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ABS	Acrylonitrile butadiene styrene
AE_C	Annual Energy Consumption
Al	Aluminium
BAU	Business-as-usual (scenario)
BEC	Base Energy Consumption
BOM	Bill of material
CEC	Comparative Energy Consumption
Cr	Chromium
Cu	Copper
DoC	Declaration of Conformity
DOE	US Department of Energy
EC	European Commission
EEI	Energy Efficiency Index
EPDM	Ethylene Propylene Diene Monomer
EPS	Expanded Polystyrene
FDIS	Final Draft International Standard
FTC	US Federal Trade Commission
HiNa	High Network Availability
IA	Impact Assessment
LCC	Life cycle costs
PA	Polyamide

PBT	Polybutylene terephthalate
PCB	Printed Circuit Board
PE	Polyethylene
PMMA	Polymethylmethacrylate
POM	Polyoxymethylene
PP	Polypropylene
ppm	parts per million
PS	Polystyrene
PU	Polyurethane
PVC	Polyvinylchloride
PWB	Printed Wiring Board
RRT	Round Robin Test
SAE_C	Standard Annual Energy Consumption
US	United States
VA	Voluntary Agreement
Zn	Zinc

Introduction

Background

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 2010) and the Ecodesign Regulation (EC) 1015/2010 on household washing machines (European Commission 2010), as well as the Energy Label Directive 96/60/EC on household combined washer-dryers (European Commission 1996).

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 2007b) 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 revising 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 for being 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 preparatory study on household washing machines and washer-dryers builds on existing knowledge as far as possible. However, additional and complementary investigation is required to achieve the goals of the study. With this respect, the objective of this report is to:

- Summarise the background information so far gathered for household washing machines and washer-dryers.
- Identify areas which need to be revised, updated and integrated to reflect the current state of play and to align with the MEErP methodology.

The present document is prepared as input for the first TWG meeting (24 June 2015, in Seville).

This document is structured in the following chapters, following Tasks 1 to 4 of MEErP::

- Chapter 1 - Scope, defining the products and presenting relevant standards and legislation;
- Chapter 2 - Markets, presenting economic and market data of washing machines and washer-dryers at the EU28 level;
- Chapter 3 – Users and system aspects, describing user behaviour, key aspects influencing such practices and system aspects related to washing machines and washer-dryers;
- Chapter 4 - Technologies, analysing products from a technical point of view with a special focus on design, technology and innovation.

A summary and a list of key discussion points for the revision of the Regulations are presented at the end of each chapter. Where necessary, stakeholders are also informed where key decisions must be taken and where a gap of information must be filled with their support.

Once the necessary data has been collected, this background document will be enlarged to address all sections prescribed in MEErP, including:

- an environmental and economic assessment of base-cases;
- an analysis of the improvement potential achievable for this product group through the implementation of best available technologies and best not available technologies;
- a streamlined impact assessment of different policy options.

A first questionnaire to stakeholders has been sent in March 2015 to collect preliminary information for the study (JRC IPTS 2015a). Feedback received has been reported in this document to the extent possible. Additional questionnaires may also be sent in the coming months to fill any gaps of information needed to complete the study.

Stakeholder written feedback

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

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 this meeting are also welcome to provide written comments, once registered as stakeholders

1. Task 1: Scope

The aim of Task 1 is to analyse scope, definitions, standards and assessment methods and other legislation of relevance for the product group and to assess their suitability for the existing Ecodesign and Energy Label Regulations.

1.1. Product Scope

The following sections first provide an analysis of existing definitions of household washing machines and washer-dryers, as used for example in European statistics, EU legislation, standards and other voluntary initiatives such as ecolabel; followed by stakeholder feedback regarding the existing scope and definitions of the current EU ecodesign and energy label Regulations.

Based on this information and further research and evidence, a preliminary revised scope and revised definitions are proposed.

1.1.1. Existing definitions

The following section provides an overview of existing definitions of washing machines and washer-dryers given in key standards and legislation:

- Commission Regulations 1015/2010 and 1061/2010
- Commission Directive 96/60/EC
- Standard EN 50229
- European statistics
- European Ecolabels
- US Energy Star
- Ecodesign Preparatory study Lot 24

The analysis shall support a revision of the scope and definitions of the Ecodesign and Energy Label Regulations of household washing machines and washer-dryers, if necessary.

Commission Regulations EC/1015/2010 and EC/1061/2010

The Commission Regulation 1015/2010 with regard to ecodesign requirements for household washing machines (European Commission 2010) and Commission Regulation 1061/2010 with regard to Energy Labelling of household washing machines (European Commission 2010a) apply to

> *'Electric mains-operated household washing machines and electric mains-operated household washing machines that can also be powered by batteries, including those sold for non-household use and built-in household washing machines.'*

For household washing machines and household combined washer-dryers, the following definitions are given, among the others:

> *'<u>Household washing machine</u>' means an automatic washing machine which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes.*
>
> *'<u>Built-in household washing machine</u>' means a household washing machine intended to be installed in a cabinet, a prepared recess in a wall or a similar location, requiring furniture finishing.*
>
> *'<u>Automatic washing machine</u>' means a washing machine where the load is fully treated by the machine without the need for user intervention at any point during the programme.*

'Household combined washer-drier' means a household washing machine which includes both a spin extraction function and also a means for drying the textiles, usually by heating and tumbling.

Specific Ecodesign requirements for household washing machines are further differentiated by the rated capacity of the appliance, i.e. the maximum mass of dry textiles of a particular type (white cotton items only, clearly defined in the performance measurement standards, cf. section 1.2.2.1) which the manufacturer declares can be treated in the washing machine on the programme selected, expressed in kilograms:

- Requirements regarding the Energy Efficiency Index (EEI):
  - Stricter for household washing machines with a rated capacity equal to or higher than 4 kg;
  - Lower for household washing machines with a rated capacity lower than 4 kg.
- Requirements regarding the Washing Efficiency Index (I_W):
  - Stricter for household washing machines with a rated capacity higher than 3 kg;
  - Lower for household washing machines with a rated capacity equal to or lower than 3 kg.
- Requirements regarding the Water Consumption (W_t):
  - As a linear function of the rated capacity for the standard cotton programmes.

Commission Directive 96/60/EC

The scope of Commission Directive 96/60/EC with regard to Energy Labelling of household combined washer-dryers is defined as follows (without providing further definition of 'combined washer-dryers'):

'Electric mains operated household combined washer-driers. Appliances that can also use other energy sources are excluded.'

Standards IEC/EN 60456 The standards IEC 60456 (edition 5.0 from February 2010), and EN 60456:2011 'Clothes washing machines for household use – Methods for measuring the performance' apply to clothes washing machines for household use, with or without heating devices utilising cold and/or hot water supply. It also deals with appliances for water extraction by centrifugal force (spin extractors) and is applicable to appliances for both washing and drying textiles (washer-dryers) with respect to their washing related functions. The standards define household washing machines as follows:

Washing machine: appliance for cleaning and rinsing of textiles using water which may also have a means of extracting excess water from the textiles.

Further, sub-categories of washing machines are defined in the standards IEC / EN 60456:

Washer-dryer: washing machine which includes both a spin extraction function and also a means for drying the textiles, usually by heating and tumbling

Spin extractor: separate water-extracting appliance in which water is removed from textiles by centrifugal action (spin extraction)

Standard extractor: spin extractor used to remove water remaining in the base load at the completion of the programme where a rinse performance measurement is required

Vertical axis washing machine: washing machine in which the load is placed in a drum which rotates around an axis which is vertical or close to vertical. For the purposes of this document, vertical axis is where the angle of the axis of rotation is more than 45 degrees to horizontal. Where the drum does not rotate, the washing machine shall be classified as a vertical axis washing machine.

Horizontal axis washing machine: washing machine in which the load is placed in a drum which rotates around an axis which is horizontal or close to horizontal. For the purposes of this docu-

ment, horizontal axis is where the angle of the axis is less than or equal to 45 degrees to horizontal.

NOTE: The classification of vertical axis or horizontal axis in this document is only used to define the placement of the load into the drum.

Automatic machine: washing machine where the load is fully treated by the machine without the need for user intervention at any point during the programme prior to its completion

Manual washing machine: washing machine where the machine requires user intervention at one or more points during the programme to enable the machine to proceed to the next operation. NOTE: Examples of user intervention could include manual fill (non-automatic water level), transfer of the load between a washing drum and a spin extractor drum or manual draining. Manual washing machines have special requirements regarding the programme which is tested for this document.

Standard EN 50229

The standard EN 50229:2007 ''Electric clothes washer-dryers for household use - Methods of measuring the performance' specifies the test methods which shall be applied in accordance with the Commission Directive 96/60/EC of 19 September 1996 implementing Council Directive 92/75/EEC with regard to Energy Labelling of household combined washer-dryers. Regarding terms and definitions of appliance types, however, standard EN 50229 refers to the definitions provided by EN 60456, see above.

European statistics

The European statistical database for manufactured goods PRODCOM (Eurostat n.d.) , classifies washing machines under the following NACE Rev.2 code:

2751.13.00 – Cloth washing and drying machines, of the household type

In 2002, a major revision of NACE was launched. The Regulation establishing NACE Rev. 2 was adopted in December 2006. It includes provisions for the implementation of NACE Rev. 2 and coordinated transition from NACE Rev. 1.1 to NACE Rev. 2 in various statistical domains. NACE Rev. 2 is to be used, in general, for statistics referring to economic activities performed as from 1 January 2008 onwards. For washing machines, the NACE Rev. 1.1 code used in the Preparatory Study Lot 14 of 2007 was 2971.13.00 – Cloth washing and drying machines, of the household type.

European Ecolabels

The scope of the Nordic Ecolabelling of white goods (Nordic Ecolabelling 2014) covers inter alia household washing machines; a further definition is not provided. The requirements for spinning performance are further differentiated by capacity:

- Household washing machines ≤ 3.5 kg capacity
- Household washing machines > 3.5 kg capacity

The scope of the German Ecolabel Blue Angel RAL-UZ 137 for Household Washing machines (Ral gGmbH 2013a) is given as follows – a further definition of 'electric mains operated household washing machines' is not provided:

The Basic Criteria apply to electric mains operated household washing machines.

The calculation of specific requirements on water consumption of household washing machines is further differentiated by capacity:

- Household washing machines < 7 kg rated capacity

- Household washing machines ≥ 7 kg rated capacity

US Energy Star

The scope of the US ENERGY STAR Program Requirements for Clothes Washers – Eligibility Criteria 7.0 (US EPA 7.3.2015) covers following products:

> *A. Included Products: Products that meet the definition of a Residential Clothes Washer or Commercial Clothes Washer as specified herein are eligible for ENERGY STAR qualification, with the exception of excluded products.*
>
> *B. Excluded Products: The following products are not eligible for ENERGY STAR qualification:*
>
> *i) products with a clothes container volume of less than 1.6 cubic feet (about 45 litres),*
>
> *ii) products configured in any way other than a front- or top-loading design,*
>
> *iii) Combination All-in-One Washer-Dryers,*
>
> *iv) Residential Clothes Washers with an Optional Dry Cycle, and*
>
> *v) Commercial Clothes Washers with a clothes container volume larger than 6.0 cubic feet (about 170 litres).*

Further, the US Energy Star Program Requirements Version 7.0 for Clothes washers provides definitions for "clothes washers" and the following sub-categories:

> *A1. Residential Clothes Washer: A consumer product (cf. 10 CFR 430 Subpart A, Section 430.2) designed to clean clothes, utilizing a water solution of soap and/or detergent and mechanical agitation or other movement, and must be one of the following classes: automatic clothes washers, semi-automatic clothes washers, and other clothes washers.*
>
> *A2. Residential Clothes Washer with Optional Dry Cycle: A Residential Clothes Washer that has an optional add-on dry cycle, where drying is accomplished through use of electricity or gas as a heat source and forced air circulation; drying cannot be selected independently from a wash cycle (this is interpreted as if the machine cannot used as dryer only).*
>
> *B. Commercial Clothes Washer: A soft-mounted front-loading or soft-mounted top-loading clothes washer that is designed for use in applications in which the occupants of more than one household will be using the clothes washer, such as multi-family housing common areas and coin laundries.*
>
> *C. Combination All-in-One Washer-Dryer: A consumer product designed to clean and dry fabrics in a single drum, where a separate drying cycle uses electricity or gas as a heat source and forced air circulation.*

Specific US ENERGY Star requirements for clothes washers are further differentiated by capacity (cubic feet), design format (top- or front-loading) and intended use (residential or commercial):

- Residential Clothes Washers, Front-loading (> 2.5 cu-ft)
- Residential Clothes Washers, Top-loading (> 2.5 cu-ft)
- Residential Clothes Washers (≤ 2.5 cu-ft)
- Commercial Clothes Washers.

The US Energy Star Program refers to the US standards mentioned in section 1.2.4.3 and to the definition of consumer product given in the U.S. Code of Federal Regulations (CFR). The cited U.S. Code of Federal Regulations (CFR), Title 10 / Part 430 (Energy Conversation Program for Consumer Products), § 430.2 provides the following definition of "Consumer products" (U.S. Government 2014a):

Consumer product means any article (other than an automobile, as defined in Section 501(1) of the Motor Vehicle Information and Cost Savings Act): (1) Of a type— (i) Which in operation consumes, or is designed to consume, energy or, with respect to showerheads, faucets, water closets, and urinals, water; and (ii) Which, to any significant extent, is distributed in commerce for personal use or consumption by individuals; (2) Without regard to whether such article of such type is in fact distributed in commerce for personal use or consumption by an individual.

The U.S. Code of Federal Regulations (CFR), Title 10 / Part 431 (Energy Efficiency Program for Certain Commercial and Industrial Equipment), § 431.152 provides the following definition of Commercial Clothes Washers (U.S. Government 2014b):

Commercial clothes washer means a soft-mounted front-loading or soft-mounted top-loading clothes washer that—

(1) Has a clothes container compartment that—

(i) For horizontal-axis clothes washers, is not more than 3.5 cubic feet (about 99 litres); and

(ii) For vertical-axis clothes washers, is not more than 4.0 cubic feet (about 113 litres); and

(2) Is designed for use in—

(i) Applications in which the occupants of more than one household will be using the clothes washer, such as multi-family housing common areas and coin laundries; or

(ii) Other commercial applications.

The ENERGY STAR definition of a commercial clothes washer differs from the CFR definition of commercial clothes washers by: 1) not specifying a maximum capacity; and 2) not covering "other commercial applications."

Ecodesign Preparatory study Lot 24

The Preparatory study for Eco-design Requirements of Energy-using Products, Lot 24: Professional Washing Machines, Dryers and Dishwashers, Part Washing Machines and Dryers, Task 1 (Scope), defines professional washing machines as follows (Graulich et al. 2011):

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

Within the preparatory study, seven sub-categories of professional washing machines were defined which include the categories

- semi-professional washer-extractor (up to 7 kg),
- professional washer extractor < 15 kg and
- professional washer dryer.

Compared to household washing machines and washer-dryers, however, the main aspect considered in the design of semi-professional appliances is to provide satisfactory levels of performance quickly and continuously to meet exigencies of commercial users. As a result, semi-professional appliances present different characteristics, e.g. higher input of water and energy and recycle of these resources, shorter programme durations and larger capacities, different components and longer durability in terms of cycles, customised and partial programmability, possible heating of water by means of steam.

The delimitation of professional washing machines to washing machines for household use is defined through the Machinery Directive 2006/42/EC, that explicitly exclude washing machines intended for household use and which defines essential health and safety requirements for washing machines which are intended for professional use. Professional and semi-professional appliances have to comply with the machinery directive: they either need higher voltage or different safety requirements. According to the Machinery Directive, manufacturers have to determine the 'intended use' (domestic or commercial / industrial use) and state this in the product information or the so called Declaration of Conformity. "Household appliances intended for domestic use", on the other hand, must fulfil the safety objectives of the Low Voltage Directive 2006/95/EC instead (European Parliament 2006).

The term "domestic use" is defined as "use by private persons (consumers) in the home environment". While it is possible for a consumer to acquire an appliance intended for professional use or for a professional to acquire an appliance intended for domestic use, the criterion to be taken into account for determining the intended use is the use intended and stated by the manufacturer of the appliance in his product information or his Declaration of Conformity. Evidently, this statement must accurately reflect the foreseeable use of the product, as indicated in the Guide to application of the Machinery Directive 2006/42/EC (European Commission 2010).

Currently, semi-professional washing machines, professional washer extractors and professional washer-dryers are excluded from the scope of the Ecodesign and Energy Label Regulations on household washing machines.

Table 1.1: Main differences between household and semi-professional washing machines

	Household washing machines (in-house elaboration)	Semi-professional washing machines and washer extractor; source: (Graulich et al. 2011)
Typical number of operations	220 cycles per year	1,800 cycles per year
Typical cycle times (depending on the chosen programme)	30-200 minutes	35-55 minutes
Safety requirements	Low Voltage Directive	Machinery Directive

Table 1.2: Systematic of existing definitions for household washing machines

Table header	EU Ecodesign / Energy Label Regulations	IEC / EN standards	EU Prodcom statistics	German Blue Angel / Nordic Swan ecolabels	US Energy Star label (based on CFR definitions)
Function	"Machine which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes."	"Appliance for cleaning and rinsing of textiles using water which may also have a means of extracting excess water from the textiles."	"Clothes washing and drying"	---	"Product designed to clean clothes, utilizing a water solution of soap and/or detergent and mechanical agitation or other movement"
Operation	Automatic	• Automatic • Manual	---	---	• Automatic • Semi-automatic • Other
Intended use	• "Household washing machine", • including "those sold for non-household use"	"for household use"	"of the household type"	"household"	• "Residential / Consumer product: means any product which to any significant extent, is distributed in commerce for personal use or consumption by individuals." • "Commercial: designed for use in applications in which the occupants of more than one household will be using the clothes washer, such as multi-family housing common areas and coin laundries."
Design format	Including "Built-in, i.e. intended to be installed in a cabinet, a prepared recess in a wall or a similar location,	Vertical axis Horizontal axis	---	---	Front-loading Top-loading

Table header	EU Ecodesign / Energy Label Regulations	IEC / EN standards	EU Prodcom statistics	German Blue Angel / Nordic Swan ecolabels	US Energy Star label (based on CFR definitions)
	requiring furniture finishing”				
Capacity and/or dimensions	Energy Efficiency Index requirements: <4 kg / ≥ 4 kg Water Efficiency Index requirements: ≤ 3 kg / > 3 kg Water consumption: function of the rated capacity	---	---	• Blue Angel (water consumption): < 7 kg/ ≥ 7 kg • Nordic Swan (spinning performance): ≤ 3.5 kg / > 3.5 kg	Scope: < 1.6 cubic feet (excluded) Specific requirements on energy / water consumption: > 2.5 cu-ft ≤ 2.5 cu-ft
Power supply	“Electric mains-operated” and “Electric mains-operated that can also be powered by batteries”	---	---	---	---

For washer-dryers, only the definitions provided in the EU Ecodesign and Energy Label Regulations 1015/2010 and 1061/2010 and in the IEC / EN 60456 standards apply (which are almost identical), as well as the US Energy Star definition.

1.1.2. Feedback from stakeholders with regard to the existing scope

In March 2015, a questionnaire has been circulated by the study team to gather input and opinions from stakeholders for use in the revision of the Ecodesign and energy/resource label requirements of household washing machines and washer-dryers (JRC IPTS 2015a). Regarding the scope and definitions in the current Regulations, stakeholders were asked

- if the existing definitions are comprehensive and clear or should be modified,
- if the existing functional definitions of washing machines and washer-dryers are exhaustive and coherent, or if additional functional parameters are of relevance,
- if devices that can also be powered by batteries should still be listed separately in the scope,
- if there is still a need to list built-in household appliances as a separate category,
- if there are any examples of niche or special purpose types of household washing machines and washer-dryers which should be included or excluded from the scope, and
- if semi-professional appliances should be excluded from the scope.

The following answers and recommendation were provided by stakeholder feedback:

Clarity of the existing definitions

Industry stakeholders also propose to delete "built-in"; a differentiation is not needed since there is no difference, in terms of covered efficiency and performance, between built-in and not built-in machines. Also, "automatic" is proposed to be deleted as there are only automatic washing machines sold in the European market.

Two stakeholders ask to clarify if the scope includes automatic washing machines that use hot water (hot water being 'another energy source'). It is also recommended to add definitions for "hot fill"; "solar heated" or "renewable energy heated"; "integrated in power management system", etc. on the basis that a system approach would be needed to identify additional energy saving potential beyond those within the appliance (e.g. the use of solar-heated water).

According to a stakeholder, combined washer-dryers should be included inside the scope of the Ecodesign Regulation for washing machines (and for dryers) as market shares are increasing and they are less efficient than washing machines and tumble dryers; on the other hand, high efficient washer-dryers (with heat pump) are available on the European market.

Industry stakeholders recommend modifying the definition of "household combined washer-dryer" by deleting the word "usually" of the definition and clarifying they include also "…means for drying the textiles by heating and tumbling" as the washer-dryer needs to have a device to heat the process air which can be based on different technologies.

Functional parameters

Regarding functional parameters, following differentiation is made according to stakeholders' feedback:

- Primary functions:
  - Washing machines: Washing / cleaning; rinsing; spin extraction
  - Washer-dryers: Washing / cleaning; rinsing; spin extraction; the drying (only) or continuous washing-drying function is seen either as primary function by some stakeholders or as secondary function by others.

- Secondary functions: Automatic detergent dosage; possibility of adapting the spin speed or capability to be remotely controlled are seen as secondary functions of washing machines and washer-dryers by some stakeholders. Also, some stakeholders see the drying (only) function as secondary function of washer-dryers. One argument provided for the drying function of a washer-dryer being considered as a secondary function, at least as stand-alone function, is that results from household testing and user surveys demonstrate washer-dryers being mainly used as a washing machine and only occasionally as a dryer.

Two stakeholders explain that the separation of spinning function from washing and rinsing is historical: automatic washing machines were able to wash and rinse only and additional spin extractors were used. Currently, the spinning function has become a primary function of the so-called "fully automatic washing machines" (cf. section 1.4.1.2). Moreover, for households not equipped with a dryer or a separate laundry room with external ventilation, spinning is essential to prevent excess humidity and consequently formation of mould.

