cycle measurement procedure is based on 1x full load wash + 2 x partial load drying, measured in discontinued cycles. So far, for WD there exist no ecodesign requirements.	Business as usual; keep the existing measurement method and A-to-E Label classes, but adjusting them to the current consumption levels	ED / EL / SM	Continuity	Does not reflect knowledge of how consumers use WD (mostly wash and continuous wash/dry cycles; lower temperatures used; possible partial loads)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
4b	cf. 4a	Define a new measurement method for testing the most used programmes for the continuous wash&dry cycle (different temperatures, full/partial load, taking the average of a certain number of cycles in the end): Specific information for wash & dry function can be provided by testing WD in two treatments: - Treatment 1: 60°C cotton wash at full WD load + drying to cupboard dry status - Treatment 2: 40°C cotton wash at half WD load + drying to iron dry status It is for example recommended to perform 7 tests, with three times treatment 1 and 4 times treatment 2 to maintain the frequency of seven cycles for the test load, as required by the measurement standard as interval between normalisation and conditioning. The specific values of these seven test runs shall be taken as absolute values or divided by the maximum rated capacity for the wash&dry process as specific consumption values. If a continuous cycle is possible this should be preferred compared to an interrupted operation (e.g. test performed at the maximum drying capacity). If no specified final drying status can be selected (time controlled drying only) the appropriate time needed to reach the final drying status shall be assessed by pre-testing.	ED / EL / SM	Better alignment to real-life conditio of use. With the proposed approach a primary function of WD is tested. All washing performance tests according to EN60456 can be applied for washer dryers without exception. Additionally, the function 'continuous wash&dry' can be tested with partial loads. This function should be a main part of the WD label to take this important function of the appliance into account.	Adaption of the measurement standard necessary; increased testing effort (tests must be performed for both washing and wash&dry functions). The current standard is limited to washing performance testing with unspecified washing and cotton cupboard drying; i.e. there is the need to offer and define more performance testing conditions. All drying performance tests according to EN61121 can be applied for washer dryers with the special condition that the initial moisture content for the drying needs to be defined based on washing tests in related programmes (cotton, easy care). The special test sequences for interrupted and continuous washing + drying cycles for other programme combinations like easy care drying and other final moisture contents than cupboard drying could be for instance applied
4c	cf 4b	Completely new definition of an ECO programme: Define a <u>most efficient</u> Eco programme for the wash/dry function of WD which can wash and dry normally soiled cotton labelled textiles for 40°C and 60°C *together.* (cf. option 5a in the options listed in Annex I for washing machines)	ED / EL / SM / CI	cf. 5a	cf. 3a n the sheet 'WD (WASH, DRY, GEN)') (and 5a in the sheet 'WM (WASH)')
5	Approaches for WM applicable to the drying function	*For the other policy options listed for washing machines (cf. Annex I, options 1-20), stakeholders were asked to check which of them could be applicable also to the drying / wash+dry functions of washer-dryers as well (e.g. time cap, consumer information)*			

Table 8.13: Full list of possible policy options for household washer-dryers (general approach)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
A	Common regulations for WM and WD	Include the WD into the revised Ecodesign and Energy label regulations of Washing Machines: - Washing function of WD: Same/similar requirements as for WM - Drying function of WD: Requirements for *drying only cycle and/or continuous wash&dry cycle (see above)* Energy label: - Two different label scales for the washing and for the wash&dry function (combined label as for air conditioners) - Information of potential interest for WD: Absolute energy / absolute water consumption, cycle time, rated capacity for wash&dry, noise for drying Example of possible requirements for ecodesign measures (based on in-house preliminary estimations): 1. Washing performance: >1.03 (respectively 'A' class) 2. Energy consumption: < 0.7 kWh/kg or < 4 kWh 3. Water consumption: < 15 L/kg or < 80 L	ED / EL	Fair comparison with WM and TD possible for consumers; the concept of a combined label scale on one appliance is already introduced for air conditioners. Less regulatory work compared to two separate regulations; update / revision of the WD regulation	WM/WD are different appliances, the wash&dry procedures differ from single wash procedures (e.g. thermo-spin ability). Two labels may confuse. WD will come up always to be worse than separate WM and TD - due to its limitations!
B	Split regulations for WM and WD	Separate regulations for WM and WD, each for Ecodesign and Energy label Values for interrupted or continuous wash&dry process and washing function to be assessed for EL/ED	ED / EL	Each machine (WM, WD) is rated according to its specific function, i.e. highlights better the character of a washer dryer	Will show relative high absolute energy (and water) consumption values for WD. In case of no alignment of the washing function to the WM revisions, the washing function WD will not be comparable to WM for consumers. More regulatory work; due to the small market share of WD, a separate regulatory work for this product group might be dropped at all, i.e. no revision at all.
C	Integration of WD in WM (washing function) and TD (drying function)	Split wash and dry functions of WD: - Washing function: Include requirements into the revised regulations of WM - Drying functions: Include requirements into revised regulations of tumble dryers (TD) (current EU regulations 932/2012 and 392/2012)	ED / EL	Transparency for consumers: Direct comparibility of the wash-function with WM and of the dry-function with the requirements for TD	Does not highlight the characteristics of the washer-dryer. WM/WD are different appliances, the wash-dry process differs from single wash processes (e.g. thermo-spin ability); different timelines of revisions. Confusing for consumers as WD would have two labels; continuous wash-dry cycle (which is often used, cf. 2015 consumer survey) would not be covered; handling and maintenance of regulations might have

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					different retention periods.

8.5. Full list of possible policy options for material efficiency of washing machines and washer-dryers

The following Table 8.14 provides a full list of possible policy options for material efficiency of household washing machines and washer-dryers and that have preliminarily discussed with stakeholders in the course of study. The policy instruments addressed are the Energy label (EL), generic and/or specific Ecodesign-measures (ED), standards and measurement methods (SM), as well as consumer information (CI) measures. Please note that policy options for material efficiency of household washing machines and washer-dryers are the same of those presented for dishwashers.

Table 8.14: Full list of possible policy options for material efficiency of household washing machines and washer-dryers (durability/reparability and end-of-life (EoL) management)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
Policy measures with regard to **durability & reparability** of washing machines (WM) and washer dryers (WD)					
1a	Unsatisfactory mechanical robustness / durability of certain components and/or the whole appliance which lead to early failure rates There are standards on safety that could be used as starting point to handle such aspects.	Requirement on performing durability tests of certain components which are known to be prone for early failures	ED / SM	Decreased failure rate of appliance components	No clear evidence of certain components which usually fail more often (might be different from appliance to appliance); high effort / costs for testing; quality of just performing tests might be variable from manufacturer to manufacturer; testing alone would not lead automatically to higher durability