Built-in appliances

One stakeholder proposes that a separate category would be needed only if requirements were different from those for freestanding machines.

Most stakeholders answering to this question state that generally there is no need for a separate category because they are basically same appliances. “Built- in” was in the past used as one of the differentiation criteria for professional appliances.

Battery-powered washing machines and washer-dryers

The picture of those stakeholders answering on this topic is rather indifferent.

On the one hand, some stakeholders inform that the market relevance of this kind of machines is very low (production volume is estimated to be lower than 200,000 pieces per year), thus they should be excluded from the scope.

On the other hand, two stakeholders argue that they may become relevant in the future in the framework of smart grids and demand-response and renewable energy management.

Further, one stakeholder argues that battery powered appliances would need a different amount of energy in case of battery usage as compared to being operated by electric mains. It is also recommended to consider such products separately as they may not reach the same performance levels as traditional machines.

Finally, several industry stakeholders inform that the current test standard does not explicitly describe the test procedure for battery driven appliances, i.e. if included inside the scope, standards should be improved accordingly.

Niche or special purpose products

The following niche products or special purpose equipment are proposed by stakeholders to be excluded from the scope:

- Battery or continuous current appliances, as not enough data is available and products are not yet present in the market, although they could become relevant in the future.
- Micro-washing machines, i.e. washing machines with a capacity of 1 kg or less, as the test standard is suitable only for 1 kg and above.
- Water heated washing machines and washer-dryers, i.e. appliances with no own heating element that use external sources of water for heating and cooling the process water (not to be confused with appliances with hot/cold fill), cf. also section 4.1.3.5), as no test method independent from the water heating/cooling system is available (according to stakeholder information, this product

was available on the market before 2010, and then was phased out from the current Ecodesign regulation because it could not reach A class washing performance).

- Waterless washing machines (which are excluded by the current definition) as they have a different technology and not foreseen for laymen usage.

On the other hand, the following niche products or special purpose equipment are proposed by stakeholders to be included from the scope:

- Alternative heated appliances as potential new technologies
- Smart-grid ready appliances as upcoming technology where only the time of the energy consumption will be adjusted, i.e. which have no direct energy savings (see section4.1.3.13). As reason for inclusion into the scope, one stakeholder argues that they will shortly stop being a niche market and any washing machine might/will have this function. Further, he proposes that the energy efficiency of the wireless LAN modules of these appliances should be evaluated / rated separately for instance in relation to networked standby.

Semi-professional appliances

Several of the stakeholders answering to this question argue that semi-professional appliances are different from household appliances and have to comply with the Machinery Directive. They either need higher voltage or different safety requirements. They cannot be compared with household washing machines and washer-dryers as they have different types of use and cannot be evaluated as single machines without consideration of external water and energy recycling systems installed in professional laundry shops. Further, industry stakeholders inform that to meet the requirement of high productivity, resources (water, energy) are used typically in higher amounts and will be centrally recycled.

Two stakeholders see that semi-professional washing machines and washer-dryers should have Ecodesign and Energy Label requirements since the use of resources is more intensive. However, because of their characteristics, they are handled together with professional appliances.

On the other hand, one stakeholder argues that the current definition states that household washing machine means an automatic washing machine, which is designed 'to be used principally for non-professional purposes'. With regards to semi-professional appliances the primary question is whether they are accessible/marketed to consumers and to what extent. It could not be excluded that there could be such purchases e.g. for common laundry rooms in apartment blocks or student accommodation. Moreover, these machines have certain features as shorter cycles and longer durability which could represent a purchase incentive for some consumers. Thus, the stakeholder sees it to be important also to consider sales information.

For some stakeholders the definition, the current definition should be sufficient. However, one stakeholder proposes alignment with the definitions provided in the LVD 2014/35/EU and in the MD 2006/42/EC as this would avoid potential misinterpretations.

1.2. Legislation and standards for ecodesign, energy efficiency and other performance characteristics

In the following sections of chapter 1.2, the EU legislation (section 1.2.1), test standards (section 1.2.2) and ecolabels (section 1.2.3) of relevance for ecodesign, energy efficiency and other performance criteria are described, followed by a compilation of *international and third-country* legislation and standards (section 1.2.4).

1.2.1. European legislation on Ecodesign, energy efficiency and other performance characteristics

1.2.1.1. Ecodesign regulations relevant for washing machines and washer dryers

Ecodesign Regulation 1015/2010 on washing machines

Commission Regulation (EU) No 1015/2010 of 10 November 2010 is implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Ecodesign requirements for household washing machines. At the present time (April 2015), the following EU Ecodesign requirements apply for washing machines sold on the EU market (Commission Regulation (EU) No 1015/2010 and Corrigendum) on the basis of the testing framework set with the standard EN 60456:2011:

- Energy Efficiency Index (EEI): Since 2011, for all household washing machines, the Energy Efficiency Index (EEI) shall be less than 68 (i.e. Energy Label class A or better); further, since 1 December 2013, for all washing machines ≥ 4 kg the EEI has to be < 59 (Energy Label class A+ or better).
- Water consumption (W_t): has to be ≤ 5 x $c_{1/2}$ + 35, where $c_{1/2}$ is the washing machine's rated capacity for the standard 60°C cotton programme at partial load or for the standard 40°C cotton programme at partial load, whichever is the lower.
- Washing Efficiency Index (I_w): for household washing machines with a rated capacity > 3 kg it must be greater than 1.03, which corresponds to the class A according to the former Energy Label (Commission Directive 95/12/EC). For household washing machines with a rated capacity equal to or lower than 3 kg, the Washing Efficiency Index (I_w) shall be greater than 1.00, however, according to the market research, these small appliances are not provided on the market any more (cf. Figure 2-14)
- Availability of a cold wash programme (max. 20°C): Washing machines shall offer to end-users a cycle at 20°C. This programme shall be clearly identifiable on the programme selection device and/or the display.
- Further requirements are related on the calculation of the energy consumption and other parameters as well as on the booklet of instructions ((a)standard 60 °C and 40 °C cotton programmes, (b) power consumption of the off-mode and of the left-on mode; (c) indicative information on the programme time, remaining moisture content, energy and water consumption for the main washing programmes at full or partial load, or both; (d) recommendation on the type of detergents to use).

Ecodesign Regulation 1275/2008 for standby and off mode

Commission Regulation (EC) No 1275/2008 of 17 December 2008 is implementing the Directive 2005/32/EC of the European Parliament and of the Council with regard to Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (European Commission 2008).

According to the Regulation 1275/2008,

- 'stand by' is a condition where the equipment is connected to the mains power source, depends on energy input from the mains power source to work as intended and provides only the following functions, which may persist for an indefinite time: reactivation function, or reactivation function and only an indication of enabled reactivation function, and/or information or status display.
- 'off mode' means a condition in which the equipment is connected to the mains power source and is not providing any function; the following shall also be considered as off mode:

  (a) conditions providing only an indication of off-mode condition;

(b) conditions providing only functionalities intended to ensure electromagnetic compatibility pursuant to Directive 2004/108/EC of the European Parliament and of the Council.

According to Annex I of the regulation, washing machines as household appliances are falling under the scope of this regulation, as well as washer-dryers, which are not listed separately, but under the category ‘Other appliances for cooking and other processing of food, cleaning, and maintenance of clothes’.

Currently, stage 2 is applicable for products placed on the market from 7 January 2013, with the following requirements regarding power consumption for standby- and off-mode, as well as power management or similar functions:

- Power consumption in ‘standby mode(s)’:
  - The power consumption of equipment in any condition providing only a reactivation function, or providing only a reactivation function and a mere indication of enabled reactivation function, shall not exceed 0.50 W.
  - The power consumption of equipment in any condition providing only information or status display, or providing only a combination of reactivation function and information or status display shall not exceed 1.00 W.
- Power consumption in ‘off mode’:
  - Power consumption of equipment in any off-mode condition shall not exceed 0.50 W.
- Availability of off mode and/or standby mode: Equipment shall, except where this is inappropriate for the intended use, provide off mode and/or standby mode, and/or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source.
- Power management: When an equipment is not providing the main function, or when other energy-using products are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches the equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into:
  - standby mode, or
  - off mode, or
  - another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source. The power management function shall be activated before delivery.

Washing machines and washer-dryers usually have a “left-on mode” and a “delayed start” functions. According to the Ecodesign Regulation 1015/2010 for washing machines, ‘left-on mode’ means the lowest power consumption mode that may persist for an *indefinite* time after completion of the programme without any further intervention by the end-user besides unloading of the household washing machine. A definition for delayed start mode is not provided by 1015/2010. According to stakeholders, both left-on-mode and delayed start mode do not fall under the definition of a standby-mode under regulation 1275/2008. A “delayed start” function is not to be considered as standby because it does not last for an indefinite time. Also, since introduction of a power management in 2013 (see above), left-on mode does not fall under the definition of a standby-mode under regulation 1275/2008 anymore, as it is switched into off-mode after a certain time. This means that currently the requirements of regulation 1275/2008 with regard to power consumption in standby modes do not apply to household washing machines and washer-dryers. Nevertheless, the time and power in left-on mode has to be measured according to the Ecodesign and Energy Label Regulations 1015/2010 and 1061/2010 for washing machines to determine the annual energy consumption (AE_C) being the basis for the Energy Efficiency Index (EEI).

For washer-dryers, the Energy Label Directive 96/60/EC does not include stand-by and off-mode consumption. For washing machines and washer-dryers, this means that all appliances placed on the market after January 2013 have a power management system requiring the appliances to automatically switch from left-on-mode into off-mode (not exceeding 0.50 W) after each cycle after a certain time. The timeframe has not been further specified; according to stakeholder feedback, this is for example realised after 30 minutes. The power management for networked appliances is preset at 20 minutes, cf. next section.

Ecodesign Regulation 801/2013 on networked standby

The Commission Regulation 801/2013 on Networked Standby amended the Commission Regulation (EC) No 1275/2008 with regard to Ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment by adding definitions and Ecodesign requirements with regard to networked appliances. (European Commission 2013)

The Regulation establishes Ecodesign requirements related to standby and off mode, and networked standby, electric power consumption for the placing on the market of electrical and electronic household and office equipment. In this context, "networked standby" means a condition in which the equipment is able to resume a function by way of a remotely initiated trigger from a network connection, i.e. a signal that comes from outside the equipment via a network. Thus, the Regulation 801/2013 applies to all washing machines and washer-dryers being connected to a network ("smart appliances").

While Ecodesign Regulation 1275/2008 for standby and off mode requires a power management for all equipment other than networked equipment since 2013 (see section above), the following requirements apply to networked equipment (i.e. equipment that can connect to a network and has one or more network ports) since 1 January 2015:

- Possibility of deactivating wireless network connection(s): Any networked equipment that can be connected to a wireless network shall offer the user the possibility to deactivate the wireless network connection(s). This requirement does not apply to products which rely on a single wireless network connection for intended use and have no wired network connection.
- Power management for networked equipment: Equipment shall, unless inappropriate for the intended use, offer a power management function or a similar function. When equipment is not providing a main function, and other energy-using product(s) are not dependent on its functions, the power management function shall switch equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into a condition having networked standby. In a condition providing networked standby, the power management function may switch equipment automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for standby and/or off mode. The power management function, or a similar function, shall be available for all network ports of the networked equipment. The power management function, or a similar function, shall be activated, unless all network ports are deactivated. In that latter case the power management function, or a similar function, shall be activated if any of the network ports is activated. The **default period of time** after which the power management function, or a similar function, switches the equipment automatically into a condition providing networked standby **shall not exceed 20 minutes**.
- Networked equipment that has one or more standby modes shall comply with the requirements for these standby mode(s)
  - When all network ports are deactivated (since 1 January 2015)
  - When all wired network ports are disconnected and when all wireless network ports are deactivated (from 1 January 2017).

- Networked equipment other than High Network Availability (HiNA) equipment shall comply with the provisions of ‘power management for all equipment other than networked equipment’
  - When all network ports are deactivated (since 1 January 2015)
  - When all wired network ports are disconnected and when all wireless network ports are deactivated (from 1 January 2017).
- The power consumption of ‘other’ networked equipment (i.e. not HiNA equipment or equipment with HiNA functionality) in a condition providing networked standby into which the equipment is switched by the power management function, or a similar function,
  - Shall not exceed 6 W (since 1 January 2015);
  - Shall not exceed 3 W (from 1 January 2017);
  - Shall not exceed 2 W (from 1 January 2019).

Ecodesign Regulation 640/2009 for electric motors

Commission Regulation (EC) No 640/2009 of 22 July 2009 is implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to Ecodesign requirements for electric motors, including where integrated in other products. The Regulation, however, does not cover all motor types being on the market. Therefore, the preparatory study for Lot 30, finished in 2014 (cf. http://www.eco-motors-drives.eu/Eco/Home.html) aimed at identifying the environmental improvement potential of products outside the scope of Regulation 640/2009 on electric motors, such as:

- Motors below 750 W and above 375 kW;
- special-purpose inverter duty motors (asynchronous servo motors);
- permanent magnet motors;
- motors cooled by their load (fans),
- drives, such as soft starters, torque or variable speed drives (VSD) from 200W–1 000kW.

Motors are also integral part of household washing machines and washer-dryers. With the extension of the Ecodesign Regulation 640/2009 to motors below 750 W, asynchronous inverter motors and permanent magnet motors, these household appliances would indirectly also be affected (cf. also section 4.1.3.2).

On 29 April 2015, there has been an Ecodesign horizontal matters consultation forum meeting in Brussels, inter alia dealing with a discussion paper on Ecodesign for energy-related products integrated into other energy-related products, concerning inter alia Regulation 640/2009 with regard to Ecodesign requirements for electric motors which either may be sold as "stand alone" products, or integrated in other energy-related products such as washing machines and washer-dryers.

The discussion paper informs that

- It has been claimed by some manufacturers of final products incorporating other energy-related products that setting minimum requirements for components might have a negative impact on the LCC of the final products and that it is necessary to allow manufacturers flexibility in deciding the best combination of 'measures' to meet the Ecodesign requirements for the final product (or to achieve a higher energy efficiency class).
- It has to be noted that from a technical point of view, so far no evidence has been presented showing that the use of more efficient components leads to a lower energy efficiency of the final product. In reality, most of the time very efficient products are combinations of very efficient components put together in an appropriate way.

- In fact, Ecodesign requirements only remove the worst performing products from the market, leaving enough choice for final equipment manufacturers to integrate components allowing them to meet their design requirements including the minimum energy efficiency requirements set by a specific ecodesign measure.
- The results of a LCC analysis depend on the underlying assumptions regarding production costs, energy use, cost and hours of operation. If the assumptions regarding these parameters are set appropriately, the use of a more efficient component 'automatically' leads to a more efficient final product .Nevertheless, as "base cases" are abstractions of reality, not all the specific uses of equipment can be captured. For instance, the assumptions regarding the use of small motors need to reflect the "typical" use of a motor in different products (ranging from domestic washing machines and fridges to commercial chillers or industrial machine tools), the operating hours of which are all different .Moreover, the same applies to the different ways in which a final consumer may operate a (fairly homogeneous) product such as a washing machine, resulting in different LCC in reality. As an example, the preparatory study on the review of the motor Regulation assumed 400 running hours per year for small single phase motors which is line with the assumptions usually made regarding the use of domestic appliances. In reality, these running hours may differ for certain products and use patterns.

The discussion paper concludes that

- It may also lead to higher cost of the final product but if the requirements are correctly set, they will still be at the point of least LCC. Manufacturers may have less flexibility to decide what design measures to take.

The general aspect of components which are falling under the scope of other Ecodesign Regulations and which are integrated into other regulated products, such as washing machines and washer-dryers, might be relevant for instance also for:

- directional lamps, light emitting diode lamps and related equipment (Regulation 1194/2012)
- displays
- fans (Regulation 327/2011)
- water pumps (Regulation 547/2012).

Ecodesign preparatory study on smart appliances (ENER Lot 33, ongoing)

This study will provide the European Commission with an analysis of all technical, economic, environmental, market and societal aspects that are relevant for a broad market introduction of smart appliances. The study team started effectively in the autumn of 2014 and is expected to be finished in September 2016. A first discussion note had been published, presented and discussed at the first stakeholder meeting of the study in March 2015, providing initial information on the expected scope of the study, standardisation activities at EU level (cf. section 1.2.2.8), interoperability (i.e. the link between the individual appliance and the supply side) and options to reduce the interoperability gaps.

According to (VITO et al. 2015), the overall idea of a smart grid with smart appliances is to achieve a better balancing of energy supply and energy demand while accommodating more renewable energy and reducing peak load power generation. Flexibility of the energy demand is obtained through smart appliances for which the energy consumption load patterns can be shifted with acceptable user impact. The load shifting can take place when needed – typically at power peaks and times with renewable energy power surplus – and in accordance with the agreements with the consumers. Shifting of the energy consumption load patterns take typically place through (VITO et al. 2015):

- Control signals from the power system as direct appliance control (start, stop, modulate load etc.) after an agreement with the consumer.

- Price signals that the appliance can react on according to consumer settings.
- Appliances with internal voltage and/or frequency measurement and control, where the appliances switch on/off or modulate the consumption in function of those measurements and according to consumer settings.

One of the case studies chosen in the preparatory study is a washing machine. According to (VITO et al. 2015), in this use case, the user has an electricity contract based on variable prices, e.g., prices based on the day ahead energy market. Those prices are directly downloaded to the washing machine, which has a communication interface that supports the used pricing scheme and which is equipped with dynamic pricing scheduling logic. When the user configures the machine, he/she sets a deadline when the laundry should be finished the latest, and the washing machine then automatically starts the washing program such, that the total energy price for the program is cheapest, while the laundry is still finished in time. The washing machine may also give indications via its user interface to the user on when the cheapest and/or highest prices occur, such that the user can take this into account during configuration. The same principle might also apply to household washer-dryers.

For further details, please refer to the dedicated website http://www.eco-smartappliances.eu.

1.2.1.2. Legislation on energy efficiency and other performance characteristics for washing machines and washer-dryers

EU Regulation 1061/2010 with regard to Energy Labelling of household washing machines

The Energy Labelling Directive 2010/30/EU replaced 92/75/EEC in May 2010. This extends the scope of the directive from energy using products to include energy related products and also extends from domestic products to include products in commercial and industrial sectors. The Energy Labelling Directive requires appliances to be labelled to show their power consumption in such a manner that it is possible to compare the efficiency with that of other product options. The intention is that consumers will prefer more energy efficient appliances over those with a higher consumption, resulting in less efficient products eventually being withdrawn or decommissioned.

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 introduces new energy efficiency classes (A+, A++ and A+++), in addition to A-G ratings. This Delegated Regulation replaces the Energy Labelling of household washing machines as established by Commission Directive 95/12/EC of 23 May 1995 implementing Council Directive 92/75/EEC with regard to Energy Labelling of household electric washing machines (OJ L 47, 24.2.1996, p. 35).

Delegated Regulation (EU) No 1061/2010 (European Commission 2010a) requires for all washing machines placed on the European market to present following information to the customer:

- 7 classes maximum: from A+++ to D
- Coloured arrows are used to differentiate energy efficient from lower energy efficient products: dark green indicates a highly efficient product and red a low efficient product.
- The label for washing machines no longer includes a washing performance class as an A class washing performance is mandatory for all washing machines with a washing efficiency class greater than 3 kg.
- Annual energy consumption in kWh (assuming 220 cycles per year and including standby consumption)
- Pictograms highlighting selected performances and characteristics:
- Noise emissions in decibels

- Spin-drying efficiency class
- Capacity in kilograms
- Annual water consumption in litres

The annual energy & water consumptions, and the spin-drying efficiency class indicated on the label, are calculated, in accordance with the technical specifications set in the standard EN 60456:2011, on the basis of:

- 60°C cotton programme at full and partial load
- 40°C cotton programme at partial load
- Left-on mode and in off-mode

Values for the annual water consumption and the spin-drying efficiency class are based on the same set of washing cycles as the energy consumption data.

The classification of individual machines to the efficiency classes A^{+++} to D is done in accordance with the given ranking criteria (Table 1.3)

Table 1.3: Energy efficiency classes for household washing machines; (European Commission 2010a)

Energy efficiency class	Energy Efficiency Index (EEI)
A^{+++}	EEI < 46
A^{++}	46 ≤ EEI < 52
A^{+}	52 ≤ EEI < 59
A	59 ≤ EEI < 68
B	68 ≤ EEI < 77
C	77 ≤ EEI < 87
D	EEI ≥ 87

In order to classify an appliance, the **energy efficiency index (EEI)** is calculated according to equation 1-1:

$$EEI = \frac{AE_C}{SAE_C} \times 100$$ **Equation 1-1**

where: AE_C = annual energy consumption of the household washing machine

SAE_C = standard annual energy consumption of the household washing machine

The **standard annual energy consumption (SAE_C)** is calculated in kWh/year as follows and rounded to two decimal places:

$$SAE_C = 47.0 \times c + 51.7$$ **Equation 1-2**

where:

c = rated capacity of the household washing machine for the standard 60 °C cotton programme at full load or the standard 40 °C cotton programme at full load, whichever is the lower.

As shown in Equation 1-3, the **Annual Energy Consumption AE_C** results from the energy consumption of the standard test programme and the power consumption of left-on mode and off mode, each of them taken into account to 50% percent where no power management is present. A usage frequency of 220 cycles per year is assumed for the calculation of EEI and annual consumption of energy and water for household washing machines

$$AE_C = E_t \times 220 + \frac{\left[P_o \times \frac{525600 - (T_t \times 220)}{2} + P_l \times \frac{525600 - (T_t \times 220)}{2} \right]}{60 \times 1000} \quad \textbf{Equation 1-3}$$

Where

E_t = weighted energy consumption for the standard cycle, in kWh

P_l = weighted power in 'left-on mode' for the standard cycle, in W

P_o = weighted power in 'off mode' for the standard cycle, in W

T_t = weighted programme time for the standard cycle, in minutes

Since January 2013, according to the second tier of the Regulation 1275/2008 for standby and off-mode, all household washing machines have to be equipped with a power management system, with the household washing machine reverting automatically to 'off-mode' after the end of the programme. Therefore, another equation is applied for calculating the **Annual Energy Consumption**, taking into consideration the effective duration of 'left-on mode'.

$$AE_C = E_t \times 220 + \frac{\{ P_l \times T_l \times 220 + P_o \times [525600 - (T_t \times 220) - (T_l \times 220)] \}}{60 \times 1000} \quad \textbf{Equation 1-4}$$

Where

T_l = measured time in 'left-on mode' for the standard washing cycle, in minutes.

The weighted **energy consumption (E_t)** is calculated in kWh as follows and rounded to three decimal places:

$$E_t = 3 \times E_{t,60} + 2 \times E_{t,60\frac{1}{2}} + 2 \times E_{t,40\frac{1}{2}} \quad \textbf{Equation 1-5}$$

where:

$E_{t,60}$ = energy consumption of the standard 60 °C cotton programme;

$E_{t,60½}$ = energy consumption of the standard 60 °C cotton programme at partial load;

$E_{t,40½}$ = energy consumption of the standard 40 °C cotton programme at partial load.

The **weighted power in 'off-mode' (P_o)** is calculated in W, as follows and rounded to two decimal places:

$$P_O = 3 \times P_{O,60} + 2 \times P_{O,60\frac{1}{2}} + 2 \times P_{O,40\frac{1}{2}} \quad \textbf{Equation 1-6}$$

where:

$P_{o,60}$ = power in 'off-mode' of the standard 60 °C cotton programme at full load;

$P_{o,60½}$ = power in 'off-mode' of the standard 60 °C cotton programme at partial load;

$P_{o,40½}$ = power in 'off-mode' of the standard 40 °C cotton programme at partial load.

The **weighted power in the 'left-on mode' (P_l)** is calculated in W, as follows and rounded to two decimal places:

$$P_l = 3 \times P_{l,60} + 2 \times P_{l,60\frac{1}{2}} + 2 \times P_{l,40\frac{1}{2}}$$ **Equation 1-7**

where:

$P_{l,60}$ = power in 'left-on mode' of the standard 60 °C cotton programme at full load;

$P_{l,60½}$ = power in 'left-on mode' of the standard 60 °C cotton programme at partial load;

$P_{l,40½}$ = power in 'left-on mode' of the standard 40 °C cotton programme at partial load.

The **weighted programme time (T_t)** is calculated in minutes as follows and rounded to the nearest minute:

$$T_t = 3 \times T_{t,60} + 2 \times T_{t,60\frac{1}{2}} + 2 \times T_{t,40\frac{1}{2}}$$ **Equation 1-8**

where:

$T_{t,60}$ = programme time of the standard 60 °C cotton programme at full load;

$T_{t,60½}$ = programme time of the standard 60 °C cotton programme at partial load;

$T_{t,40½}$ = programme time of the standard 40 °C cotton programme at partial load.

The **weighted time in 'left-on mode' (T_l)** is calculated in minutes as follows and rounded to the nearest minute:

$$T_l = 3 \times T_{l,60} + 2 \times T_{l,60\frac{1}{2}} + 2 \times T_{l,40\frac{1}{2}}$$ **Equation 1-9**

where:

$T_{l,60}$ = time in 'left-on mode' of the standard 60 °C cotton programme at full load;

$T_{l,60½}$ = time in 'left-on mode' of the standard 60 °C cotton programme at partial load;

$T_{l,40½}$ = time in 'left-on mode' of the standard 40 °C cotton programme at partial load.

Further, calculation methods for the washing efficiency index, spin-drying efficiency, annual water consumption, remaining moisture content and the maximum allowed verification tolerances are provided by regulation 1061/2010/EU (European Commission 2010a), on the basis of the testing framework set with the standard EN 60456:2011.

Recently, the Regulation 1061/2010/EU was amended by the Commission Delegated Regulation (EU) No 518/2014, providing indications for the labelling of energy-related products on the internet.EU Directive 96/60/EC with regard to Energy Labelling of washer-dryers

Household Combined washer-dryers are addressed in Directive 96/60/EC of 19 September 1996 implementing Council Directive 92/75/EEC with regard to Energy Labelling of household combined washer-dryers and are exempted from the scope of the Delegated Regulation (EU) No 1061/2010. The label contains:

- The energy consumption per cycle (washing and drying)
- The energy consumption per cycle – washing only
- Washing performance – with a class from A to G
- The maximum spin speed
- The total cotton capacity (washing and drying separately)

- Water consumption for a full load washed and dried – note that condenser dryers may use significant amounts of water on the drying cycle
- Noise in dB (A) (separately for washing, spinning and drying)

For combined washer-dryers the energy efficiency scale is based on the energy consumption 'C' in kWh per kg complete operating (washing, spinning and drying) cycle using standard 60 °C cotton cycle, and 'dry cotton' drying cycle is in kWh per kilogramme of load.

The allocation of individual machines to the efficiency classes A to G is done in accordance with the given scheme (Table 1.4)

Table 1.4: Energy efficiency classes for household washer-dryers

Energy efficiency class	Energy Consumption (C)
A	C ≤ 0.68
B	0.68 < C ≤ 0.81
C	0.81 < C ≤ 0.93
D	0.93 < C ≤ 1.05
E	1.05 < C ≤ 1.17
F	1.17 < C ≤ 1.29
G	1.29 < C

The washing performance class of an appliance is measured based on using a standard 60 °C cotton cycle and shall be determined in accordance with Table 1.5.

Table 1.5: Washing performance classes for household washer-dryers

Washing performance class	Washing Performance Index (P)
A	C ≤ 0.68
B	0.68 < C ≤ 0.81
C	0.81 < C ≤ 0.93
D	0.93 < C ≤ 1.05
E	1.05 < C ≤ 1.17
F	1.17 < C ≤ 1.29
G	1.29 < C

1.2.1.3. Legislation on safety and other aspects of potential relevance for washing machines and washer dryers

LVD Directive 2014/35/EU

Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 is on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (European Parliament 2014).

The purpose of this Directive is to ensure that electrical equipment on the market fulfils the requirements providing for a high level of protection of health and safety of persons, and of domestic animals and property, while guaranteeing the functioning of the internal market. The Directive applies to electrical equipment designed for use with a voltage rating of between 50 and 1,000 V for alternating current and between 75 and 1,500 V for direct current, which is new to the Union market when it is placed on the market, i.e. it is either new electrical equipment made by a manufacturer established in the Union or electrical equipment, whether new or second-hand, imported from a third country. Also for household appliances, inter alia washing machines and washer-dryers, the Directive covers all health and safety risks, thus ensuring that these appliances will be used safely and in applications for which they were made.

Manufacturers of electrical equipment covered by the Directive are obliged to carry out the conformity assessment procedure. The CE marking, indicating the conformity of electrical equipment, is the visible consequence of a whole process comprising conformity assessment.

The new requirements under LVD 2014/35/EU will be applicable from 20 April 2016 and replace the former LVD 2006/95/EC.

EMC Directive 2014/30/EU

Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States regulates the electromagnetic compatibility of equipment (European Parliament 2014). It aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility, i.e. the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment.

Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:

- the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;
- it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.

Manufacturers of equipment covered by the Directive are obliged to carry out the conformity assessment procedure. The CE marking, indicating the conformity of apparatus, is the visible consequence of a whole process comprising conformity assessment. Apparatus shall be accompanied by information on any specific precautions that must be taken when the apparatus is assembled, installed, maintained or used, in order to ensure that, when put into service, the apparatus is in conformity with the essential requirements set out in the Directive.

The new requirements under EMC 2014/30/EU will be applicable from 20 April 2016 and replace the former EMC Directive 2004/108/EU.

Further legislation

Further, according to stakeholders, the following legislation might be relevant for household washing machines and washer-dryers:

- Radio and Telecommunications Terminal Equipment (R&TT) Directive 1999/5/EC
- The new European Radio Equipment Directive (RED) 2014/53/EU (mandatory in 2016)

1.2.2. European standards, basis for ecodesign and energy efficiency legislation

1.2.2.1. Performance standard for washing machines

The standard EN 60456:2011 "Clothes washing machines for household use. Methods for measuring the performance" was developed under mandate M/458, which relates to Directive 2009/125/EC of the European

Parliament establishing a framework for the setting of ecodesign requirements for energy-related products, to Council Directive 92/75/EEC on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances and to measures implementing these Directives, for which a Harmonised Standard(s) should be developed to cover essential requirements.

The standard is available and in line with the current regulations. It was published in the OJ (2013/C 355/04) together with EN 60456:2011/AC:2011, which corrected the amount of detergent to be used for the reference machine. In the OJ, a note states that "This standard needs to be completed to clearly indicate those legal requirements aimed to be covered. Clause ZB on tolerances and control procedures is not part of the present citation." This clarification is underway in an amendment of this standard (see below).

EN 60456: 2011, which supersedes EN 60456:2005 + A11:2006 + FprAB:2010, consists of the text of the analogous international standard IEC 60456:2010 with common modifications prepared by CENELEC TC 59X.

There are significant technical differences compared to IEC 60456:2010:

a) A test procedure for a combined test sequence of cotton 40 °C and cotton 60 °C with full load and partial load is introduced;

b) A test procedure for measuring power consumption in low power modes is introduced;

c) A formula to calculate the energy consumption of washing machines, including low power modes, is added;

d) The detergent dosage is reduced to 75% for cotton and synthetic/blends;

e) The detergent dosage of the reference machine type 1 (new type in IEC60456) is adjusted to maintain the washing performance level of the reference machine type 2 (old type);

f) The reference machine type 1 is to be used for testing according to Commission Regulations with regard to Energy Labelling and Ecodesign; and

g) Control procedures for checking measured values in comparison to values declared by the manufacturer under consideration of permitted tolerances are updated.

The procedures described in this European Standard were modified substantially compared to the previous versions, e.g. with regard to detergent dosage. Therefore, results of tests according to this standard cannot be directly compared to results of similar procedures of previous versions. Additionally, results based on a specific reference programme cannot be compared to results based on other reference programmes, like they are used for other countries or textile types.

This European Standard also specifies, as far as necessary, the test methods which will be applied in accordance with the Commission Delegated Regulation (EU) No. 1061/2010, supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to Energy Labelling of household washing machines, and in accordance with the Commission Regulation (EU) No. 1015/2010, implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines.

In brief, the testing procedure, as laid out in this standard, prescribes a well-defined measurement procedure of how to load a washing machine using distinct textiles (white cotton items only: sheets, pillowcases and towels. The partial load is half of the nominal load or rated capacity) under well-controlled conditions (ambience, water, voltage, frequency), together with well-specified test swatches with five different stain monitors and using a well-defined powder detergent. The amount of textiles, test swatches and detergent depend on the rated capacity of the washing machine to be tested. The rated washing capacity is the maximum mass of conditioned textiles (conditioned according to sub-clause 6.3.3 in EN 60456), in kg, which the manufacturer declares can be treated in one complete washing cycle, According to the 2011 regulation, and with the aim to simulate real use conditions, two tests are carried out in a programme called “standard cotton 40 °C programme” with half the rated capacity, and additional two programmes in the “standard cotton 60 °C programme” with half of the load, and three programmes in the “standard cotton 60 °C programme” with a full load.

No measurement of the real temperature in the load is determined. The standard allows the programme temperature to be a maximum value suitable for the kind of textiles to be washed. The actual temperature used during the programme cycle can be lower. This is supported by the sentence in Annex I of 1015/2010, which states that the booklet of instructions should indicate that the values are based on “the ‘standard 60 °C cotton programme’ and the ‘standard 40 °C cotton programme’”, that these programmes are “suitable to clean normally soiled cotton laundry" and "the most efficient programmes in terms of combined energy and water consumption", and that "the actual water temperature may differ from the declared cycle temperature”.

After having carried out a washing process, the test monitors are evaluated by measuring the colour of any remaining stains by a spectral photometer. The averaged sum of the values of the remaining stains are then compared to the results achieved by a washing process carried out under similar conditions and in parallel to the machine under test in a reference washing system. This usage of a reference system allows the leverage of uncontrollable factors of the whole test, such as batch to batch variations of the stain monitors or the detergent. In parallel to the washing process, all consumption values (water, energy, programme time) are recorded and the weighted average of all relevant measures of all seven cycles is calculated.

At the end of the spinning process, the final humidity is determined by comparing the amount of water retained in the load with the conditioned weight of the load. Additionally, the spinning speed is recorded during the spinning process and analysed afterwards to determine the maximum spin speed as the highest spin speed determined during a period of 60 seconds.

Rinsing performance

Mandate M/458 also requires the development of “procedures and methods for measuring the rinsing efficiency of household washing machines”. In principle, EN60456:2011 describes a procedure for measuring rinsing efficiency by measuring the remaining alkalinity in the load after final spinning. This methodology is well used within laboratories of manufacturers and test houses and used for publishing results in consumer organisation tests of washing machines. Unfortunately, tests of the same washing machine in different locations have shown a poor reproducibility of this methodology. This means that it is possible to compare rinsing efficiencies of machines within one laboratory, but a re-measurement on the similar machines in other laboratories may deliver significantly different absolute results. A workshop on washing machine rinsing efficiency measurement took place in Brussels on the 27 October, 2010, with participants from the EU (DG Energy) and relevant experts from the textile, detergent, consumer and machine industries to review the status and discuss possible options to improve rinsing performance measurements. As this resulted in no immediate solution, the task to work on an improved method was forwarded to CLC TC59X WG1 and IEC 59D WG20.

Actual work of CLC TC59X WG1

The responsible working group at CENELEC level (working group 1 of TC59X) is preparing an amendment of EN60456:2011 which correct some editorial mistakes and will update the performance measurement procedure (e.g. load definition, half load definition, reference machine, soils strips, low power mode measurements). This is especially needed for all references to EN 62301: 2005 “Household electrical appliances. Measurement of standby power” (see below), as it was replaced by the new standard EN 50564:2011 “Electrical and electronic household and office equipment – Measurement of low power consumption” prepared by a combined working group of CLC TC59X and TC108X. This European standard was prepared under standardisation mandate M/439. To fulfil the requirements of the mandate, the scope of EN 50564 had to be broadened in comparison with IEC 62301:2011 to cover a range of electrical and electronic household and office equipment. This is reflected in the title of EN 50564 in comparison with the title of IEC 62301:2011.

Additionally this amendment will have a new Annex ZB 'Tolerances and control procedures' clarifying the rule of tolerances in the verification procedure (see above).

The CLC TC59X WG1 is also working on new methods for the preparation of hard water to include in the standard IEC/EN 60734:2012 "Household electrical appliances - Performance - Water for testing"

1.2.2.2. Performance standard for washer-dryers

The European Standard EN 50229 'Electric clothes washer-dryers for household use - Methods of measuring the performance' specifies the test methods which shall be applied in accordance with the Commission Directive 96/60/EC of 19 September 1996 implementing Council Directive 92/75/EEC with regard to Energy Labelling of household combined washer-dryers. It deals with:

- Performance criteria, including energy and water consumption, for the 60 °C cotton wash programme as specified in EN 60456,
- Energy and water consumption of the drying cycle based on the "Dry cotton programme" as specified in EN 61121.

It defines relevant terms:

- Rated washing capacity - maximum mass of conditioned textiles (conditioned according to subclause 6.3.3 in EN 60456), in kg, which the manufacturer declares can be treated in one complete washing cycle,
- Rated drying capacity - maximum mass of conditioned textiles (conditioned according to subclause 6.3.3 in EN 60456), in kg, which the manufacturer declares can be treated in one complete single drying operation,
- Complete operation cycle - complete washing and drying process, as defined by the required programme(s), consisting of a the washing cycle and the drying cycle,
- Washing cycle - complete washing process, as defined by the required programme, consisting of a series of different operations (wash, rinse, spin),
- Drying cycle - complete drying process, as defined by the required programme, consisting of a series of different operations (heat, cool down). The drying cycle comprise drying of all partial loads, if the base load is split up,
- Automatic drying - drying process which automatically switches off when a certain moisture content of the load is reached.

As the rated washing capacity is normally higher as the rated drying capacity this standard requires that the load after being washed is divided in two or more parts that are dried individually. Water and energy consumption are calculated by adding up all individual consumption values, so from washing and two or more drying processes (when the rated washing capacity is more than twice the rated drying capacity).

Updates of EN 50229

The basic standards for measuring the energy consumption and performance of a washer-dryer (EN50229) are the measurement standards for washing machines (EN60456) and for tumble dryer (EN61121)

EN50229 was first published in 1997 but was regularly updated to adjust to the modification of EN60456 and EN61121, the European standards for testing washing machines and tumble dryers performance, respectively. The latest version of EN50299 (2007) needs to be updated to align with recent changes applied to the standards for washing machines (EN60456:2011) and for tumble dryer (EN61121:2013), as shown in Figure 1-1.

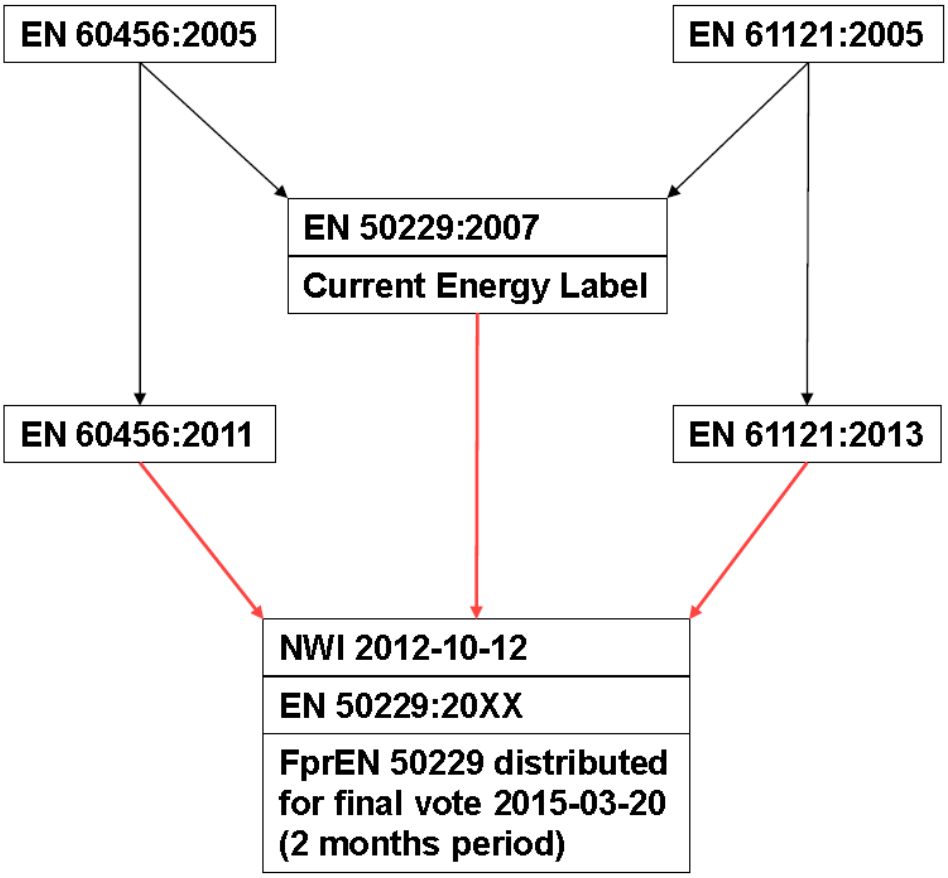


Figure 1-1 **Relationship between the washing machine standard En60456 and the standard for measuring tumble dryer EN61211 with the measurement standard for washer-dryer EN50229. Timeline is from top to bottom of the graph.**

The revision of the standard EN50229:2007 is currently in formal voting process (draft standard prEN 50229 finalised in March 2015 by CENELEC TC 59X). The main changes introduced with the 2015 update are:

- Alignment with EN60456:2011 and EN61121:2013 due to e.g.
  - New reference machine for washing performance test
  - New stains and corresponding detergent composition
  - New general structure of EN60456 and EN61121 (update of performance measurement procedures and references)
- New structure to improve readability
- Clear definition how to test e.g.
  - Drying performance test in automatic or timer mode
  - Load splitting (Rated capacity and load composition)
  - Implementation of test procedure to ensure getting valid tests for drying process
- Clear structure of data to be reported
- Technical modification to avoid circumvention

This update, when approved, will be published in the OJ to form the legal basis for testing washer-dryers according to the Energy Labelling as defined in Commission Directive 96/60/EC of 19 September 1996 implementing Council Directive 92/75/EEC.

1.2.2.3. Standby

Standby modes measurement for washing machine (no standby is specified for washer-dryers)

'Left-on mode' power and energy consumption measurements shall be made once for each treatment. The measurement will be started after the end of the programme. Power measurements for the 'left-on mode' will be in accordance with the requirements of EN 62301 "Household electrical appliances - Measurement of standby power" (IEC 62301:2005, modified), except the requirement defining the air speed (EN 62301:2005, 4.2). The air speed close to the appliance under test is not limited to ≤ 0.5 m/s. It is not possible to reduce it, because there is too much ventilation around the washing machine. The washing machine will not be disconnected from the power supply after the end of the programme. No user intervention, besides unloading, will take place on the test washing machine before 'left-on mode' power and energy measurement. Data for the parameters required will be recorded at regular intervals of 1 second or less throughout the test, using a data logger or computer. These provisions are necessary to ensure that the real-life 'left-on mode' consumption is correctly measured. However, this requires specific energy measuring equipment, as the normal power level is at about 2,300 W during the washing operation, while it may be below 0.5 W during 'left-on mode' operation and only a tolerance of 0.1 W is given by the regulation. This may require manual switching of the measurement range on the instrument. Additionally, the machine will also need time to revert from programme end status (where indications on the programme control indicate that the programme has ended and lamps may come on inside the drum to ease unloading) to a steady state called 'left-on mode'. This mode is defined in EN60456:2011 as the "lowest power consumption mode that may persist for an indefinite time after the completion of the programme and unloading of the machine without any further intervention of the user". This is different from the 'off-mode', which is defined as the "condition where the product is switched off using appliance controls or switches that are accessible and intended for operation by the user during normal use to attain the lowest power consumption that may persist for an indefinite time while connected to a mains power source and used in accordance with the manufacturer's instructions. Where there are no controls, the washing machine is left to revert to a steady state power consumption of its own accord." Both definitions are equivalent as defined in EU 1061/2010.