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
1b	cf. 1a	Requirements on a minimum operational lifetime of certain components which are known to to be prone to early failures	ED / SM	Decreased failure rate of appliance components	Measurement standard needed; high effort for market surveillance authorities
1c	cf. 1a	Consumer information on the operational lifetime of certain components (e.g. motor)	ED / SM / CI	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this as a competitive argument	Claims on operational lifetime must be backed with verifiable durability tests (not only marketing instrument); does not ensure that other components / the whole appliance are defective due to other reasons
2a	cf. 1a	Requirement on performing durability tests of the whole product (e.g. endurance tests; and/or tests for extraordinary constraints like shocks, vibratio, accidental drop, high temperatures, water, …)	ED / SM	Decreased failure rate of appliances	Specification of typical extreme stresses for those appliances needed; measurement standards needed; high effort / costs for testing; quality of just performing tests might be variable from manufacturer to manufacturer; testing alone may not lead automatically to higher durability
2b	cf. 1a	Requirements on a minimum operational lifetime of the whole appliance (e.g. machines to run a minimum number of cycles)	ED/SM	Decreased failure rate of appliances	cf. 1b; further: market intervention which might hinder/prevent innovations; few incentives for manufacturers to design the appliance beyond this mandatory minimum lifetime; disadvantage for those manufacturers providing already better quality (as market surveillance might not be effective enough to override bad quality products to a large extent); must be combined with legal rights for consumers to claim if the minimum lifetime is in practice not reached
2c	cf. 1a	Consumer information about the expected operational lifetime of the whole product (e.g. label, manual)	ED / SM / CI / EL	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this information as a competitive argument	cf. 1c
3a	Wrong user behaviour leading to defects of appliances (e.g. incorrect use, insufficient maintenance)	General consumer information about correct use and maintenance of appliances	ED / CI	Decreased misuse, decreased defects of appliances	Those consumer information is already mostly available in the manuals; is does not generally prevent consumers from misuse (precondition is that they read the information at all and act accordingly)
3b	cf. 3a	Compulsory direct feedback on necessary maintenance intervals via the machine's display	ED / CI	Possibly more regular maintenance done by consumers	Not all appliances are equipped with a display so far; communication of such information requires special displays (TFT; text to be displayed) and a sensoric which measures the next maintenance interval to be necessary (e.g. counting number of cycles); significant raise of appliances prices expected especially in the low-price segment; impact is not clear (if consumers would really change their behaviour)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
3c	Early replacement of appliances due to changes in consumer preferences and needs (e.g. larger / newer products, design, …)	Consumer information about the environmental (and economic) benefits of prolonged product use (e.g. campaign, sign on the appliance etc.)	ED / CI	Might reduce early replacements by consumers	No clear evidence of the impact; consumers might have still other predominant arguments / reasons for exchanging products
4a	In case of a defect, appliances are increasingly discarded although a repair might have increased the lifetime; reasons might be e.g. a certain product design impeding repairs, missing and/or no access to spare parts, high costs for repairs compared to purchase of a new product etc.	Design for upgrades and repairs: components being prone to early failures should not be designed in a manner prohibiting repairs (e.g. high integration of different components)	ED	Modular design facilitates repairs in a cost-effective manner: otherwise whole component groups might have to be exchanged in case of a defect of only a single component which is more costly	Modular design might be more expensive. No clear evidence of certain components which usually fail more often (might be different from appliance to appliance); market intervention possibly hindering innovations; highly integrated components might have advantages themselves (e.g. better quality of the whole component group due to integration)
4b	cf. 4a	Design for upgrades and repairs: components being prone to early failures should be easily accessible and exchangeable by the use of universal tools	ED	Facilitates repairs in a cost-effective manner	No clear evidence of certain components which usually fail more often (might be different from appliance to appliance); high effort / costs for testing / market surveillance; 'easily accessible' should be well defined
4c	cf. 4a	Appliance internal failure diagnosis systems to report error specific messages to the user	ED	Digital pre-diagnosis of the specific failure would reduce duration and costs of repairs	Not all appliances are equipped with such a system and display so far; communication of such information requires special displays (TFT; text to be displayed) and a system which recognizes the kind of failure; significant raise of appliances prices expected especially in the low-price segment; impact is not clear)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
4d	cf. 4a	Information requirements on reparability (e.g. repair label), e.g. 1) indicating if the machine can be repaired or not; 2) indicating which components are not reparable	ED / CI / (EL)	Transparency for consumers; they might choose products being better reparable or which contain e.g. modular components	1) Manufacturers would always claim reparability; difficult to define / measure, i.e. difficult to prove non-compliance (standard needed) 2) Difficult to define; in general, most components will be reparable or exchangeable - cost factor
4e	cf. 4a	Consumer information about access to professional repairs (e.g. information in user instruction / manufacturer's website / on the appliance itself to let the user know where to go to obtain professional repairs and servicing of the product, including contact details)	ED / CI	Facilitates the possibilities for repairs	Those consumer information is already mostly available in the manuals; (precondition is that they read the information at all and act accordingly); it does not generally prevent consumers from not repairing the devices as other reasons might play a role (e.g. costs of repairs, inconvenience of long waiting times); often only authorized repair shops listed which might be more expensive than independent ones
4f	cf. 4a	Information about the availability (and price) of spare parts (current practice: from 0 to 10-15 years after production)	ED / CI	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this information as a competitive argument	Price indications are variable and dependent on several factors; costs for spare parts is only one factor of the total costs of repair (labour costs, travel costs); indication of prices in advance might even discourage consumers from doing repairs
4g	cf. 4a	Guarantee of public availability of spare parts for a certain period following the end of the production of the model; ensure original and backwardly compatible spare parts	ED, EL, CI	Facilitates that products can be repaired for a long period and by repair centres which are not manufacturer-bound	Costly for manufacturers to hold a stock of spare parts for a long time; for longlasting large household appliances, this period might be at least 5 years to cover early breaks, but up to 10-15 years; environmental benefits not clear (if spare parts are not needed in this period, the might be destroyed without being used);
4h	cf. 4a	Repair manual: clear disassembly and repair instructions to enable non-destructive disassembly of product for the purpose of replacing key components or parts for upgrades or repairs. Information publicly available or by entering the products unique serial number on a webpage to facilitate access for recognized / independent repair centres. A diagram of the inside of the housing showing the location of the components available online for at least 5 years	ED	Might decrease of repair costs for consumers if independent repair organisations and approved re-use centres have information access and are able to perform repairs	Accountability (e.g. safety, lifetime, guarantee) and confidentiality of manufacturers might not be ensured if information is public available / non-authorized repair centres can do the repairs