The Delegated Regulation (EU) No. 1061/2010 requires that the energy consumption in 'left-on mode' and 'off-mode' is to be calculated differently depending on the presence of a power management system in the machine itself. If the household washing machine is without a power management system, the time of the year the machine is not in operation is split 50:50 to be in 'left-on mode' and 'off-mode'. If the household washing machine is equipped with a power management system, with the household washing machine reverting automatically to 'off-mode' after the end of the programme, the weighted annual energy consumption is calculated, taking into consideration the effective duration of the 'left-on mode'. According to Regulation 1275/2008 for standby and off mode, since 2013 a power management system is mandatory for all household washing machines, however the maximum timeframe to switch into off mode has not been defined (cf. section 1.2.1.1).

A testing laboratory asked to verify the energy consumption of a washing machine would, therefore, need to measure the time it takes this machine to revert from the 'left-on mode' status to the 'off-mode' automatically. This would mean an indefinite time to wait and observe the machine behaviour. As this is not a practical (and is a very expensive) procedure, standardisation had to transfer the requirements given in the regulation into an operational procedure. This was done by splitting the left-on phase into two parts:

- The post-programme phase LU (unstable 'left-on mode') starts after the end of programme and adjustment of measurement devices, and immediately after opening the door.

- The post-programme phase LO (‘left-on mode’) starts after LU is finished. Its measurement will last for 10 min.

When the test washing machine is equipped with a power management system to revert the machine automatically to ‘off-mode’ after the end of the programme and the ‘left-on mode’ duration is declared by the manufacturer to last longer than 30 min, the measurements of the post-programme phase LU will be prolonged to the duration declared.

When the test washing machine is equipped with a power management system to revert the machine automatically to ‘off-mode’ after the end of the programme and the ‘left-on mode’ duration is declared by the manufacturer to last less than 30 min, the measurements of the post-programme phase LU will be carried out for 30 min, irrespective of the declared duration.

The time between the end of programme and start of unstable ‘left-on mode’ power and energy consumption measurements should be ≤ 5 min. After starting power and energy consumption measurements in post programme phase LU, the load will be removed within 5 min. The door remains fully open at the completion of unloading.

The measurements to determine ‘off-mode’ power and energy consumption will be run for the test washing machine once for each treatment. At the completion of the programme, the test washing machine will be unloaded. For the determination of this mode, the test washing machine will then be switched off in accordance with the manufacturers’ instructions.

A graphic representation of this procedure is given in Figure 1-2. This procedure avoids any circumvention possibility which might exist during the unstable part of the ‘left-on mode’ and ensures that the measurement of the ‘left-on mode’ can be finished within a reasonable length of time (45 min) after the programme end. Consequently, the calculation of the Annual Energy consumption AEc had to be adjusted in the standard compared to the regulation:

$$AE_C = W_{total} \times 220 + \left\{ \frac{P_O}{1.000} \times \left[\frac{525.600 - ((t_t + t_{mLU}) \times 220)}{2 \times 60} \right] \right\} + \left\{ \frac{P_{LO}}{1.000} \times \left[\frac{525.600 - ((t_t + t_{mLU}) \times 220)}{2 \times 60} \right] \right\} + \left[\frac{P_{LU}}{1.000} \times \frac{(t_{mLU} \times 220)}{60} \right]$$

where

- W_{total} is the average total energy consumption kWh;
- P_{LU} is the average power during post-programme phase LU in W;
- P_{LO} is the average power during post-programme phase LO in W;
- t_{mLU} is the measurement time for post-programme phase LU in min;
- P_O is the average power in ‘off-mode’ in W;
- t_t is the average programme time in min;
- 220 is the total number of standard washing cycles per year;
- 525 600 are the minutes in a year.

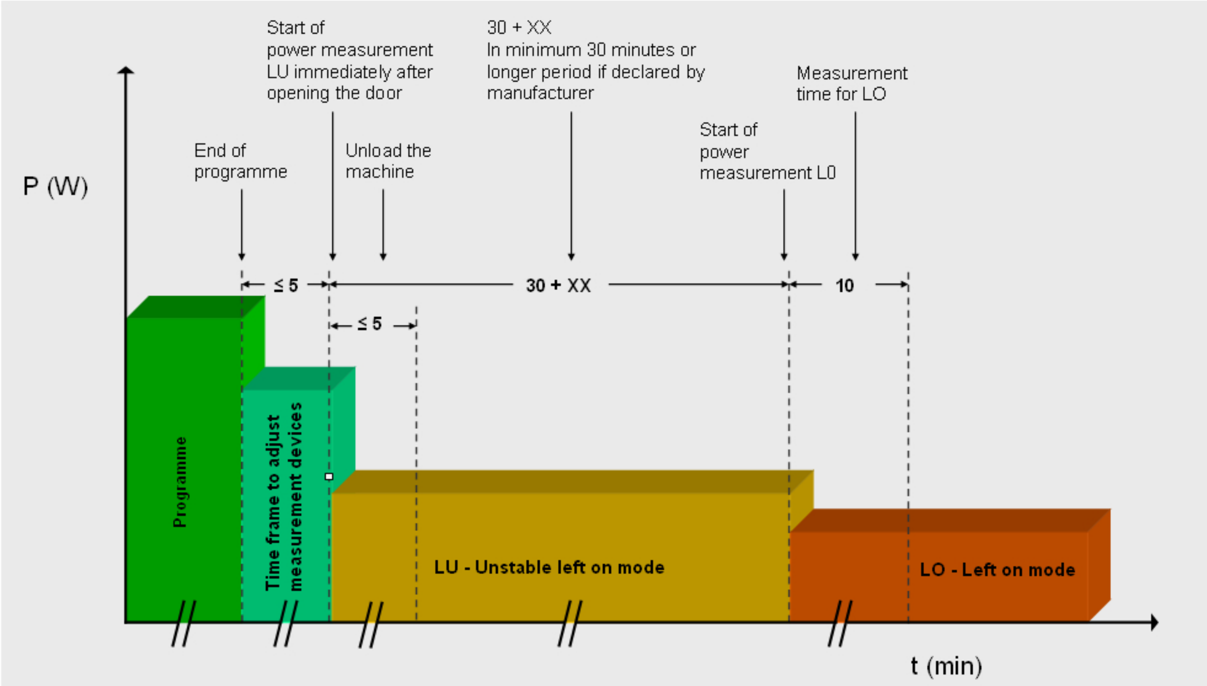


Figure 1-2 **Graphical presentation of various low power modes timing**

It has been shown that with this formula, the calculated annual energy consumption values are equal to or slightly higher than with those formulas given in the regulation.

1.2.2.4. Safety

Safety for wash appliances (washing machine and washer-dryer) is mainly dealt by the following standards:

- The general part EN 60335-1:2012 Household and similar electrical appliances - Safety - Part 1: 'General requirements' that is common to all the electric motor appliances. A set of "Part 2 documents" addresses safety issues for specific products. Updates of the EN 60335-1: 2012 + A11: 2014 + AC: 2014 "General requirements for household appliances" include also new requirements considering use by vulnerable people (children and persons with reduced physical, sensory or mental capabilities) and reduction in the surface temperatures.
- For washing machines, EN 60335-2-7:2014 'Household and similar electrical appliances - Safety - Part 2-7: Particular requirements for washing machines' applies. If the washing machine includes also a spinning function, then EN 60335-2-4:2010 'Household and similar electrical appliances - Safety - Part 2-4: Particular requirements for spin extractors' applies and if also a drying function is included in the appliance (the so called "washer-dryer"), the standard EN 60335-2-11:2014 'Household and similar electrical appliances - Part 2-11: Particular requirements for tumble dryers' deals with the drying part. Recent updates to these standards include EN 60335-2-7: 2010 + A1: 2013 + A11: 2013 (i.e. similar changes as for Part 1 and to the conduction of the spillage test) and EN 60335-2-11: 2010 + A11: 2012 (i.e. additional standards of relevance for washer-dryers).
- As far as the connection with the water supply is concerned, washing machines shall also comply with EN 61770:2010: 'Electric appliances connected to the water mains - Avoidance of back-siphonage and failure of hose-sets'.

The mentioned standards address and implement an internationally accepted level of protection against hazards (such as electrical, mechanical, thermal, fire and radiation) when appliances are operated as in normal use, taking into account the manufacturer's instructions. The same standards cover also protection against further hazards deriving from abnormal situations that can be expected to happen during normal use.

It has been assumed in the drafting of these international standards that the execution of its provisions is entrusted to appropriately qualified and experienced persons.

The standards take into account the requirements of IEC 60364 ‘Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics’ as far as possible so that there is compatibility with the wiring rules when the appliance is connected to the supply mains. However, national wiring rules may differ.

If the functions of an appliance are covered by different parts 2 of IEC 60335, the relevant part 2 is applied to each function separately, as far as it is considered reasonable by the test performer. If applicable, the influence of one function on the other is taken into account.

For appliances not covered by a particular Part 2 of EN 60335 additional consideration may need to be given to particular categories of likely users, including vulnerable people and children and to related specific risks (e.g. access to live parts, or to hot surfaces or to moving parts) that may be covered by a particular Part 2 considered to be closest to the product under examination.

When a part 2 standard does not include additional requirements to cover hazards dealt with in Part 1, Part 1 applies.

Individual countries may wish to consider the application of the standard, as far as is reasonable, to appliances not mentioned in a part 2, and to appliances designed on new principles.

An appliance that complies with the text of this standard will not necessarily be considered to comply with the safety principles of the standard if, when examined and tested, it is found to have other features which impair the level of safety covered by these requirements.

An appliance employing materials or having forms of construction differing from those detailed in the requirements of this standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be considered to comply with the standard.

The principal objectives of the Low Voltage Directive, 2006/95/EC, are covered by these standards. The essential safety requirements of the following directives, which can be applicable to some household and similar appliances, have also been taken into account in these standards:

- 2006/42/EC – Machinery directive;
- 89/106/EEC – Construction products directive;
- 97/23/EC – Pressure equipment directive.

The Essential Health and Safety Requirements (EHSR) of the Directive 2006/42/EC are covered by Annex ZE of EN60335-1. The application of EN 60335-1 alone does not give presumption of conformity for a product. This is achieved by complying with the requirements of EN 60335-1 and the relevant Part 2, when this Part 2 is also listed in the OJ under the Directive.

1.2.2.5. Noise

M/458 requires the measurement of airborne acoustical noise emissions:

- EN 60704-1:2010+A11:2012 "Household and similar electrical appliances - Test code for the determination of airborne acoustical noise - Part 1: General requirements"
- EN 60704-2-4:2012 “Household and similar electrical appliances – Test code for the determination of airborne acoustical noise — Part 2-4: Particular requirements for washing machines and spin extractors”, which is a modified version of IEC 60704-2-4:2011. Compared to the previous version, this

standard has specified the textile load and the test programme more clearly. Additionally the test enclosure was modified. The publication of this standard in the OJ 2013/C 355/04 notes that: "This standard needs to be completed to clearly indicate those legal requirements aimed to be covered." This sentence refers to the missing Annex ZZ in this standard.

- EN 60704-3:2006 "Household and similar electrical appliances. Test code for the determination of airborne acoustical noise. Procedure for determining and verifying declared noise emission values"

A standard for the measurement of noise in washer-dryer is also under development.

1.2.2.6. Electromagnetism

- EN 55014-1: 2006 + A1: 2009 + A2: 2011 Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission
- EN 55014-2: 1997 + A1: 2001 + A2: 2008 Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 2: Immunity
- EN 61000-3-2: 2006 + A1: 2009 + A2: 2009 Electromagnetic compatibility (EMC) – Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)
- EN 61000-3-3: 2013 Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection
- EN 62233: 2008 Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure

1.2.2.7. Uncertainty, tolerance, repeatability and reproducibility

To encourage the efficient use of energy and other resources, the European Parliament and Commission have issued regulations, which mandate the provision of information to consumers or sets up essential requirements. This information is conveyed by label obligations according EU Label Directive 2010/30/EU and Ecodesign requirements according EU Energy Related Products Directive (2009/125/EC). According this regulation the information has to be provided at point of sale or in the manuals by manufacturers. EU Mandates may be issued in order to cover these obligations.

Methods for measuring of resource consumptions and performance characteristics must be of sufficient accuracy to provide confidence to governments, consumers and manufacturers. The accuracy of a test method is expressed in terms of bias and precision. Precision, when evaluating test methods, is expressed in terms of two measurement concepts: repeatability (intra-laboratory variability) and reproducibility (inter-laboratory variability). Therefore, standard procedures are required for determining the repeatability and the reproducibility of test methods developed by technical committee and its subcommittees. The repeatability of a test method must be sufficiently accurate for comparative testing. The reproducibility of a test method must be sufficiently accurate for the determination of values which are declared and for checking these declared values.

Uncertainty reporting is essential to ensure measured data are interpreted in a correct way. Especially when data of measurements are to be compared between laboratories or when normative requirements are set up, it is necessary to know the uncertainty with which data can be measured. Measurement uncertainty is unavoidable always a combination of the variance of the product itself and the measurement method applied. This is subject of the measurement standard only. It should not be confused with production variation which in contrast is the very own responsibility of the manufacturer.

The Market Surveillance Authorities have the responsibility for verifying the information given at the point of sale or requested by eco-design measures and they do this by carrying out an independent set of measurements with other test sample(s). Both sets of measurements are subject to the uncontrollable factors described above. In addition to the product to product variation these uncontrollable factors will contribute to possible differences between the measurement result and what was declared by the manufacturer. Verification tolerances given in the regulations are supposed to consider these possible differences to ensure correct judgement of the compliance of the product under verification. A false judgement of non-compliance could have severe consequences (withdraw from market, fines, etc) for the manufacturer.

1.2.2.8. Additional standardisation activities

Avoiding test cycle recognition

Mandate M/458 also asks "to ensure that the prospective harmonised standard(s) includes a procedure that avoids an appliance being programmed to recognize the test cycles, and reacting specifically to them". This provision is overruled by the delegated regulation 1061/2010 and the ecodesign regulation (EU) No. 1015/2010, asking specifically for a clear identification of the "standard 60 °C cotton programme" and the "standard 40 °C cotton programme".

Uncertainty and tolerances

The assessment of verification tolerances is identified as a revision need for both the Regulation 1061/2010 and the Regulation 1015/2010.

CENELEC TC59X WG16 "Uncertainty and tolerances" has taken up the initiative of IEC 59D and produced an internal document (TC59X/(Sec.)0554/INF "Household and similar appliances – Method for calculation of uncertainty of measurements") for all working groups under CLC TC59X "Household and similar Appliances" asking for the reporting of expanded uncertainty values for all measurements defined in their standards.

However, the assessment of the expanded uncertainty and the definition of verification tolerances will, in many cases, only be possible after a round-robin test (also called ring test) has been performed, where one or more appliances are sent around to many different laboratories to be measured under the same conditions as those defined in the measurement standard. The analysis of these results will deliver a good knowledge of the repeatability and reproducibility of the relevant measurement. How to perform such a round-robin test is also described in a technical report (CLC/TR 50619:2013 "Guidance on how to conduct Round Robin Tests"). Another informative document of CLC 59X was released (TC59X/ (Sec)0597/INF "Application of measurement uncertainty in setting verification tolerances") in May, 2014, where the relation of the expanded uncertainties as a characteristic value of the measurement to the political issue of how tolerances are set is explained.

Performing a round-robin test involves measurements in many, mostly independent, testing laboratories. If the latter are not willing to participate for free, it is necessary to provide some funding. Money is also necessary for the proper organisation and a qualified analysis of the round-robin test data. Present experience of CLC TC59X concerning asking for funding for round-robin tests shows that this is a time-consuming and bureaucratic process.

CECED has also provided the industry positions with respect to

- the verification tolerances in Ecodesign and Energy Labelling (see: http://www.ceced.eu/site-ceced/media-resources/Position-Papers/2014/10/Verification-tolerances-in-Ecodesign-and-Energy-Labelling-future-legislation.html)
- the noise verification procedure (see: http://www.ceced.eu/site-ceced/media-resources/Position-Papers/Archive/2015/03/CECED-comments-on-the-noise-verification-procedure.html)

With respect to washer-dryers, tolerances applicable for this appliance (fixed in the test standard EN50229 and not in the EU regulation) are not based on any round robin test to estimate the expanded uncertainty of the measurement method. The value is influenced by washing machines – though not 100% mirrored.

The current tolerances (15% for single test and 10% for 3 appliances test) have been indicated to fit well from the manufacturer point of view. However, a stakeholder suggests that tolerances could be smaller, about 6%.

Industry stakeholders also reported that products are designed in a manner which seeks to meet and exceed the verification tolerances provided in the relevant standards and regulations.

New rinsing performance measurement

Actually, a new measurement procedure is developed in Europe (CENELEC TC59X WG1) based on measuring the remaining surfactant (LAS - Linear Alkylbenzene Sulfonate) via UV spectroscopy on the un-soiled part of the test strip after the washing and rinsing process. This procedure has the advantages that it is a direct measure of one relevant detergent's ingredient (compared to the alkalinity which is influenced by many factors) and it is applicable also for washer-dryers. In the latter case the alkalinity method cannot be used in the continuous washing and drying cycle as no separate water extraction of the washed load can take place. Additionally this new procedure may be used also for liquid detergents. This procedure is now under comparison with other procedures developed and used in other countries, namely in US, China and Australia/ New Zealand. The result of this investigation will hopefully deliver sound data to answer the question how precise and how reproducible a rinsing process in a washing machine can be measured.

Demand response appliances (*smart* appliances): overview on standardisation activities in Europe

In order to promote European Smart Grid deployment, several measures has been taken by the European Commission (EC). In 2011, the EC issued the Standardisation Mandate 490 to European Standardisation Organizations (ESOs) to support European Smart Grid deployment. To accomplish this task, a Joint Working Group (Smart Grid Coordination Group (SG-CG)) has been created by the three European Standardisation Organizations CEN (the European Committee for Standardisation), CENELEC (the European Committee for Electrotechnical Standardisation) and ETSI (the European Telecommunications Standards Institute). The aim was a set of consistent standards which will support the information exchange and the integration of all users into the electric system operation. This mandate's reports were finalised by the end of 2014.

Currently, the Preparatory Study on Smart Appliances is carried out for the European Commission, DG Energy under framework contract ENER.C3.2012-418-lot 1. The preparatory study analyses all technical, economic, environmental, market and societal aspects that are relevant for a broad market introduction of smart appliances. The project started in autumn of 2014 and is expected to be finished in September 2016 (cf. also section 1.2.1.1).

In the following, the most relevant standardisation activities in view of demand response appliances will be summarised:

SG-CG developed a generic functional architecture for the flexibility use cases, which is represented in the figure below.

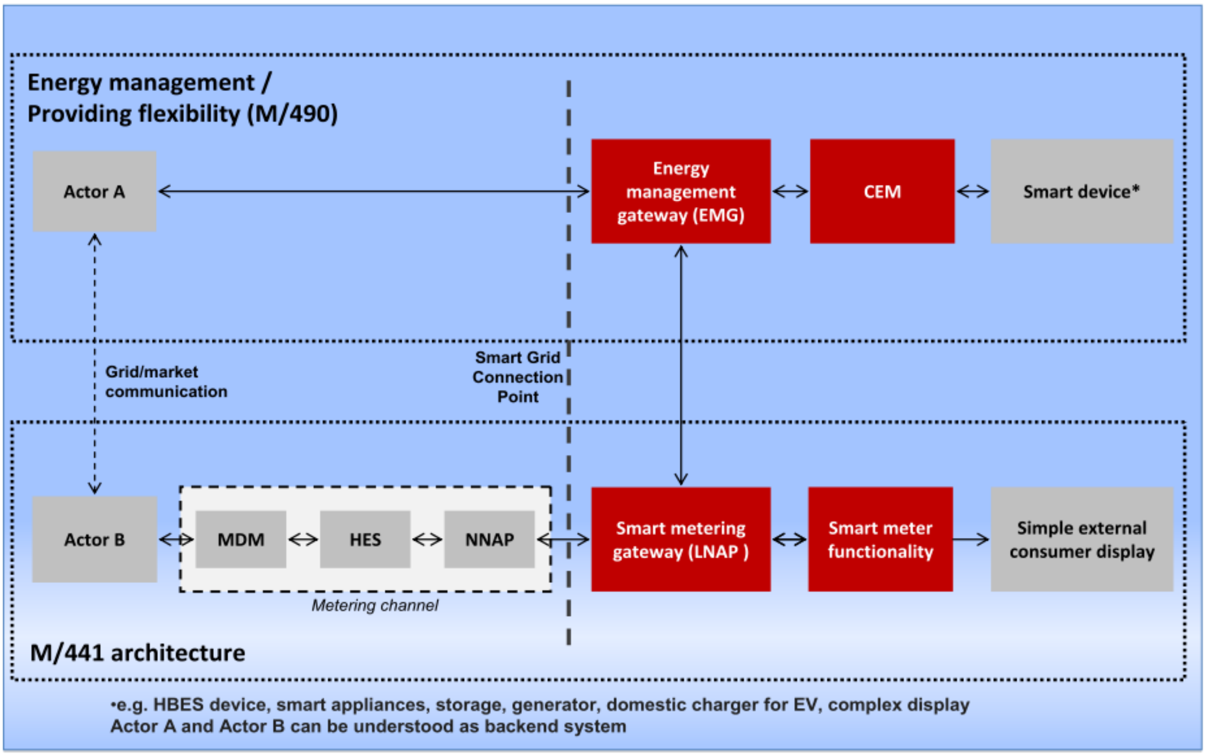


Figure 1-3 Flexibility functional architecture (CEN-CENELEC-ETSI, 2012)

In this architecture, the customer energy manager (CEM) provides the flexibility of connected smart devices, through the energy management gateway (EMG). The EMG communicates with the metering channel and the smart meter functionality through the Smart Metering Gateway. The gateways in this architecture split different networks and may be integrated with other functional entities. As the actors of this architecture are functional/ logical entities, some of them may be part of the same physical device.

Standardisation aspects concerning smart meter interface are currently handled by IEC/TC 13 “Equipment for electrical energy measurement and load control”, CEN/TC 294 “Communication systems for meters and remote reading of meters” CLC/TC 205 “Home and Building Electronic Systems (HBES)” and IEC/TC 57 “Power systems management and associated information exchange”. The most relevant standards developed in this field are IEC 62056 series covering the exchange of consumption information registered in the electricity meter and the transfer of demand response related data (e.g. tariff information, power limitation, prepayment settings). EN 13757 series are the corresponding standards with focus on non-electricity meters (e.g. gas, water and heat). IEC 62056-7-5 standard covers the unidirectional data transfer from a meter to an external device (e.g. consumer display). prEN 50491-11 concerns Smart Metering - Application Specifications in view of simple external consumer display, prEN 50491-12 Smart grid - Application specification concerning interface and framework for customer.

Standardisation activities related to smart appliances and smart home interoperability are handled by IEC/TC 57 WG 21 “Interfaces and protocol profiles relevant for systems connected to the electrical Grid”, IEC/TC 59 WG 15 “Connection of household appliances to smart grids and appliances interaction” and CLC/TC 59x WG 7 “Smart household appliances”. Data definitions for demand response and functionalities (Use Cases) are provided in IEC TR 62746. In IEC TR 62476-2, use cases and requirements for Smart Grid/ Smart Home are listed covering for example the provision of energy consumption information, controlling smart appliances, charging of electric vehicles, battery management and consumer offering flexibility. The focus of IEC/TS 62950 “Household and similar electrical appliances - Specifying and testing smart capabilities of smart appliances – General aspects” is on the development of a common architecture that applies to different appliance types and use cases. Moreover, general aspects of measuring smart performance within the context of the common architecture are addressed. prEn 50631 “Home network and smart grid connectivity” deals with the improvement of functionalities of domestic appliances through the use of network communication (e.g. smart grid, smart home or home network).

1.2.3. European and national ecolabels – focus on energy and other performance criteria

<u>Note</u>: This section only presents energy and other performance criteria of European national ecolabels existing for washing machines and washer-dryers. Resource related criteria are presented separately in section 1.3.2.

In the preparatory study for Ecodesign requirements Lot 14 on domestic dishwashers and washing machines, Task 1 on definitions (ENEA/ISIS 2007b), the following European policy instruments and measures were described:

- Two Voluntary Industry Commitments on Reducing Energy Consumption of Domestic Washing Machines (2000 to 2001 and 2002 to 2008), and
- EU Ecolabel for washing machines.

The Voluntary Industry Commitment was not renewed. The EU Ecolabel for washing machines expired in 2007 and no new criteria have been established, although AEA published a ‘Discussion Report: EU Ecolabel for Washing Machines’ in September 2009 (AEA 2009).

Further, few additional national ecolabelling schemes were described: in Lot 14:

- The Nordic Swan for washing machines (see Section 1.2.3.1),
- the Czech Environmentally Friendly Products label for washing machines (not valid any more), and
- the National Programme of Environmental Assessment and Ecolabelling in the Slovak Republik (NPEHOV) for washing machines (not valid any more).

In addition to them, the Blue Angel Environmental Label for Household Washing Machines (RAL-UZ 137) is currently available on the German market (see Section 1.2.3.2).

The Swedish “Environmental Product Declaration (EPD) scheme for washing machines and dishwashers for household use”, described in Lot 14, has been valid until September 2004 (cf. http://epdsystem.it/en/PCR/Detail/?Pcr=5656). On 12 March 2015, however, the EPD secretariat has launched a call for product category rules (PCR) moderators in order to update these expired product category rules (cf. http://www.environdec.com/en/News-archive/).

The “UK Energy Saving Trust Recommended” logo described in Lot 14 was a UK-based labelling and certification scheme for energy efficient products. The scheme was run by the Energy Saving Trust and was launched in 2000. The logo was registered with the UK Patent Office and could be used by manufacturers, retailers and suppliers to signpost consumers to best-in-class energy efficient products. Today, the Energy Saving Trust no longer awards a "Recommended" certification. Its product certifications now include "Energy Saving Trust Endorsed" (brandmark shows products on the market which have met industry agreed standards for energy performance), "Energy Saving Trust Listed" (independent listing of energy efficient products; however only covering insulation products), and "Verified by Energy Saving Trust" (manufacturers can enhance the credibility of their claims concerning the energy efficiency of their products with a product verification service) (Energy Saving Trust n.d.). For washing machines, 25 models of two manufacturers are currently listed as “verified”; no washer-dryers are listed.

Last but not least, the Topten web portal for best products of Europe is also an important activity run at European level to guide consumers towards the purchase of the most energy efficient appliances and cars (see Section 1.2.3.3).

1.2.3.1. Nordic countries: Nordic Ecolabelling of white goods

In September 2014, version 5.0 of the Nordic Ecolabelling requirements for white goods (refrigerators and freezers, dishwashers, washing machines and tumble dryers) has been published, valid from 20 June 2013 to 30 June 2017. Gas-powered appliances and washer-dryers are not in the scope of this criteria document. (Nordic Ecolabelling 2014)

Criteria are referring to the manufacture and to the operation of the white goods; further, there are specific product requirements for each of the product categories, and finally, there are criteria on customer information as well as quality and regulatory requirements. The following energy efficiency and performance criteria apply to washing machines:

Table 1.6: Nordic Ecolabelling criteria for washing machines; source: (Nordic Ecolabelling 2014)

Criteria category	Requirements
Operation requirements for washing machines	
Energy efficiency	Washing machines must achieve energy efficiency class A+++ or better in accordance with the applicable Energy Labelling Regulation.
Noise	Maximum limit for airbourne noise of washing machines (wash programme, cotton 60 °C, to EN 60456): • 56 dB(A) during wash programme • 76 dB(A) during spin
Specific product requirements for washing machines	
Water consumption	The washing machine must meet the requirement for maximum permitted water consumption on the standard programme as outlined in Ecodesign Regulation (EU) No 1015/2010.
Spinning performance	• Machines with a capacity of over 3.5 kg must achieve a remaining moisture content of less than 54% (According to EN 60456 standard, the final humidity is determined by comparing the amount of water retained in the load with the conditioned weight of the load) • Machines with a capacity of 3.5 kg or less must achieve remaining moisture content of less than 60%
Washing performance	The machine must, on the standard programme, have a wash efficiency index ≥ 1.03 in line with Ecodesign Regulation (EU) No 1015/2010
Rinsing performance, alkali method	The machine must pass a rinsing performance test using the alkali method with an index 1.5 or lower. The requirement can be fulfilled based on the standard programme, a separate programme or with the help of an option function for the standard programme. If the rinsing performance is fulfilled based on the standard programme, separate programme or with the help of an option function for the standard programme, the washing machine energy consumption should not exceed 0.19 kWh/kg.
Requirements on customer information for washing machines	
Installation and user instructions for washing machines	Inter alia • Information on the washing machine's consumption of energy and water at different temperatures and with different load sizes, so that the consumer can select the appropriate programme for minimum energy and water consumption. • Energy consumption of switched off, timer set and programme finished; Instructions that the washing machine should be turned off once the programme has finished to avoid any energy losses. • Information on how long the different programmes take.

1.2.3.2. Germany: Blue Angel Environmental Label for Household Washing Machines (RAL-UZ 137)

Basic criteria for the award of the German environmental label "Blue Angel" for household washing machines have been published in January 2013, being valid until December 2015.

The Blue Angel eco-label for washing machines (RAL-UZ 137) is to distinguish appliances that apart from featuring low power consumption also offer minimal low water consumption at different washing temperatures. In addition, the laundry must even be washable at a temperature of only 20 degrees. This saves energy and – by using the proper washing agents – delivers equally good wash results. Thus, Blue Angel-labelled washing machines can help consumers to tangibly reduce the running costs for electricity, water and wastewater.

In January 2013, basic criteria for award of the German environmental label "Blue Angel" have been published for household washing machines, expiring end of December 2015.

According to (Ral gGmbH 2013b), the Blue Angel eco-label for washing machines may be awarded to appliances with the following environmental properties: low water consumption, low energy consumption at different wash temperatures, reduced water and energy consumption at half load, low-temperature wash cycles (e.g. 20°C wash cycle), low noise emissions, longevity and serviceability, avoidance of pollutants, and consumer information on environmentally friendly and economical washing.

Besides consumption criteria (energy and water), the Blue Angel Ecolabel further sets performance criteria on spin drying efficiency and noise emissions. Further, there are requirements on materials (prohibition of certain hazardous substances and biocidal silver, requirements for insulation materials), and finally criteria facilitating repairs (spare parts) and recycling, which are detailed in section 1.3.2.2.

The detailed energy efficiency and performance criteria are as follows (Ral gGmbH 2013b):

Energy Efficiency and Spin-Drying Efficiency

- The appliances shall be rated at least A+++ for their energy efficiency (equal to energy efficiency index (EEI) < 46) in accordance with Regulation (EU) 1061/2010 relating to household washing machines.
- The appliances shall be rated at least Class A for their spin-drying efficiency (spin-drying efficiency class) and come with a maximum spin speed of at least 1400 rpm.

Power Consumption in „End-of-cycle", „Delay Start" and "Off" Mode

- In "End of Cycle" mode (from this time on, the door can be opened) the power consumption of the appliance shall not exceed 0.5 watts. If the device comes with a display the power consumption in "End of Cycle" mode (End of cycle in „Left On" mode is defined as the period between the pumping out of the water and the opening of the door) shall not exceed 1.00 watt.
- In "Delay Start" mode, the power consumption of the appliance shall not exceed 4 watts.
- In "Off" mode, the power consumption shall not exceed 0.3 watts.

Water Consumption of the Appliances

The appliance shall not exceed the annual water consumption limits listed in the following table. The calculation of the average load shall be based on a mixed calculation of full load at 60°C, partial load at 60°C and partial load at 40°C at a ratio of 3:2:2. For washing machines with a load capacity ≥ 5 kg to 7 kg the calculation shall be based on a maximum water consumption of 12 litres per kg of laundry, for washing machines with a load capacity ≥ 7 kg the calculation shall be based on a maximum water consumption of 10 litres per kg of laundry.

Table 1.7: Maximum allowable water quantities (in litres) of washing machines per year according to Blue Angel requirements; source (Ral gGmbH 2013b)

Rated capacity (target load) [kg]	Average load/cycle [kg]	Annual laundry amount for 220 cycles/year [kg]	Maximum allowable water consumption per year [litres]
5	3.5	785.7	9,429
6	4.3	942.9	11,315
7	5.0	1,100.0	11,00
8	5,7	1,257.2	12,572
9	6.4	1,414.3	14,143
10	7.1	1,571.5	15,715
11	7.9	1,728.6	17,286

The calculation shall be made using the following formula (based on German EcoTopTen criteria 2011):

- Machines with a rated capacity c < 7kg:

(c x 42.86 % + ((c x 57.14 %)/2)) x 220x12) = maximum allowable annual water consumption [litres]

- Machines with a rated capacity ≥ 7kg:

(c x 42.86 % + ((c x 57.14 %)/2)) x 220x10) = maximum allowable annual water consumption [litres]

AquaStop

The appliance shall come with an aquastop system for the inlet water hose and a "drip tray". These are design / safety systems for preventing water leakage and collecting water in case of leakage, respectively. The applicant shall provide warranty on the proper functioning of the system for the entire life of the washing machine, if properly installed. The product manual shall include the corresponding warranty information.

Noise Emissions

The evaluation of the noise emissions shall be based on the sound power levels in dB(A) rounded up to the integer L_{Cn}. The washing machines shall not exceed the following sound power levels L_C in the following operation modes:

- operating mode: „washing": L_{C1} ≤ 50 dB(A)
- operating mode: „spin-drying": L_{C2} ≤ 72 dB(A)

The product manual shall list both the operating modes and the sound power levels.

Requirements for Low-Temperature Wash Cycles

The washing machine shall feature a low-temperature wash option (20°C). The product manual shall include information on its use.

Auto Half Load

The appliance shall come with an "auto half load" feature to automatically reduce water and energy consumption when the washing machine is not fully loaded. This function shall reduce the water consumption irrespective of the temperature by at least 15% on appliances with a rated capacity <7kg and by at least 20% on appliances with a rated capacity ≥7kg. Electric power consumption shall be reduced at half load irrespective of the rated capacity by at least 20% on the 60°C cycle and by at least 15% on the 40°C cycle.

Delay Start/ Interconnectivity

The appliance shall feature a delay start option (delay timer) that allows the user to delay the start of the wash cycle for at least 8 hours. From January 1, 2015, the appliances shall additionally be equipped with an interface enabling communication and control (interconnectivity) via the grid.

Consumer Information with regard to energy efficiency and performance

The energy, water and detergent consumption of washing machines greatly depends on the user behaviour (above all, by the user's way of loading and cleaning program selection). The operating instructions/product manual as well as manufacturer's website shall at least include the following basic user information/instructions:

- Instructions for proper loading of the drum,
- Instructions for sorting the laundry according to type of fabric and colour,
- Information on the use of low-temperature cycles (e.g. 20°C wash cycle),
- Information on water and energy consumption as well as on the length of all wash cycles (in minutes),
- A note that energy and water consumption won't be reduced by 50 percent when the drum is filled to half its capacity. The actual power and water saving potentials shall be expressed in percent.
- Information on the offers for the use of time-variable power supply.
- Explanation of the EU Energy Labelling,
- Reference to the website „Forum Waschen" providing information on proper washing: http://www.forum-waschen.de/waeschewaschen.html

1.2.3.3. EU and several Member States: Topten web portal for best products of Europe

Topten (www.topten.eu) is a web portal guiding consumers to the most energy efficient appliances and cars in Europe. By December 2014 funded by EU's programme Intelligent Energy Europe (IEE) in the programme area "SAVE, Market transformation for energy-efficient products", from 2015 it will now be funded for three more years under the Horizon 2020 programme by the Executive Agency for Small and Medium-Sized Enterprises (EASME).

Altogether 19 national Topten websites present up-to-date, consumer-oriented information on the most energy-efficient models in a number of product groups, inter alia domestic appliances, cooling and lighting equipment, consumer electronics, and vehicles. Also washing machines and partly washer-dryers are listed. The selection of the most energy-efficient models is based on specific selection criteria for each of the product categories. The information is built on independent market surveys selecting the best available technologies (BATs) amongst the product categories. Participating Member States with national Topten websites are: Austria, Belgium, Croatia, Czech Republic, Finland, France, Germany, Greece, Italy, Lithuania, Luxemburg, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and the UK.

The national Topten web portals including the national product lists and country-specific selection criteria can be retrieved via www.topten.eu.

Topten Washing machines

Topten.eu presents three categories of the most energy efficient household washing machines of Europe:

- Washing machines with a capacity < 8 kg
- Washing machines with a capacity of 8 kg

- Washing machines with a capacity > 8 kg

In order to qualify for topten.eu, washing machines must meet the following technical criteria:

- Energy efficiency class: A+++ according to the EU Energy Label
- Spin-drying efficiency class: A according to the EU Energy Label
- Water consumption: according to the ecodesign requirements for washing machines Commission Delegated Regulation (EU) No 1061/2010 (≤ 5 x c1/2 + 35):

Capacity (c)	Annual water consumption
6 kg	≤ 11'000 litres
7 kg	≤ 11'550 litres
8 kg	≤ 12'100 litres
9 kg	≤ 12'650 litres
10 kg	≤ 13'200 litres
11 kg	≤ 13'750 litres

In addition, suppliers have to provide Topten with the following data:

- Energy Efficiency Index (EEI)
- Energy consumption per cycle in kWh for the 60°C programme at full load, the 60°C programme at half load and the 40°C programme at half load
- Programme time for the 60°C programme at full load, the 60°C programme at half load and the 40°C programme at half load
- Power in left-on-mode and off-mode
- Availability of a 20°C programme (cotton)
- Maximum spin speed
- Availability of a water protection system (Aqua Stop, waterproof, water control system etc.)

TopTen Washer-dryers

Topten.eu presents washer-dryers (combined washing machine and tumble dryer in one appliance) with integrated heat pump. These are the most energy efficient washer-dryers and have moderate water consumption.

In order to qualify for topten.eu, washer-dryers must meet the following criteria (data sources: suppliers' declarations):

- Energy efficiency: max. 0.5 kWh per kg laundry (full wash & dry cycle / washing capacity)
- Water consumption: max. 12 litres per kg laundry (full wash & dry cycle / washing capacity)

The products are ordered according to their Energy Efficiency (kWh/kg full cycle).

1.2.4. International legislation and standards

1.2.4.1. International: IEC 60456 standard for washing machines

Key technical elements

The sub-committee SC59D "Performance of household and similar electrical laundry appliances" of IEC is in charge for preparing global standards for measuring performance on laundry appliances. The major standard describing the measurement of primary performance measures is IEC 60456 'Clothes washing machines for household use – Methods for measuring the performance'. The 5th ed. published in 2010 has considerable changes compared to the 4th edition from 2003.

This edition includes the following significant technical changes from the previous edition:

- Modified test load mass requirement for cases where rated capacity of test machine is not declared. Test load mass determination in case rated capacity is not declared was changed, to remove ambiguity and to encourage declaration.
- Introduction of soft water option.
- Expanded stain/soil set (for assessment of washing performance).
- Improved method of loading and folding test load items to better suit vertical axis, horizontal axis and twin tub systems.
- Revised and amended reference machine specification reflecting full qualification of new Electrolux Wascator CLS.
- New reference programmes for lower temperatures and vertical axis systems. New informative annex comparing reference programmes to typical household programmes.
- Refined rinsing efficiency method.
- Introduction of low power modes "Off" and "Left On" (for assessment of energy consumption).
- New annex about uncertainty of measurements.

Additional work was invested to define an alternative rinsing performance measurement which should have a better reproducibility than the present alkalinity method. Work is also under way to define a load calibration procedure which may eliminate, to some extent, the change of the properties of cotton load items during each washing process in which the load is used in testing of a washing machine.

Mechanical action – gentleness of action

Mechanical action is a main parameter in a washing process. This parameter improves, on the positive side, the washing performance, but can cause, on the other side, damage to the textiles. Mechanical action has not been determined as a single parameter in washing processes in today's IEC 60456 measurement standard.

Mechanical action has a high relevance for consumers and manufacturers of washing machines and, therefore, a comparison of this parameter (especially in relation to the washing performance achieved as measured in IEC 60456) in different washing machines is very important.

"Gentleness of action" defines the mechanical action influence of washing machine parameters on irreversible changes of the textile properties. These changes can be visible or invisible.

Examples of these irreversible changes are:

- Loss of tensile tear strengths,
- Surface friction (abrasion, pilling),

- Dimensional changes (shrinkage or elongation),
- Creasing, or
- “Structural disorientation”.

Due to the fact that washing programmes cover a wide range of mechanical action (gentle cycles to heavy-duty cotton programmes, single cycles to multiple cycles), three methods for different ranges of mechanical action are described to measure and quantify the influences of the machine parameters by measuring one or several of these irreversible changes:

- Thread Removal Method (TRM – preferable for low to medium mechanical action),
- Dot Removal Method (DRM – preferable for high mechanical action) and
- Fraying Method (FM – preferable for medium to high mechanical action).

All three methods are described in document IEC/PAS 62473:2007 “Clothes washing machines for household use - Methods for measuring the mechanical action in household washing machines.” Meanwhile, this document has expired, as, in the IEC, any PAS document may exist only for a maximum of six years. Nevertheless, it was decided by the IEC 59D committee to include parts of it in the 6th ed. of the IEC 60456 measurement standard.

There is not much experience and no information on measurement uncertainty regarding “gentleness of action”. Nevertheless, it is a complementary measure to the washing performance, as a very long washing time, which is positive to get a better washing performance, may cause increased damage to the textiles.

Hygiene assessment

IEC59D decided to limit its standardisation activities for washing machines to the measurement of the microbial contamination reduction on textiles. SC 59D decided to develop a globally acceptable Publicly Available Specification (PAS) to respond to the increase in consumer complaints regarding odour from washed laundry caused by the presence of microorganisms. This IEC/PAS 62958 Ed.1: “Clothes washing machines for household use – Method for measuring the microbial contamination reduction” was published in 2015.

There is not much experience and no information on measurement uncertainty on the use of PAS 62958. Nevertheless, this measure may be seen as a complementary measure to the washing performance.

Additional standardisation work - uncertainty reporting

In order to encourage the efficient use of energy and other resources, national governments and regional authorities have issued regulations which mandate the provision of information to consumers regarding the energy and water consumption of household appliances and associated performance characteristics. This information is usually conveyed by labels attached to appliances at the point of sale and also by brochures provided by manufacturers.

Methods for measuring declared values for energy and water consumption and performance characteristics must be of sufficient accuracy to provide confidence to governments, consumers and manufacturers. The accuracy of a test method is expressed in terms of bias and precision. Precision, when evaluating test methods, is expressed in terms of two measurement concepts: repeatability and reproducibility. Therefore, standard procedures are required to determine the repeatability and the reproducibility of test methods developed by the Technical Committee 59 and its subcommittees. Repeatability and reproducibility of a test method must be sufficiently accurate for the determination of values which are declared and for verifying and comparing these values.
Uncertainty reporting is essential to ensure measured data are interpreted in a correct way. It is necessary to know the uncertainty with which data can be measured especially when data of measurements are to be

compared between laboratories or when normative requirements are set up. Details of this are described in IEC TR 62617 "Home laundry appliances – uncertainty reporting of measurements".

IEC TR 62617 publishes expanded uncertainty of measured values of IEC 60456 4th Edition for horizontal drum washing machines (see Table 1). Values for IEC 60456 5th Edition have not yet been published. No round-robin test for EN 60456:2011 was carried out. The values may not be the same as the testing procedure is somehow different from the procedure defined in IEC 60456.