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
4i	cf. 4a	Commercial guarantee providing a minimum of 3 years guarantee effective from the purchase of the product during which manufacturers shall ensure the goods are in conformity with the contract of sale (without passing the burden of proof to the consumer). It includes service agreement with a pick-up and return option.	ED	Manufacturers might improve the quality of their products to prevent claims	Costly for manufacturers; risk that costs are transferred to the total product purchase price; risk that appliances (especially low-cost) would be replaced by a new model instead of being repaired; for the long-lasting large household appliances, 3 years are quite a short time.
4j	cf. 4a	Mandatory consumer information about commercial guarantees, i.e. the number of years the producer guarantees the full functioning of the appliance for free and without passing the burden of proof to the consumer	ED / CI	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this information as a competitive argument	
Policy measures with regard to **End-of-life (EoL) management** of machines					
5a	The design of appliances can influence the practicability of recycling facilities at the EoL according to WEEE requirements (dismantling of certain PCBs, displays, refrigerant containing components like heat pumps etc.) or to recover valuable resources (e.g. rare earth elements in permanent magnets of motors)	Design for recovery and recycling which allows better / easier access to dismantle / separate WEEE relevant components or components containing valuable resources	ED	These requirements are devised to help recyclers to better comply with the WEEE directive by providing information relevant for depollution, disassembly and or shredding operations	Measurement standard needed otherwise it would be too generic; high effort for manufacturers and market surveillance authorities

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
5b	cf 5a	Clear marking of special components and/or identification of appliances with heat-pumps (recyclers of category 1 waste (large household appliances') are not always certified to also treat appliances with refrigerants)	ED	Better transparency for recycling facilities to treat separately refrigerant-containing appliances	New WEEE categories will be introduced from August 2018 which restructures large household appliances with refrigerants into another category (temperature exchange equipment)
5c	cf 5a	Clear marking of appliances with permanent magnet motors containing rare earth elements	ED	A clear marking would facilitate the motors being manually removed before a subsequent shredding process and separately treated to improve the recycling potential of the rare earths which would otherwise be lost	Might have no relevance if not or nearly not applied to a large extent to motors of WM/WD/DW; only effective if such motors are treated separately in the recycling facility
5d	cf 5a	Marking of plastic parts containing hazardous substances (e.g. halogenated flame retardants); example: brominated fire retardants logo as proposed in the ED draft for electronic displays	ED	Might improve to get recyclates without hazardous substances (avoid contamination)	Effective only if it is possible to separate the recycled plastic streams (those free from hazardous substances)
5e	cf 5a	'End-of-life report' for recyclers containing information relevant for disassembly, recycling and recovery at end-of-life at least on exploded diagram of the product labelling the targeted components defined together with a documentation of the sequence of dismantling operations needed to access to the components	ED	These requirements might help recyclers to better comply with the WEEE directive by providing information relevant for depollution, disassembly and or shredding operations	In the daily recycling practice such documents might not be used at all.
5f	cf 5a	Declaration of the recyclability index for products indicating the share of recyclable materials, as for example proposed in the ED draft for electronic displays	ED	Transparency, market differentiation of machines	Well developed and widely accepted procedures needed; so far only a theoretical number as the real treatment of the specific appliances and thus their recyclability depends of further factors; does not help to improve the real recycling process
6a	Effectiveness of EoL efforts only if proper collection and treatment of appliances after use is ensured. Ongoing standardization	Require the mandatory application of the standard that CENELEC is developing	ED	Activity supported by industry	A standard is not yet available