Table 1.8 Expanded uncertainty of measured values of IEC 60456 4th Edition for horizontal drum washing machines (from IEC TR 62617)

	Relative **expanded uncertainty** of measured value (k = 2)
Wash performance ratio q	4%
Total energy W_{total} (in kWh)	10%
Total water V_{total} (in l)	5%
Remaining moisture RM (in %)	5%
Programme time (in min)[5]	6%

Future work of IEC 59D

In preparation for the 6th edition of IEC 60456, the Technical Sub-Committee IEC SC59D is actually working on many additional issues which may improve the measurement standard, e.g. in terms of consumer relevance (change of cotton load to mixed polyester-cotton load, liquid detergent), coverage and ease of testing. Usually any new IEC standard will be taken over in Europe as a new EN standard. So these modifications may be relevant for Europe as well. However, no new version of IEC60456 is expected to come before 2020.

1.2.4.2. International: IEC 62512 standard for washer-dryers

The first edition of IEC 62512 'Electric clothes washer-dryers for household use - Methods for measuring the performance' has been prepared by the International Electrotechnical Commission (IEC) subcommittee 59D: Home laundry appliances, of IEC Technical Committee 59: Performance of household electrical appliances.

Based on the fourth edition (2012) of IEC 61121 for measuring the performance of tumble dryers and the fifth edition (2010) of IEC 60456 for measuring the performance of clothes washers, this standard specifies the conditions needed to test the combined function of washing and drying in a washer-dryer. This International Standard therefore specifies only the test methods for testing of household combined washer-dryers in their function to wash and dry textiles. **This international standard does not apply for testing individual washing or drying functions.**

The object is to state and define the principal performance characteristics of household electric washer-dryers of interest to users and to describe standard methods for measuring these characteristics.

A note clarifies that washer-dryers for communal use in blocks of flats or in launderettes are also included within the scope of this standard. However, it does not apply to washer-dryers for commercial laundries.

The main elements of this standard are:

- The definition of the loads to be tested in continuous and interrupted operation cycles;
- The method for testing automatic and not automatic operation of the drying cycles;
- The way to handle the load for interrupted operation cycles;

- The correction to be applied to test results for continuous and interrupted operation cycles.

For the purposes of this standard, the terms and definitions given in IEC 60456, as well as the following apply:

- Rated washing capacity: maximum mass of conditioned textiles, in kg, which the manufacturer declares can be treated in one complete washing cycle
- Rated drying capacity: maximum mass of conditioned textiles, in kg, which the manufacturer declares can be treated in one complete drying cycle
- Rated washing-drying capacity: maximum mass of conditioned textiles, in kg, which the manufacturer declares can be treated in one continuous operation cycle
- Complete operation cycle: washing and drying process, consisting of a washing and a drying cycle
- Continuous operation cycle: complete operation cycle without interruption of the process or additional action by an operator
- Interrupted operation cycle: complete operation cycle where operators action is required to continue the process
- Washing cycle: complete washing process, as defined by the required programme, consisting of a series of different operations (wash, rinse, spin, ...)
- Drying cycle: complete drying process, as defined by the required programme, consisting of a series of different operations (heat, cool down, ...) and comprising drying of the partial load with the rated drying capacity
- Automatic drying: drying process which automatically switches off when a certain moisture content of the load is reached
- End of programme: the programme is complete when the machine indicates the end of the programme and the load is accessible to the user. Where there is no end of programme indicator and the door is locked during operation, the programme is complete when the load is accessible for the user. Where there is no end of programme indicator and the door is not locked during operation, the programme is complete when the power consumption of the appliance drops to some steady condition and is not performing any function.

IEC 62512 defines in detail the procedure how an interrupted and a continuous operation cycle of a washer-dryer has to be tested.

If the test shall be done at the rated washing capacity, this amount of test load is washed and dried. If the rated drying capacity of the machine under test is lower as the rated washing capacity, the base load is split after the washing cycle into a first partial load p whose weight is equal to the weight of the rated drying capacity and a second partial load of the remaining items. This causes an interrupted operation cycle as the test load has to be split between washing and drying operation. Stain test strips have to be removed at the end of the washing process. The items used in the first partial load have to be identified in advance of a test series in using their conditioned weight forming a test load at the required rated drying capacity.

If test shall be done at the rated washing-drying capacity a test load according to IEC 60456 shall be used and washed and dried in a continuous operation cycle. Stain test strips are removed at the end of the drying process.

For washer-dryers with automatic drying (continuous and interrupted) the programme shall be selected which gives the target final moisture content value. For washer-dryers without automatic drying (continuous and interrupted) the timer shall be set to obtain the target final moisture content value given above. The time required for this shall be determined by monitoring the drying process. This can be done by pre-testing.

If at the end of programme the final moisture content is not below the upper limit of the range of allowable moisture contents a time depending programme may be added with the shortest possible time, but not less than 20 minutes. The additional use of time controlled programmes shall be reported.

The time this programme takes (including cool-down of this programme) and all energy and water used during this time are added to the consumption values. In the IEC standard any programme can be tested.

1.2.4.3. United States

Washer Energy regulations & standby power - History and summary

In December 2007, the Congress enacted EISA, setting the first minimum water efficiency requirements for clothes washers. Minimum energy efficiency requirements, however, were left unchanged from the existing levels set by DOE in 2001, which became effective in January 2007. The 2007 standards which went into effect on January 1, 2011, required residential clothes washers to be manufactured with a **modified energy factor (MEF)** of at least 1.26 and a maximum **water factor (WF)** of 9.5 or less.

- MEF is expressed in cubic feet of washer capacity per kWh per cycle and incorporates the machine electrical energy consumption, the hot water energy consumption, and the energy required to remove the remaining moisture in the clothes.
- WF is expressed in gallons per cubic feet of capacity. A higher MEF indicates better energy efficiency while a lower WF indicates better water efficiency.

In May 2012, DOE adopted new clothes washer standards based on a 2010 agreement between manufacturers and efficiency proponents. DOE uses new metrics called **IMEF (integrated modified energy factor)** and **IWF (integrated water factor)** which add standby and off-mode energy consumption into the formula. The IMEF/IWF standard levels in the 2012 final rule are equivalent to the MEF/WF levels in the negotiated agreement.

<u>Standards for top-loading washers</u> with capacity equal or greater than 1.6 ft^3 (45.3 litres) require:

- a minimum IMEF of 1.29 (corresponding to a MEF of 1.72) and a maximum IWF of 8.4 (corresponding to WF of 8.0) effective since March 2015 and
- a minimum IMEF of 1.57 IMEF (2.0 as MEF) and a maximum IWF of 6.5 (6.0 as WF) effective since January 2018.

Compared to the current standards, the energy and water savings achievable with the 2018 standards are about 33% and 19%, respectively.

<u>Standards for front-loading washers</u> with capacity equal or greater than 1.6 ft^3 (45.3 litres) are effective since March 2015 and require

- a minimum IMEF of 1.84 (2.2 as MEF) and
- a maximum IWF of 4.7 (4.5 as WF).

Compared to the current standards, the energy and water savings achievable with the 2015 standards are about 15% and 35%, respectively.

According to DOE, the standards for top and front loading washers will save about 2 quads of energy, 3 trillion gallons of water and about 113 million metric tons of CO2 emissions over 30 years. DOE estimates total net dollar savings for U.S. consumers over that same period will exceed $31 billion.

Currently, ENERGY STAR-qualified products must meet a minimum MEF of 2.0 and a maximum WF of 6.0.

Front-loaders are generally more efficient than top-loaders, although manufacturers have introduced some new high-efficiency top-loading models that are as efficient as some front-loaders. Until recently, top-loaders were much more common than front-loaders, but front-loaders now make up about half of annual sales in the

US market. Clothes washer efficiency improvements can be achieved through advances in mechanical technology (efficient motors); reductions in the amount of water consumed to clean a given volume of laundry; and higher spin speeds to remove more moisture from the clothes at the end of the cycle (see for instance: www.appliance-standards.org/product/clothes-washers).

US Federal Energy Conservation Standard for residential clothes washers – amended

Clothes washers manufactured and distributed in commerce, as defined by 42 U.S.C. 6291(16), on or after March 7, 2015, and before January 1, 2018, must meet the energy conservation standards shown in the Table 1.9, as specified in the Code of Federal Regulations, 10 CFR 430.32(g)(3).

Table 1.9 Amended Energy Conservation Standards for Residential Clothes Washers as of March 7th, 2015

Product Class	Integrated Modified Energy Factor IMEF (ft^3/kWh/cycle) (Minimum values)	Integrated Water Factor IWF (gal/cycle/ft^3) (Maximum values)
1. Top-loading, Compact (less than 1.6 ft^3 capacity)	0.86	14.4
2. Top-loading, Standard (1.6 ft^3 or greater capacity)	1.29	8.4
3. Front-loading, Compact (less than 1.6 ft^3 capacity)	1.13	8.3
4. Front-loading, Standard (1.6 ft^3 or greater capacity)	1.84	4.7

Clothes washers manufactured and distributed in commerce on or after January 1, 2018 must meet the energy conservation standards shown in the Table 1.10:

Table 1.10 Amended Energy Conservation Standards for Residential Clothes Washers as of January 1^{st}, 2018

Product Class	Integrated Modified Energy Factor IMEF (ft^3/kWh/cycle) (Minimum values)	Integrated Water Factor IWF (gal/cycle/ft^3) (Maximum values)
1. Top-loading, Compact (less than 1.6 ft^3 capacity)	1.15	12.0
2. Top-loading, Standard (1.6 ft^3 or greater capacity)	1.57	6.5
3. Front-loading, Compact (less than 1.6 ft^3 capacity)	1.13	8.3
4. Front-loading, Standard (1.6 ft^3 or greater capacity)	1.84	4.7

New Test Procedure: summary of changes

The test methods for domestic and commercial washing machines in force since March 2012 in USA is described in the Federal Register: 10 CFR Section 430.23(j), Appendix J2 to Subpart B of Part 430—Uniform Test

Method for Measuring the Energy Consumption of Automatic and Semi-Automatic Clothes Washers (US Govenrment Publishing Office). This replaces Appendix J1 from 2005 which was already described in Lot 14 Task 1 in 2007.

Summary of changes of the current test standard compared to the Appendix J1 (see EuP study Lot 14, Task 1):

IMEF & IWF calculations

Include the effects of all power modes and other changes. The metrics now 'integrate' all of these items.

Integrated modified energy factor (IMEF) means the quotient of the cubic foot (or litre) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of:

(a) The machine electrical energy consumption;

(b) The hot water energy consumption;

(c) The energy required for removal of the remaining moisture in the wash load; and

(d) The combined low-power mode energy consumption.

Integrated water factor (IWF) means the quotient of the total weighted per-cycle water consumption for all wash cycles in gallons divided by the cubic foot (or litre) capacity of the clothes washer.

Annual # of cycles revised from 392 to 295

Based on 2005 surveys, 295 cycles/year have been considered to represent consumer use. This is also needed for the annual cost calculation.

Updates to TUFs (Temperature Use Factors) and DUFs (Dryer Use Factors)

Kept all the same TUFs (Temperature Use Factors) but warm/warm will be now treated as a complete wash/rinse cycle and warm/cold will be adjusted when warm/warm is available (US machines do not have temperature setting but just warm or cold water inlets).

Based on 2005 survey data, the DUF (Dryer Use Factor) has been increased from 0.84 to 0.91 to reflect higher use of spin drying.

Eliminate the LAF (Load Adjustment Factor) and replace the representative load size with the weighted average. load size

The LAF was judged to be duplicative and was eliminated. Representative Load Size used in the drying energy equation will be replaced with an average load size that utilizes the LUFs (Load Usage Factors).

Energy Test Cycle definition changes

Extensive changes and discussion on the new definition took place. The new energy test cycle will require testing of the normal cycle similar to J1 but also requires testing of TUFs that are available in other cycles but not in the normal cycle.

Appendix J2 defines: 1.13 Energy test cycle for a basic model means:

(A) The cycle selection recommended by the manufacturer for washing cotton or linen clothes, and includes all wash/rinse temperature selections for each of the temperature use factors (TUFs) offered in that cycle, and

(B) If the cycle selection described in Part (A) does not include all wash/rinse temperature selections for each of the TUFs available on the clothes washer, the energy test cycle shall include, in addition to Part (A), the alternate cycle selection(s) offering these remaining wash/rinse temperature selection(s), tested only at the wash/rinse temperature selection(s) for each TUF not available on the cycle selection described in Part (A).

Where multiple alternate cycle selections offer a wash/rinse temperature selection for which a TUF has been developed, and that is not available on the cycle selection recommended by the manufacturer for washing cotton or linen clothes described in Part (A), the alternate cycle selection certified by the manufacturer to have the highest energy consumption for that TUF, as measured according to section 2.13, shall be included in the energy test cycle, so that each TUF that is available on the clothes washer has been tested once.

(C) All cycle selections included under Part (A) and all cycle selections included under Part (B) shall be tested using each appropriate load size as defined in section 2.8 and Table 5.1 of this appendix.

(D) For any cycle selection tested under (A) or (B), the manufacturer default settings shall be used, except for the temperature selection, if necessary. This includes wash conditions such as agitation/tumble operation, soil level, spin speed(s), wash times, rinse times, and all other wash parameters or optional features applicable to that cycle, including water heating time for water heating clothes washers.

(E) Each wash cycle included as part of the energy test cycle shall include the entire active washing mode and exclude any delay start or cycle finished modes.

(F) The energy test cycle shall not include any cycle, if available, that is dedicated for cleaning, deodorizing, or sanitizing the clothes washer, and is separate from clothes washing cycles.

Table 1.11 New TUF factors (Table 4.1.1 from J2)

TABLE 4.1.1—TEMPERATURE USE FACTORS

Max Wash Temp Available	≤135 °F (57.2 °C)			>135 °F (57.2 °C)	
No. Wash Temp Selections	Single	2 Temps	>2 Temps	3 Temps	>3 Temps
TUF_m (extra hot)	……	……	……	0.14	0.05
TUF_h (hot)	……	0.63	0.14	……	0.09
TUF_{ww} (warm/warm)	……	……	0.27*	0.27*	0.27*
TUF_w (warm)	……	……	0.22/0.49**	0.22/0.49**	0.22/0.49**
TUF_c (cold)	1.00	0.37	0.37	0.37	0.37

* Only applicable to machines offering a warm/warm cycle. For machines with no warm/warm cycle, TUF_{ww} (warm/warm) should be zero.

** For machines offering a warm/warm cycle, TUF_w (warm) should be 0.22. For machines with no warm/warm cycle, TUF_w (warm) should be 0.49.

<u>New Capacity Measurement method</u>

To assure consistency among stakeholders, the measurement methods have either been revised or clarified.

<u>Other changes (i.e. test cloth, detergent spec., extractor 650g force requirement, etc.)</u>

Test Cloth - Clarification of 'lot' and 'roll' definitions, size and weight tolerances and preconditioning requirements. These are detailed in the J2 test procedure.

Detergent - Specifies the use of the detergent formula described in the AHAM (Association of Home Appliance Manufacturers) standard test at a dosage of 27.0g + 4.0 g/lb in J1 & J2

Extractor – J1 specifies tests for extractors up to 500 units of gravitational acceleration (g, or g-force) in order to determine the remaining moisture content (RMC) correlation curve for test cloth lots. To account for washers that can spin faster, a 650 g extraction test has been added to J2.

<u>Annual operating cost calculation (includes low-power modes & # cycles)</u>

Since new power modes are part of the calculations, these costs must be added to the annual cost.

<u>Low-Power mode inclusion (based on IEC 62301 ed. 2.0)</u>

The new test procedure includes energy use in low-power modes in addition to the regular washing mode.

- Active mode: Includes all of the washing functions along with delay start and cycle finished functions.

  "… a mode in which the clothes washer is connected to a mains power source, has been activated, and is performing one or more of the main functions of washing, soaking, tumbling, agitating, rinsing, and/or removing water from the clothing, or is involved in functions necessary for these main functions, such as admitting water into the washer or pumping water out of the washer. Active mode also includes delay start and cycle finished modes…"

- Active washing mode: Includes only the washing functions in a test cycle (i.e. not delay start and cycle finish)

  "… a mode in which the clothes washer is performing any of the operations included in a complete cycle intended for washing a clothing load, including the main functions of washing, soaking, tumbling, agitating, rinsing, and/or removing water from the clothing…"

- Inactive mode: This is one of two 'Low-power' modes and includes the stand-by modes

  "… a standby mode that facilitates the activation of active mode by remote switch (including remote control), internal sensor, or timer, or that provides continuous status display…"

- Off mode: This is one of two 'Low-power' modes and can include power for an indicator

  "… a mode in which the clothes washer is connected to a mains power source and is not providing any active or standby mode function, and where the mode may persist for an indefinite time. An indicator that only shows the user that the product is in the off position is included within the classification of an off mode…"

- Standby mode: Included in the 'Inactive mode' and includes functions that take place outside of the active washing mode

  "… any mode in which the clothes washer is connected to a mains power source and offers one or more of the following user oriented or protective functions that may persist for an indefinite time:

  (a)To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, or timer;

  (b) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

  A timer is a continuous clock function (which may or may not be associated with a display) that provides regular scheduled tasks (e.g., switching) and that operates on a continuous basis…"

  ➢*'Delay Start' falls within this mode because by definition in J2, it "… is facilitated by a timer."*

  ➢*'Cycle Finish' falls within this mode because by definition in J2, it "… provides continuous status display …"*

- Combined low-power mode: This includes all of the low-power modes

  "… the aggregate of available modes other than active washing mode, including inactive mode, off mode, delay start mode, and cycle finished mode."

Energy use is accounted for in 2 distinct areas:

1. Active Power – Basically the same as J1. Accounts for power consumed during the energy cycle and includes all energy used in the Active washing mode.

2. Low Power – Accounts for power consumed in all modes other than the Active Washing mode. Modes included are Standby, Off, Delay Start, Cycle Finish

Low-power energy consumption per cycle is calculated by (section 4.4 in the J2 procedure):

a. measuring and averaging power consumption in each low power mode per IEC 62301
b. multiplying this average power consumption by the annual hours not accounted for by annual use hours (i.e. 8465 hours)

   (8760 hours per year – 295 hours of use per year = 8465 hours)

c. and then divide this total by the annual number of cycles (295 cycles)

Combined Low-Power (ETLP) per cycle = [(Pia x Sia) + (Po x So)] x Kp/295

= Average of (Inactive power + Off power)/annual cycles

Where:

Pia = Washer inactive mode power, in watts, as defined in section 3.9.1 of the Appendix for clothes washers capable of operating in inactive mode; otherwise, Pia = 0.

Po = Washer off mode power, in watts, as defined in section 3.9.2 of the Appendix for clothes washers capable of operating in off mode; otherwise, Po=0.

Sia = Annual hours in inactive mode as defined as Soi if no off mode is possible, [Soi/2] if both inactive mode and off mode are possible, and 0 if no inactive mode is possible.

So = Annual hours in off mode as defined as Soi if no inactive mode is possible, [Soi/2] if both inactive mode and off mode are possible, and 0 if no off mode is possible.

Soi = Combined annual hours for off and inactive mode = 8,465.

Kp = Conversion factor of watt-hours to kilowatt-hours = 0.001.

295 = Representative average number of clothes washer cycles in a year.

US Energy Guide

According to (US EPA [n.d.]), major home appliances such as clothes washers must meet the Appliance Standards Program set by the US Department of Energy (DOE). Manufacturers must use standard test procedures developed by DOE to prove the energy use and efficiency of their products. Test results are printed on a yellow Energy Guide label, which manufacturers are required to display on their appliances according to the Appliance Labeling Rule of the Federal Trade Commission (FTC). This label estimates how much energy the appliance uses, compares energy use of similar products, and lists approximate annual operating costs. Your exact costs will depend on local utility rates and the type and source of your energy. Appliances which are ENERGY STAR qualified (cf. next section) must carry the Energy Guide label.

For clothes washers, the Energy Guide label (transitional label, mandatory beginning March 7, 2015) shall provide the following information (FTC 2012):

- Models for which the Energy Guide label applies
- Capacity class; and capacity (tub volume) in cubic feet
- Estimated Yearly Energy Cost (US Dollar), when used with an electric water heater (the indication of a cost range of similar models, as for example given for dishwashers, is not available for clothes washers).

- Estimated yearly electricity use (kWh).
- Estimated Yearly Energy Cost (US Dollar), when used with a natural gas water heater.
- US Energy Star logo if applicable for the Energy Guide labelled appliance.

The estimated energy cost is based on six wash loads a week and a national average electricity cost of 12 cents per kWh and natural gas cost of $1.09 per therm.

US Energy Star for Residential Clothes Washers

ENERGY STAR is a U.S. Environmental Protection Agency (EPA) voluntary programme to identify and promote energy–efficient products in order to reduce energy consumption through voluntary labelling of or other forms of communication about products that meet the highest energy efficiency standards.

Clothes washers that have earned the ENERGY STAR are about 25% more efficient than non-qualified models and are more efficient than models that simply meet the federal minimum standard for energy efficiency.

Current Specification Effective Date: March 7, 2015

Only front and top loading clothes washers meeting the ENERGY STAR definitions for residential clothes washer and commercial clothes washer, with capacities greater than 1.6ft^3 (45.3 l) are eligible to earn the ENERGY STAR certification. Such definitions correspond with the definitions provided for the DOE standards.

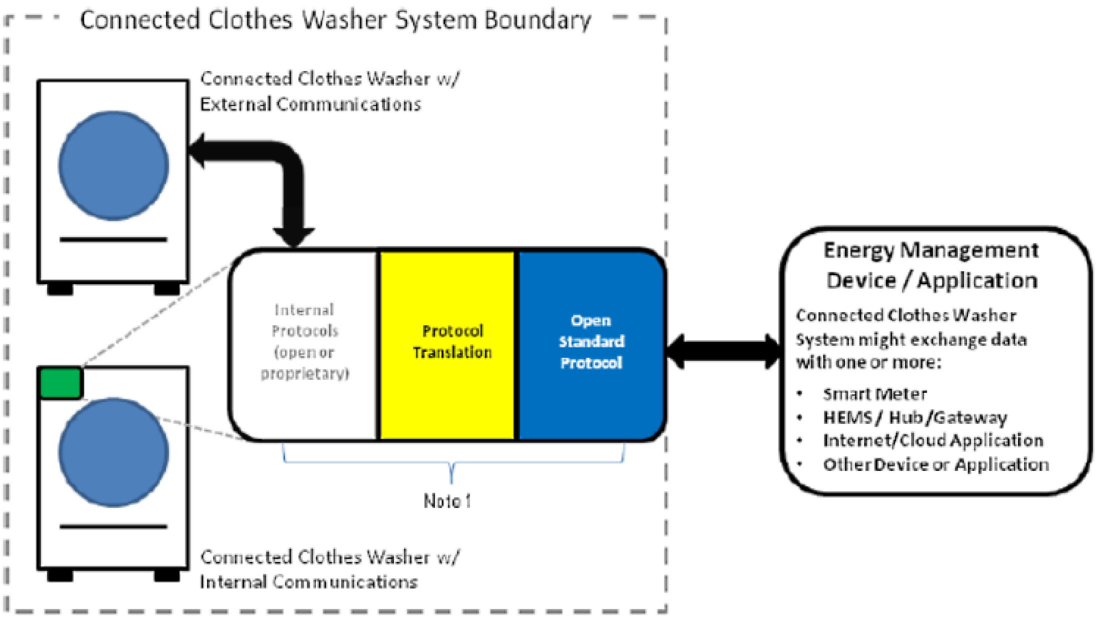
ENERGY STAR allowance for connected appliances

Energy Star has published new eligibility criteria and partner commitments which are effective since March 2015 to qualify a product for the ENERGY STAR label. These include some 5% allowance on the Integrated Modified Energy Factor (IMEF) if the washing machine fulfils some 'connected criteria'. With this allowance it will be easier to qualify for the ENERGY STAR or any of the established tiers of the Consortium for Energy Efficiency (CEE) (cf. Table 1.12 further below).

The following criteria are required for being a 'connected appliance' (extracted from ENERGY STAR® Program Requirements Product Specification for Clothes Washers Eligibility Criteria Version 7.0) (Energystar):

A) Connected Clothes Washer System

To be recognized as connected and to be eligible for the connected allowance, a "connected clothes washer system" (Connected Clothes Washer System, as shown in Figure 1-4) shall include the base appliance plus all elements (hardware, software) required to enable communication in response to consumer-authorized energy related commands.



Note 1: Communication device(s), link(s) and/or processing that enables open standards-based communication between the Connected Clothes Washer System and Energy Management Device/Application(s). These elements could be within the base appliance, and/or an external communication module, a hub/gateway, or in the Internet/cloud.

Figure 1-4 Connected Clothes Washer System Boundary – Illustrative Example

B) Communications

1. Open Standards – Communication with entities outside the Connected Clothes Washer System that enables connected functionality must use, for all communication layers, standards.

2. Communications Hardware Architecture – Communication with entities outside the Connected Clothes Washer System that enables connected functionality shall be enabled by any of the following means, according to the manufacturer's preference:

a. Built-in communication technology

b. Manufacturer-specific external communication module(s) and/or device(s)

c. Open standards-based communication port on the appliance combined with open standards-based communications module

d. Open standards-based communication port(s) on the appliance in addition to a, b or c, above

C) Open Access

To enable interconnection with the product, in addition to section 4B1 that requires open-standards, an interface specification, Application Programming Interface (API) or similar documentation shall be made available to interested parties that at a minimum, allows transmission, reception and interpretation of the following information:

1. Energy Consumption Reporting specified (must include accuracy, units and measurement interval);

2. Operational Status, User Settings & Messages (if transmitted via a communication link);

3. Demand Response

D) Energy Consumption Reporting

In order to enable simple, actionable energy use feedback to consumers and consumer authorized energy use reporting to 3rd parties, the product shall be capable of transmitting energy consumption data via a communication link to energy management systems and other consumer authorized devices, services, or applications. This data shall be representative of the product's interval energy consumption. It is recommended that data be reported in watt-hours for intervals of 15 minutes or less, however, representative data may also be reported in alternate units and intervals.

The product may also provide energy use feedback to the consumer on the product itself. On-product feedback, if provided, may be in units and format chosen by the manufacturer (e.g., $/month).

E) Remote Management

The product shall be capable of receiving and responding to consumer authorized remote requests (not including third-party remote management which may be made available solely at the discretion of the manufacturer), via a communication link, similar to consumer controllable functions on the product. The product is not required to respond to remote requests that would compromise performance and/or product safety as determined by the product manufacturer.

F) Operational Status, User Settings & Messages

1. The product shall be capable of providing the following information to energy management systems and other consumer authorized devices, services or applications via a communication link:

- Operational / Demand Response (DR) status (e.g., off/standby, cycle in process, delay appliance load, temporary appliance load reduction).

2. The product shall be capable of providing the following information on the product and/or to energy management systems and other consumer authorized devices, services or applications via communication link:

- At least two types of messages relevant to the energy consumption of the product. For example, messages for clothes washers might address performance issues or report of energy consumption that is outside the product's normal range.

G) Demand Response

A connected clothes washer shall have the capability to receive, interpret and act upon consumer-authorized signals by automatically adjusting its operation depending on both the signal's contents and settings from consumers. At a minimum, the product shall be capable of providing the following:

1. Delay Appliance Load Capability: The capability of the product to respond to a signal in accordance with consumer settings, except as permitted below, by delaying the start of an operating cycle beyond the delay period.

   a. Default settings –The product shall ship with default settings that enable a response in accordance with 4G1 for at least 4 hours.

   b. Consumer override – The consumer shall be able to override the product's Delay Appliance Load response before or during a delay period.

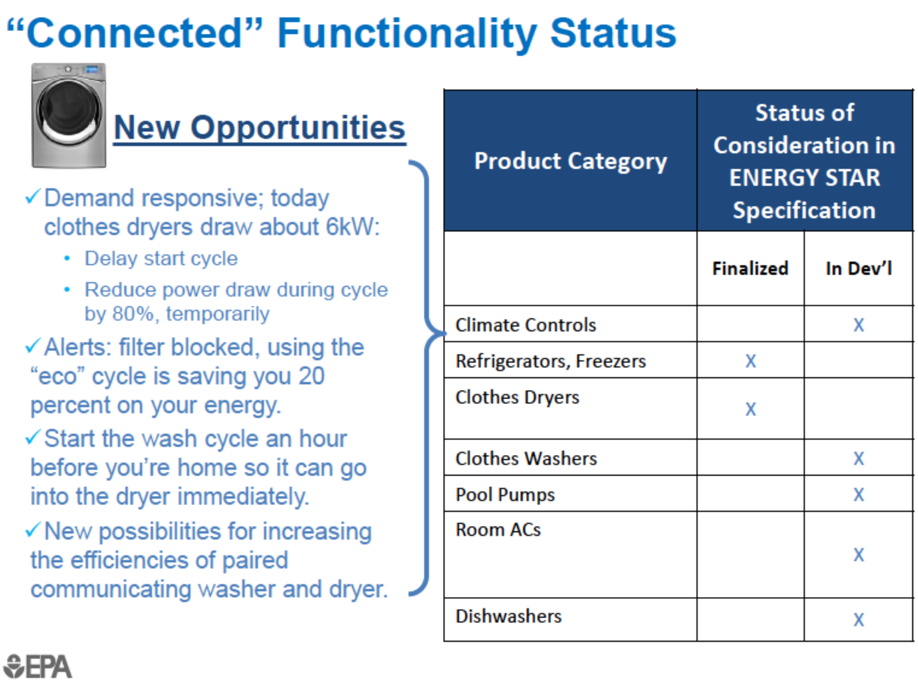
   c. The product shall be able to provide at least one Delay Appliance Load response per consumer initiated operating cycle.

2. Temporary Appliance Load Reduction Capability: TBD

H) Information to Consumers

If additional modules, devices, services and/or infrastructure are part of the configuration required to activate the product's communications capabilities, prominent labels or other forms of consumer notifications with instructions shall be displayed at the point of purchase and in the product literature. These shall provide specific information on what consumers must do to activate these capabilities (e.g. "This product has Wi-Fi capability and requires Internet connectivity and a wireless router to enable interconnection with an Energy Management System, and/or with other external devices, systems or applications.”). Compliance with Connected functionality shall be through examination of product and/or product documentation. In addition, demand response functionality shall be evaluated using the TBD ENERGY STAR Clothes Washers Test Method to Validate Demand Response in order to be eligible for the connected allowance.

This allowance given to the energy consumption or energy efficiency for cloth washers is part of a more general strategy of the U.S. Environmental Protection Agency (EPA) to support the connectivity of seven appliances as the (outdated) chart from EPA shows (cf. Figure 1-5).



Product Category	Status of Consideration in ENERGY STAR Specification	
	Finalized	In Dev’l
Climate Controls		X
Refrigerators, Freezers	X	
Clothes Dryers	X	
Clothes Washers		X
Pool Pumps		X
Room ACs		X
Dishwashers		X

Figure 1-5 **Connected functionality status**

CEE - Consortium for Energy Efficiency

CEE is a consortium primarily of efficiency program administrators from across the United States and Canada. Members leverage individual efforts by working together to accelerate energy efficient products and services in targeted markets

Energy efficiency program administrators from the United States and Canada formed the award-winning Consortium for Energy Efficiency to achieve lasting and verifiable energy efficiency. For over twenty years, CEE has been influencing markets to accelerate uptake of increasingly efficient goods and services. Members still find value in working together in a business environment characterized by increasing emphasis on energy efficiency, higher baseline standards and more ambitious savings goals.

The CEE role is not to develop or implement the programs delivered at the local level, but to influence national players - manufacturers, stakeholders, government agencies - to maximize the impact of efficiency programs. Energy efficiency is the focus of CEE, but they include demand response for higher savings. CEE also supports crosscutting trends in behavioural programs and evaluation. By joining forces at CEE, individual electric and gas efficiency program administrators support strategic initiatives that influence binational markets. They are able to partner not only with each other, but also with industry, trade associations, and government agencies. Working together, administrators can leverage the effect of their ratepayer funding, exchange information on successful practices, and achieve energy efficiency gains.

Members of the Consortium for Energy Efficiency leverage the ENERGY STAR® program

CEE members are investor-owned or municipal utilities, state or provincial energy offices, government agencies, and non-utility programme administrators. What they all have in common is a mission to serve the public by encouraging their customers to use efficient products and practices. Collectively, these members are known as energy efficiency programme administrators. Each state or province whose policies pursue energy efficiency sets goals and measures efforts differently, but all program administrators need to increase the supply and demand for energy efficient products and services. CEE members create a critical mass of market influence. Members administer programs aimed at saving energy, which means they need market uptake of products and services that become increasingly efficient over time.

High efficiency specifications for residential clothes washers

The following requirements are requested since March 2015 (Table 1.12):

Table 1.12 High efficiency specifications for RESIDENTIAL CLOTHES WASHERS

Efficiency Level	Integrated modified energy factor (IMEF)	Integrated water factor (IWF)
Federal Standard Top Load	1.29	8.4
Federal Standard Front Load	1.84	4.7
ENERGY STAR® Top Load	2.06	4.3
ENERGY STAR® Front Load	2.38	3.7
CEE Tier 1	2.38	3.7
CEE Tier 2	2.74	3.2
CEE Tier 3	2.92	3.2

1.2.4.4. Asia

China – Mainland

Minimum Energy Efficiency Standards

According to (CELC - China Energy Label Centre [n.d.]b), the standard GB12021.4-2004, implemented in May 2005, specifies the maximum energy consumption and water consumption per kilogram of laundry, and methods for determining the evaluating values of energy conservation and energy efficiency grades of household electric washing machines. It applies to household electric washing machines with a rated washing capacity of less than 13 kg cotton, hereinafter referred to as "washing machines"; it does not apply to washing machines with a washing capacity of less than 1.0 kg and single container washing machines with no water extraction function. For washer-dryers, only the washing function is assessed.

The following maximum values of energy and water consumption are allowed:

Table 1.13: Maximum values of power and water consumption allowed for household electric washing machines under Chinese Minimum Energy Efficiency Standard GB12021.4-2004; source (CELC - China Energy Label Centre [n.d.]b)

Washing machine type	Maximum allowable value of power consumption per kilogram (kWh/cycle/kg)	Maximum allowable value of water consumption per kilogram (l/cycle/kg)
Impeller-type and fully automatic agitator-type washing machines	0.032	36

Washing machine type	Maximum allowable value of power consumption per kilogram (kWh/cycle/kg)	Maximum allowable value of water consumption per kilogram (l/cycle/kg)
Drum-type washing machines	0.350	20

These maximum allowable values are the mandatory minimum requirements for products to access the market and correspond to tier 5 of the China Energy Label program (cf. next section).

Mandatory Energy Efficiency Label

The China's energy efficiency labelling management system, also known as the China Energy Label, is a mandatory energy efficiency labelling program which is based on China's Energy Conservation Law, Product Quality Law and Regulations on Certification and Accreditation. The 'Catalog of Products to Implement Energy-Efficiency Labelling' and the 'Rules for Implementing Relevant Product Labels' are the rules for execution that standardise the format specifications, testing requirements, filing procedures and verification requirements for labelling of specific products. (CELC - China Energy Label Centre [n.d.]a)

The China Energy Label program was launched in 2005 and covers 27 products (end of 2012). It is based on an energy efficiency classification set in correspondence with the energy efficiency standards. The label shows consumers how close an appliance comes to meet minimum efficiency standards, ranging from 100% (which corresponds to meet the minimum standard) to 55% of the value set with the minimum standard. Such labels now appear on 19 products, including air conditioners, household refrigerators, and clothes washers. (ChinaFAQs, The Network for Climate and Energy Information 2010)

The implementation date of the China Energy Label for washing machines was in 2007. The China Energy Label program has two classification scales – with either 3 or 5 tiers. In both scales the lower the number of the tier, the higher the energy efficiency. Tiers 3 or 5 are the mandatory minimum requirements for products to access the market (cf. section above). Tiers 2 and 1 are generally endorsement requirements for the energy efficient product certification and incentive policies. (Hu B. et al. 2013)

According to (CELC - China Energy Label Centre [n.d.]b), the following values of energy and water consumption as well as wash ability ratio are corresponding to the five tiers of the mandatory energy efficiency label.

Table 1.14: China Energy efficiency label grades for washing machines; source (CELC - China Energy Label Centre [n.d.]b)

Washing machine efficiency tier	Impeller-type washing machines			Drum-type washing machines		
	Energy consumption kWh/cycle/kg	Water consumption l/cycle/kg	Wash ability ratio	Energy consumption kWh/cycle/kg	Water consumption l/cycle/kg	Wash ability ratio
1	≤0.012	≤20	≥0.90	≤0.19	≤12	≥1.03
2	≤0.017	≤24	≥0.80	≤0.23	≤14	≥0.94
3	≤0.022	≤28		≤0.27	≤16	
4	≤0.027	≤32	≥0.70	≤0.31	≤18	≥0.70
5	≤0.032	≤36		≤0.35	≤20	

The market analysis for China energy efficient products (Hu B. et al. 2013) states that for washing machines, tier 1 products reach a share of almost half the market, whereas the share of tiers 4 and 5 products is so low that these products can be ignored when looking at the market.

Table 1.15: Share of different technologies of washing machines covered by the China Energy efficiency label; source: (Hu B. et al. 2013)

	Front-load	Top-Load	All
Tier 1	100%	22.4%	44.5%
Tier 2	0%	70.2%	42.7%
Tier 3	0%	6.4%	10.3%
Tier 4	0%	1%	2.6%
Tier 5	0%	0%	0%

When both front-load and top-load models are considered together, Tier 1 and tier 2 products equally share the market. Having a detailed look into the different technologies, 100% of the front-load models are tier 1 products, and there are no front-load washing machines available on the market for the other tiers. On the other hand, only 22 % of the top-load models are tier 1. Tier 2 takes the largest share of the top-load technology. (Hu B. et al. 2013)

According to (Hu B. et al. 2013), different testing conditions are applied for front-load and top-load models. Top-load washing machines have cold water inlet at a temperature of 30±2 °C and tested with cold water as inlet. Front-load washing machines have cold water inlet at a temperature of 15±2 °C and are tested with warm water heated by the washing machine at a temperature around 50±2 °C. The front-load washing machine has lower energy efficiency requirements for the same tier than the top-load washing machine due to the different testing conditions. The share of the top-load washing machine is much higher than the front-load ones.

Voluntary Energy Conservation Label

Besides the mandatory minimum energy efficiency standards and the Energy Efficiency Label, China has a voluntary energy efficiency endorsement labelling programme highlighting the 'best in class' products similar to the U.S. Energy Star programme. The following values of energy and water consumption as well as wash ability ratio are maximal allowable for the Voluntary Energy Efficiency endorsement label which corresponds to Tier 2 of the mandatory energy efficiency label:

Table 1.16: China Evaluating indices of energy conservation for washing machines; source: (CELC - China Energy Label Centre [n.d.]b)

	Energy consumption (kWh/cycle/kg)	Water consumption (l/cycle/kg)	Wash ability ratio*
Impeller-type and fully automatic agitator-type washing machines	≤0.017	≤24	≥0.80
Drum-type washing machines	≤0.23	≤14	≥0.94

* Rate of washing ability: The indicator shows the quality of the washing machine's washing service. The higher the rate is the better.

China Environmental Labelling

The China Environmental Labelling programme was initiated in 1993. The China Environmental Labelling is a type I eco-labelling scheme organised by MEP (Ministry of Environmental Protection of the People's Republic of China). The Environmental Certification Centre (CEC), which is the organization authorized by MEP, develops a set of technical criteria documents and carries out China Environmental Labelling certification, supervised and managed by China Certification Committee for Environmental Labelling Products (CCEL). Certification standards for 95 categories of products have been set by now, including automotive, electronics, building materials etc.

For household electric washing machines, the Technical Requirement for Environmental Labelling Products HJ/T 308-2006 is effective as of January 2007. (Chinese Government 2006)

The aims of these requirements are to improve the energy efficiency, foster low-noise machines and guarantee the indoor air quality. The scope covers washing machines, which have a rated washing capacity not exceeding 13 kilograms (including spin dryer). The scope shall NOT apply to washing machines with nominal wash capacity equal to or less than1 kilogram and without spin drying. For energy consumption, water consumption and the wash ability ratio, the same criteria as for the Voluntary Energy Conservation Label as reported in Table 1.16 apply for washing machines under the Chinese Environmental Labelling.

Table 1.17: The China Environmental Labelling criteria for washing machines with regard to noise emission

Machine type	Impeller-type (including spin dryer)		Drum-type		Agitator- type
	Capacity ≥4kg	Capacity <4kg	Number of turns > 600 r/min	Number of turns ≤600 r/min	-
Noise Level dB(A)	60	55	65	60	60

Further resource related criteria are listed in section 1.3.2.4.

Topten China

Topten China (http://www.top10.cn/english.html) is a member of the TopTen International Group (TIG), a global alliance of organizations dedicated to promote high efficiency products (cf. section 1.2.3.3).

Top10 China is an internet-based platform that provides independent and up-to-date information on the best available energy efficient products currently available on the Chinese market. Top10 provides a neutral, transparent selection and evaluation of products based on impartial testing and analysis. For large household appliances, Top10 China lists energy efficient refrigerators and washing machines; dishwashers are not included.

For washing machines, following product sub-categories are defined:

- Drum machines < 7 kg, 7 kg and > 7 kg
- Impeller machines < 7 kg and ≥ 7 kg

To be selected in the Top10 China product lists, the energy consumption, water consumption of the products must meet the following criteria:

Table 1.18: Top10 China criteria for washing machines

Machine type	Washing Capacity (kg)	Energy Consumption (kWh/cycle/kg)	Water Consumption (L/cycle/kg)	Rate of Washing Ability*
Drum machines	<7kg	≤0.097	≤8.0	≥1.03
	7kg	≤0.097	≤7.6	≥1.03
	> 7kg	≤0.089	≤7.1	≥1.03
Impeller machines	≤7kg	≤0.011	≤16.7	≥0.90
	7kg<WC	≤0.011	≤17.3	≥0.90

* Rate of washing ability: The indicator shows the quality of the washing machine's washing service. The higher the rate, the better.

China – Hong Kong

Hong Kong introduced a Mandatory Energy Efficiency Labelling Scheme (MEELS) through the Energy Efficiency (Labelling of Products) Ordinance enacted on 9 May 2008. Besides that, Hong Kong runs a Voluntary Energy Efficiency Labelling Scheme (VEELS).

The Mandatory Energy Efficiency Labelling Scheme (MEELS)

To further facilitate the public in choosing energy efficient appliances and raise public awareness on energy saving, the Government has introduced the Mandatory Energy Efficiency Labelling Scheme (MEELS) through the Energy Efficiency (Labelling of Products) Ordinance. Under MEELS, Energy Labels are required to be shown on the prescribed products for supply in Hong Kong to inform consumers of their energy efficiency performance. MEELS currently covers five types of prescribed products. Since September 2011, MEELS also has been fully implemented to washing machines. A Code of Practice on Energy Labelling of Products has been approved and issued to provide practical guidance and technical details in respect of the requirements under the Ordinance, cf. (Electrical and Mechanical Services Department (EMSD) 2014).

The scope covers "Washing machines", defined as (a) a household appliance for cleaning and rinsing of textiles using water with or without a means of extracting excess water from the textiles; and (b) includes washing machines that (i) use mains electricity as the primary power source; and (ii) have a rated washing capacity not exceeding 7 kilograms, whether or not they have built-in dryers for drying textiles by means of heating. It excludes washing machines that (a) may also use other energy sources; or (b) have no spin extraction capability.

The energy efficiency grading of a washing machine shall be determined as shown in the following table, with Grade 1 having the best performance and Grade 5 having the worst performance.

Table 1.19: Energy efficiency grades of the Hong Kong Mandatory Energy Efficiency Labelling Scheme (MEELS); source: (Electrical and Mechanical Services Department (EMSD) 2014)

Specific Energy Consumption, E_{sp} (kWh/kg/cycle)		Energy Efficiency Grade
Horizontal Axis Type	Vertical Axis Type	
$E_{sp} \leq 0.130$	$E_{sp} \leq 0.0160$	1
$0.130 < E_{sp} \leq 0.150$	$0.0160 < E_{sp} \leq 0.0184$	2
$0.150 < E_{sp} \leq 0.172$	$0.0184 < E_{sp} \leq 0.0208$	3
$0.172 < E_{sp} \leq 0.195$	$0.0208 < E_{sp} \leq 0.0232$	4
$0.195 < E_{sp}$	$0.0232 < E_{sp}$	5

In order to obtain Grade 1 to 4, the washing machine concerned shall also meet all the washing performance and water extraction performance requirements laid down in the Code of Practice.