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	activity within CENELEC in collaboration with recyclers that covers collection, transport, storage, separation and recycling of the product				
6b	cf 6a	Require the mandatory presence of a code / chip to track the appliance	ED	Possible track of the appliance	Availability of tools and infrastructures; does not solve the issue alone

9. BIBLIOGRAPHY

A.I.S.E / Insites 2014 (14 Oct 2015). Estimation of cost of detergents per washing cycle of washing machines (Email).
Alborzi, F.; Schmitz, A. & Stamminger, R. (2015). Washing behaviour of European consumers 2015.
Allacker, K.; Mathieux, F.; Manfredi, S.; Pelletier, N.; Camillis, C. de; Ardente, F. & Pant, R. (2014). Allocation solutions for secondary material production and end of life recovery: Proposals for product policy initiatives. Resources, Conservation and Recycling, 88, pp. 1–12. doi:10.1016/j.resconrec.2014.03.016.
BIO Intelligence Service (ed.) (2013). Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP): Part 1: Material Efficiency for Ecodesign – Draft Final Report. Prepared for: European Commission - DG Enterprise and Industry. Available at http://www.google.de/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&cad=rja&uact=8&ved=0CCwQFjAB&url=http%3A%2F%2Fec.europa.eu%2FDocsRoom%2Fdocuments%2F105%2Fattachments%2F1%2Ftranslations%2Fen%2Frenditions%2Fpdf&ei=iSRFVc-SFYi67gbnmoDQCw&usg=AFQjCNHSiyvwigeFrVdPMSo5FjtgldpvZQ, last accessed on 02 May 2015.
Blepp, M. & Gensch, C.-O. (2013). Einsparpotenziale durch automatische TwinDos Dosierung bei Waschmaschinen, last accessed on 14 Apr 2015.
CECED (2014). Database.
COWI and VHK (ed.) (2011). Methodology for Ecodesign of Energy-related Products MEErP 2011: Methodology Report. Part 1: Methods. Available at http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/methodology/files/meerp_methodology_part1_en.pdf, last accessed on 07 Apr 2015.
COWI and VHK (2014). EcoReport 2014: Version 3.06; VHK for European Commission 2011; modified by IZM for European Commission 2014.
ENEA/ISIS (ed.) (2007a). Preparatory Studies for Eco-design Requirements of EuPs Lot 14: Domestic Dishwashers & Washing Machines: Task 1: Definitions. Draft final report. Available at https://circabc.europa.eu/sd/a/48b885cf-3bf6-47cc-aea6-e7d071291734/Task%201%20Definitions.pdf, last accessed on 12 Mar 2015.
ENEA/ISIS (ed.) (2007b). Preparatory Studies for Eco-design Requirements of EuPs Lot 14: Domestic Dishwashers & Washing Machines: Task 5: Definition of Base Case. Task Final Report. Available at http://www.eup-network.de/fileadmin/user_upload/Task_5_Definition_of_Base_Case.pdf, last accessed on 19 Mar 2015.
Euromonitor / A.I.S.E (14 Oct 2015). Estimation of cost of detergents per washing cycle of washing machines - ‘apparent’ price per load (Email).
European Commission (1996). Commission Directive 96/60/EC of 19 September 1996 implementing Council Directive 92/75/EEC with regard to energy labelling of household combined washer-driers (OJ L 266, pp. 1–27). Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31996L0060&from=EN, last accessed on 19 May 2015.
European Commission (2010a). Commission Delegated Regulation (EU) No 1061/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household washing machines (OJ L 314, 2010, pp. 47–63). Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R1061&from=en, last accessed on 24 Feb 2015.
European Commission (2010b). 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 (OJ L

293, 2010, pp. 21–30). Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R1015&from=en, last accessed on 24 Feb 2015.

European Commission (2010c). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions: Energy 2020 - A strategy for competitive, sustainable and secure energy. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0639:FIN:EN:PDF, last accessed on 19 May 2015.

European Commission (2011). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions: Energy Efficiency Plan 2011. Available at http://eur-lex.europa.eu/resource.html?uri=cellar:441bc7d6-d4c6-49f9-a108-f8707552c4c0.0002.03/DOC_1&format=PDF, last accessed on 19 May 2015.

European Council (1992). COUNCIL DIRECTIVE 92 / 75 / EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances (OJ L pp. 16–19). Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0075&from=EN, last accessed on 15 Oct 2015.

European Environment Agency (2003). Water prices: Indicator fact sheet. Available at http://www.eea.europa.eu/data-and-maps/indicators/water-prices/water-prices/at_download/file, last accessed on 01 Oct 2015.

European Environment Agency (2005). The European environment - State and outlook 2005: Part A: Integrated Assessment. Available at http://www.eea.europa.eu/publications/state_of_environment_report_2005_1/SOER2005_Part_A.pdf/view, last accessed on 16 Oct 2015.

Eurostat (2011). Household composition statistics. Available at http://ec.europa.eu/eurostat/statistics-explained/index.php/Household_composition_statistics, last accessed on 16 Sep 2016.

Eurostat (2015). Electricity and natural gas price statistics. Available at http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_and_natural_gas_price_statistics, last accessed on 01 Oct 2015.

Kruschwitz, A.; Karle, A.; Schmitz, A. & Stamminger, R. (2014). Consumer laundry practices in Germany. International Journal of Consumer Studies, 38(3), pp. 265–277.

Lasic, E.; Stamminger, R.; Nitsch, C. & Kessler, A. (2015). Construction of a Virtual Washing Machine. Tenside Surfactants Detergents, Vol. 52(No 3), pp. 193–200.

Michel, A.; Attali, S. & Bush, E. (2015). Energy efficiency of white goods in Europe: monitoring the market with sales data: Changes and trends regarding energy efficiency, energy consumption, size and price in the markets of refrigerators, washing machines and tumble driers in the EU, France and Portugal, 2004 to 2014. Available at http://www.topten.eu/uploads/File/WhiteGoods_in_Europe_June15.pdf, last accessed on 16 Sep 2015.

Prakash, S.; Dehoust, G.; Gsell, M.; Schleicher T. & Stamminger, R. (2015). Einfluss der Nutzungsdauer von Produkten auf ihre Umweltwirkung: Schaffung einer Informationsgrundlage und Entwicklung von Strategien gegen „Obsoleszenz“: ZWISCHENBERICHT: Analyse der Entwicklung der Lebens-, Nutzungs- und Verweildauer von ausgewählten Produktgruppen. Available at http://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_10_2015_einfluss_der_nutzungsdauer_von_produkten_auf_ihre_umwelt_obsoleszenz_17.3.2015.pdf, last accessed on 06 Apr 2015.

Prakash, S.; Stamminger, R.; Dehoust, G.; Gsell, M. & Schleicher T. (unpublished). Einfluss der Nutzungsdauer von Produkten auf ihre Umweltwirkung: Schaffung einer

Informationsgrundlage und Entwicklung von Strategien gegen „Obsoleszenz“: Abschlussbericht.
Stamminger, R.; Alborzi, F. & Schmitz, A. (2015). Washer-dryer consumer behaviour and possible consequences for standardisation and energy labelling/ecodesign for washer-dryers.
Stamminger, R. et al. (2015, unpublished). Washing and drying behaviour of European consumer with a washer-dryer: Result of the consumer survey of 2015 contracted by DIN Consumer council.
VHK (ed.) (2014). Ecodesign Impact Accounting: Part 1 – Status Nov. 2013. Available at https://ec.europa.eu/energy/sites/ener/files/documents/2014_06_ecodesign_impact_accounting_part1.pdf, last accessed on 07 Apr 2015.
VHK et al. (ed.) (2014). "Omnibus" Review Study on Cold Appliances, Washing Machines, Dishwashers, Washer-Driers, Lighting, Set-top Boxes and Pumps. Available at http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/docs/omnibus_studyf_2014-03.pdf.