The Voluntary Energy Efficiency Labelling Scheme (VEELS)

Hong Kong has also introduced a Voluntary Energy Efficiency Labelling Scheme (VEELS). The scheme now covers twenty two types of household appliances and office equipment, inter alia washing machines. The scheme runs two kinds of Energy Labels: grading-type and recognition-type Energy Label. For household washing machines, the grading-type applies. The revision of the scheme for washing machines has been implemented from 8 July 2013 and Energy Labels will expire on 31 December 2016 when re-registration is necessary.

The Hong Kong Voluntary Energy Efficiency Labelling Scheme for washing machines (Electrical and Mechanical Services Department (EMSD) 2013) applies to top-loading agitator/impeller-type and top-loading/front-loading drum-type clothes washing machines.

The energy efficiency index of an appliance is defined as the ratio of the actual specific energy consumption of the appliance to the average specific energy consumption. The indices are expressed in percentages. Thus, by comparing the energy efficiency indices, all appliances can have meaningful comparison of their energy efficiencies. In other words, within a category appliance that has a lower energy efficiency index (i.e. lower percentage) consumes less energy than an appliance of higher energy efficiency index (i.e. higher percentage). The energy efficiency index is calculated as follows:

$$\text{Energy Consumption Index } (I\varepsilon) = E_{sp} / E_{av} * 100\%$$

Where E_{sp} is the actual appliance "Specific Energy Consumption" obtained from energy consumption test per rated washing capacity; and E_{av} is the Average Specific Energy Consumption: E_{av} = 0.26 for drum type washing machines and E_{av} = 0.0264 for agitator or impeller type washing machines.

To make the concept of appliance energy efficiency more readily understood by ordinary consumers, appliance energy efficiency grade is introduced by linking the energy consumption index (percentage) to the 5 grades as shown in the following table, with Grade 1 being the most energy efficient and Grade 5 the least.

Table 1.20: Converting Energy Consumption Indices to Energy Efficiency Grades within the Voluntary Energy Efficiency Labelling Scheme (VEELS); source: (Electrical and Mechanical Services Department (EMSD) 2013)

Energy Consumption Index: Iε (%)	Energy Efficiency Grade
Iε ≤ 80	1
80 < Iε ≤ 95	2
95 < Iε ≤ 110	3
110 < Iε ≤ 125	4
125 < Iε	5

In order to obtain Grade 1 to 4, the washing machine concerned shall also meet all the washing performance and water extraction performance requirements.

The Hong Kong Green Label Scheme (HKGLS)

According to (Hong Kong Green Council 2010a), the Hong Kong Green Label Scheme (HKGLS) is an independent and voluntary scheme, which aims to identify products that are, based on life cycle analysis consideration, more environmentally preferable than other similar products with the same function. The Scheme is organized by the Green Council (GC) with contributions from the HKGLS Advisory Committee and a number of supporting organizations. Product environmental criteria have been established for a wide variety of consumer products, inter alia washing machines and dishwashers.

The aim of the environmental criteria developed for washing machines is to: reduce energy consumption and promote energy-saving washing machines; reduce water consumption and promote water-saving washing machines; reduce noise emission and the use of the environmentally harmful substances; reduce detergent consumption; minimize waste production by reducing the amount of primary packaging and promoting its reusability and/or recyclability. These product environmental criteria apply to domestic washing machines with spinning function with a drum volume not exceeding 62 litres, but do not include combined washing machines and tumble dryers. Spinning may take place in the washing drum or as in twin-tub machines in a separate drum.

The product environmental criteria for washing machines are the following (Hong Kong Green Council 2010b):

- The Energy Consumption Index (ECI) of the appliance shall meet the HKSAR EMSD Energy Efficiency Label Scheme (EELS) energy efficiency grade 3 requirement or better (cf. section above).
- Water consumption per kilogram of clothing load shall not exceed 22 liters.
- Noise Emission: Airborne noise emission from the appliance, measured as sound power level, shall not exceed 60 dB (A) during washing and 76 dB(A) during spinning.

Further resource related criteria are listed in section 1.3.2.4.

China – Taiwan

The Green Mark Programme is the official eco-labelling program in Chinese Taipei which was founded in 1992 by the Environmental Protection Administration (TEPA). At present, the Programme has issued Green Mark eco-label certificates around 112 product categories, including various cleaning products, office supplies and equipment, energy/water-saving products, information technology products, construction materials, and home appliances; there are criteria documents for washing machines; washer dryers are not in the scope of the Green Mark Programme.

The Green Mark criteria apply to clothes washers; they do not include products which only have the water removal or cloth drying functions. The standard is applicable to the following types of products: Front-load/drum type; and top-load/upright type, including those involving jet stream, stirring, scrolling or whirlpool movements for cleaning purpose. The following criteria apply to clothes washers (Government of the Republic of China (Taiwan): Environmental Protection Administration 2014):

- The product's energy efficiency shall meet the Energy Efficiency and Labelling Requirements for Clothes Washers of the Energy Labelling Program managed by the Bureau of Energy of the Ministry of Economic Affairs.
- The noise level for products during water removal operation shall be below the regulatory limit of ≤ 53 dB(A).

Further resource related criteria are listed in section 1.3.2.4.

Republic of Korea

Korean Energy Efficiency Label and Standard Programme

Under the Korean Energy Efficiency Label and Standard Programme, manufacturers and importers are required to produce and import products meeting a minimum energy performance standard (MEPS). Manufacturers and importers must report product energy efficiency standards. Products must be labelled according to their energy performance, from grades 1 to 5, showing the energy performance of the product. 1 is the highest grade, and 5 the lowest grade, representing the MEPS. Any product falling below grade 5 is banned from sale. 22 products are covered under the programme, including refrigerators, washing machines and air conditioners. (International Energy Agency IEA 2012)

Korea Ecolabel

The Korea Ecolabel has been implemented since 1992. Inter alia, this scheme has certification criteria for washing machines. The scope of the Korea Ecolabel for washing machines (Korea Environmental Industry & Technology Institute KEITI 2011) applies to the volute type (i.e. revolving motion of revolving propeller equipped on the bottom of laundry tub) and agitator type (i.e. agitating motion of agitating propeller equipped on the bottom of laundry tub) household fully automatic washing machine below 12 kg class. The criteria document includes requirements with regard to

- The amount of water consumption
- Indication of Water-saving level based on water consumption
- Drum type washing machines being equipped with Cool-Water Washing function
- First class Energy Efficiency Rating (cf. bullet above)
- Noise during the operation (washing / dehydrating) of the product
- Dehydrating level > 50%; rinsing ration > 1.05
- Consumer information

Further resource related criteria are listed in section 1.3.2.4.

Other Asian countries

Further Asian countries do have voluntary Ecolabel for dishwashers and washing machines:

- The Singapore Green Labelling Scheme (SGLS) was launched in May 1992 to endorse consumer products and services that have less undesirable effects on our environment. This is administered by the Singapore Environment Council (SEC). The SGLS is also recognised as a member of the international Global Ecolabelling Network (GEN), allowing certification by mutual recognition of SGLS endorsed products by other members of the network (http://www.sec.org.sg/sgls/). This means that the countries in this network accept the Ecolabel criteria of other Members of the Network to mark products with their own label. The last updated of the Singapore Green Label Scheme (SGLS) for washing machines was in 2009.
- The Thai Green Label Scheme was initiated by the Thailand Business Council for Sustainable Development (TBCSD) in 1993. It was formally launched in August 1994 by the Thailand Environment Institute (TEI) in association with the Ministry of Industry (http://www.tei.or.th/greenlabel/). The Thai Green Label Scheme covers also clothes washing machines for household use
- The Indonesia Energy Efficiency Labelling Program (voluntary comparative label), a component of the Indonesian Government Regulation No. 70/2009 on Energy Conservation, is intended to provide information to consumers about the energy efficiency level of a product, as well as to encourage manufactures to increase the level of energy efficiency of products that they produce. The labelling system uses a star-rating system of 4 stars and includes information about the absolute energy efficiency of the product (kWh/year). The star rating shows the product's energy efficiency rank relative to similar products in the market, and is assigned by an independent and accredited test facility that tested the product. The labelling program currently covers air conditioning (voluntary), compact fluorescent lightbulbs (mandatory), refrigerators (voluntary) and freezers (voluntary). (International Energy Agency IEA 2015). Programs to cover clothes washers (and other product groups such as rice cookers, irons, ballasts, televisions, and fans) are under development in 2015.
- Philippines (Ecofys 2014): development of Mandatory Minimum Energy Performance Standards and of a Mandatory Comparative Label for clothes washers are under consideration

- India: a Voluntary Comparative Label for clothes washers was developed but neither information on registered products nor update of the criteria has been found in the literature (status 2010); source: (Ecofys 2014)

1.2.4.5. Australia & New Zealand

The Equipment Energy Efficiency (E3) program aims to increase the energy efficiency of lighting, appliances and equipment used in the residential, commercial and manufacturing sectors in Australia and New Zealand. This is achieved through the delivery of an energy efficiency standards and labelling program which apply performance standards (Minimum Energy Performance Standards [MEPS] and High Efficiency Performance Standards [HEPS]) and comparative energy rating labelling. The Australian labelling program is based on a star system, rated from one to ten. Performance standards and energy rating labelling are regulated through state and territory government regulations and penalties exist for non-compliance. The E3 program is part of the National Strategy on Energy Efficiency and overseen at a ministerial level by the Standing Committee on Climate Change. Operational oversight occurs through the E3 committee comprising officials from the Australian Government, State and Territory government agencies and the New Zealand Government. (International Energy Agency IEA 2014)

Energy

<u>Minimum Energy Performance Standards (MEPS)</u>

Minimum Energy Performance Standards (MEPS) specify the minimum level of energy performance that appliances, lighting and electrical equipment must meet or exceed before they can be offered for sale or used for commercial purposes. MEPS are mandatory for a range of products in Australia and New Zealand. These products must be registered through an online database and meet a number of legal requirements before they can be sold in either of these countries. For white goods, Minimum Energy Performance standards are only defined for domestic fridges and freezers, not for dishwashers and washing machines.

However, the Greenhouse and Energy Minimum Standards Determination 2012 for clothes washing machines defines labelling and communication requirements and other requirements on performance. (Australian Government 2012):

The Determination covers clothes washing machines that are ordinarily supplied and used for personal, domestic and household purposes irrespective of the context in which they are used. For example, the Determination applies to household clothes washing machines that are used in a commercial context. Examples of appliances covered by this Determination are both horizontal and vertical axis single bowl machines (front or top loading), twin tub units and the washing function of combination washer/dryer units. The Determination does not cover:

- Clothes washing machines that have:
  - a rated load capacity of less than or equal to 2 kilograms for all textile materials;
  - no connections to a mains water supply; and
  - no pump or other means for extracting water; and
- Clothes washing machines that are only capable of being used for cold wash operations and have:
  - no provision for internal water heating;
  - a single water connection marked only for cold water;
  - automatic fill control;

– no program that indicates (directly or indirectly) that a program other than a cold wash program is possible;

– a user manual that explicitly states it is only suitable for cold washing operations; and

– no associated product literature that states it is suitable for anything other than cold washing operations.

Labelling and communication requirements, as well as the product performance requirements (Percentage Soil Removal and Standard Deviation; Water Consumption; Water Extraction Index; Severity of Washing Action Index; Rinse Performance; and Water Pressure) refer to the requirements stated in the Australian standard AS/NZS 2040.2:2005 (cf. next section).

<u>Performance standard AS/NZS2040 for clothes washing machines</u>

Washing machines in Australia and New Zealand are measured according to the standard: AS/NZS 2040.1:2005/Amdt 1:2007(Energyrating) *Performance of household electrical appliances - Clothes washing machines* prepared by the Joint Standards Australia/Standards New Zealand Committee EL-015, Quality and Performance of Household Electrical Appliances. The AS/NZS 2040 series comprises two Parts:

- AS/NZS2040: Performance of household electrical appliances- Clothes washing machines Part 1: Energy Consumption and Performance
- AS/NZS2040: Performance of household electrical appliances- Clothes washing machines Part 2: Energy labelling requirements

Part 1 of the standard defines the test procedures for the determination of energy consumption and performance of clothes washers in Australia.

Part 2 of the standard sets out the requirements for Energy Labelling of clothes washers in Australia. An approved Energy Label for clothes washers must be displayed on all products which are offered for sale in Australia.

The overall objective of the AS/NZS 2040 series is to promote high levels of performance and energy efficiency in electric clothes washers. It is in some parts (e.g. load) based on IEC 60456:1994, *Electric clothes washing machines for household use-Methods for measuring the performance*. Nevertheless, it differs from IEC standard in a number of ways, as follows:

- Specific minimum performance requirements for washing, spinning and severity of washing are included (these are not specified by the IEC) in Part 2;
- The water hardness is specified as 0.45 mmol/litre (in IEC 60456 is 2.5 mmol/litre);
- The cold water temperature is 20 °C (in IEC 60456 is 15 °C);
- A particular phosphate-based detergent is used for other than drum type machines (not specified by IEC);
- Only IEC Type B phosphate-based detergent is used for drum type machines (IEC nominates two detergents, with the stated intention of deleting Type B in the future);
- AS9 soil swatches are used (IEC specifies four separate soil swatches which include carbon, blood, wine and chocolate);
- A mixed cotton and polyester/cotton load is used (IEC specifies only sheets, towels and pillowcases for cotton);
- Each AS9 soil batch is calibrated against a reference batch (soil batch calibration is not specified by IEC);

- Same laboratory reference machine is not used to normalize results (IEC specifies a Wascator reference machine to normalize results);
- The water extraction (spin) index is based on bone dry mass (IEC index is based on normalized mass with a nominal 8% moisture content);
- Whiteness retention test (informative) is included (not specified by IEC);
- Tests for rinse performance is included in Annex N (added in Amendment 4, of August 2005, with a different method compared with IEC);
- Tests for acoustical noise are not included (these are specified by IEC).

The standard **AS/NZS 2040-1, Amendment No. 4, August 2005** includes Appendix N - *Determination of rinse performance* and Appendix O – *Measurement of PBIS concentration in the supply water and extracted liquor samples*.

Appendix N sets out the procedure for determining the rinse performance of a clothes washing machine, through UV spectrophotometric measurement of a chemical marker (2-phenyl-5-benzimidazole-sulfonic acid or PBIS) in the rinse liquor extracted from the wet load at the end of the program.

The test for rinse performance is carried out in conjunction with tests to determine percentage soil removal, energy and water consumption, water extraction index, and severity of washing action index in accordance with Appendices D, E, F and G respectively of the standard AS/NZS 2040-1.

Rinse performance of a washing machine is determined by measuring the mass, per kilogram of rated load, of a marker (PBIS) present in the rinse liquor that is retained in the wet load at the end of the program. The marker, analytical grade 2-phenyl-5-benzimidazole-sulfonic acid (PBIS) with a purity of 98% or better, is dosed into the wash program in proportion to the rated load, the dosage being 100mg PBIS per kilogram of rated load. A standard percentage soil removal test is then conducted in accordance with Appendix D of AS/NZS 2040-1, using a conditioned load. At the completion of this test (following the weighing of the load) the load is placed in a spin extractor and a sample of rinse liquor recovered. A spin extractor of any size may be used for the purpose of this test provided that it can generate sufficient G force to extract from the rinsed load sufficient rinse liquor (typically 100 ml, but no more than 150 ml) for the purpose of UV spectrophotometric measurement of the extracted sample. Ideally a spin extractor that can accommodate the entire load in a single run should be used. If a smaller spin extractor is used, the entire load will need to be divided into two or more equal parts.

Using UV spectrophotometry the concentration of retained PBIS is then determined by comparison with measurements from solutions of known PBIS concentration.

The rinse performance is then determined from the concentration of PBIS in the extracted rinse liquor multiplied by the mass of retained moisture in the load measured at the end of the program. As a check on the accuracy of the dosing of PBIS, a sample of the wash liquor is also collected during the test and measured for PBIS concentration.

The rinse performance score (in mg/kg of load) is determined from the following equation:

$$\text{Rinse performance score} = \frac{C_m \times m_r}{RC}$$

where:

C_m = concentration of PBIS found in the rinse liquor adjusted as required for the apparent concentration of PBIS in the supply water (mg/l)

m_r = mass of retained moisture in the load (kg)

RC = rated load capacity claimed by the manufacturer for a normally soiled load (kg).

A test is not valid unless the following criterion is met:

$$PBIS_{wash} \geq 0,7 \times \frac{M_{PBIS}}{Q_{washtot}}$$

where:

$PBIS_{wash}$ = the concentration of PBIS found in the sample of wash liquor (mg/l)

M_{PBIS} = the dose (mass) of PBIS used in the test (mg)

$Q_{wash\ tot.}$ = the total volume of water, including any water added with the detergent, used in the initial wash operation (i.e. up until first pump out) (litres)

The procedure for measuring the concentration of PBIS in the supply water and extracted liquor samples is specified in Appendix O: the test procedure employs the measurement of the absorbance of ultraviolet light by a sample water at the absorbance maximum for PBIS (302 nm) and at a background point of 330 nm. The measurement of a background point at 330 nm enables correction for background absorbance due to turbid samples.

<u>Energy Rating Label</u>

The Energy Rating Label, or ERL, is a mandatory comparative Energy Label that provides consumers with product energy performance information at point-of-sale on a range of appliances. Attached to each appliance, it allows comparison between similar appliance models through a star rating of between one and six stars (the greater the number of stars, the higher the efficiency) and the annual energy consumption. For televisions and refrigerators, the rating scale is up to 10 stars. Further, the label provides information about the energy use of the appliance in kilowatt-hours (kWh) per year when tested to the relevant standard.

In Australia and New Zealand, clothes washers are mandatory required to display the Energy Rating Label under the Greenhouse and Energy Minimum Standards (GEMS) Act 2012. For clothes washers, the standard star rating system has a minimum of 1 star and a maximum of 6, shown in half star increments, cf. sample label in the figure below.

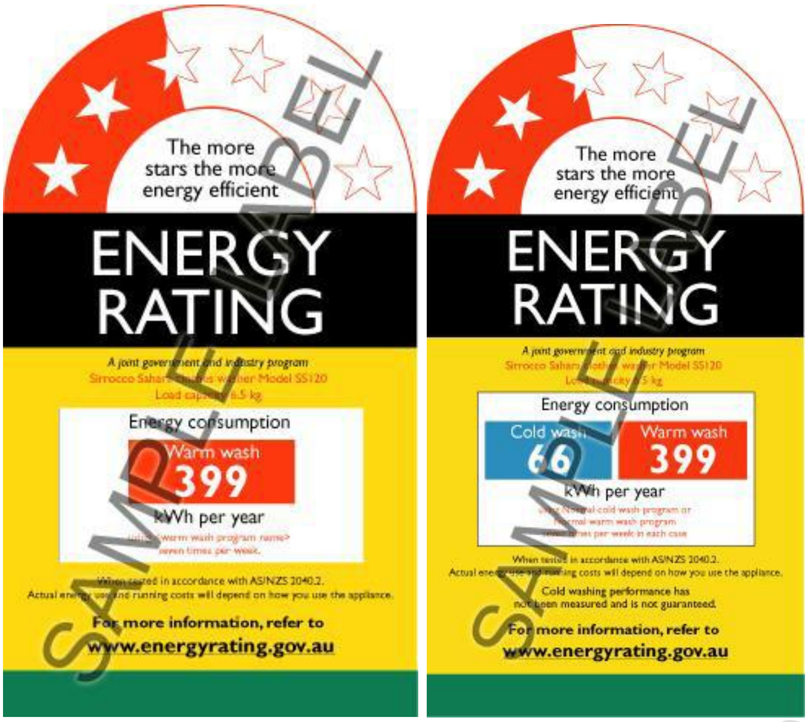


Figure 1-6 **Australia's Energy Rating Label for washing machines. Left: warm wash only; right: warm and cold wash; source (Australian, State and Territory and New Zealand Governments 2014c)**

Different procedures and equations have been developed to rate the least efficient products at around 1 star. The Base Energy Consumption (BEC) defines the "1 star" line for particular products. An additional star is awarded when the so called Comparative Energy Consumption (CEC) of the model is reduced by a defined percentage from the BEC.

For washing machines, the Base Energy Consumption is defined as BEC = 115 x rated capacity. The energy reduction factor per star is 0.27, i.e. 27%. For example, a model that had a CEC that was 0.73 of the BEC or less would achieve 2 stars. Similar, a CEC of 0.533 (0.73 x 0.73) of the BEC or less would achieve 3 stars and so on. For clothes washers, front and top loading models are rated on the same basis. The warm wash energy consumption and a component of residual moisture (spin performance) are used to define the star rating in comparison with the BEC. Therefore a model that has a good spin performance may get a marginally higher star rating than a model of the same capacity and CEC with a poor spin performance. (Australian, State and Territory and New Zealand Governments 2014b)

The Comparative Energy Consumption of a washing machine is measured under conditions specified in an Australian and New Zealand Standard. Over a year, it is assumed that the washing machine is used 7 times per week (365 times per year). For clothes washers, the star rating index is also influenced by the spin performance of the machine, as it is assumed that some of the load will be put into a dryer. So the normal ratio of CEC/BEC in the Star Rating Index (SRI) equation is replaced as follows (Energy Efficient Strategies (EES) 2010):

$$SRI = 1 + \left[\frac{\log_e\left(\dfrac{CEC + Em}{BEC + Eref}\right)}{\log_e(1 - 0.27)} \right]$$

where $\mathrm{Em} = \frac{F \times WEI \times RC \times 365}{1.08}$ and $\mathrm{Eref} = \frac{F \times WEI_{ref} \times RC \times 365}{1.08}$

SRI = Star Rating Index

F = 0.1;

WEI = water extraction index for the model (also called spin index);

WEI_{ref} = 1.03.

WEI is usually in the range of 1.1 (maximum allowable) to about 0.55 (best on the market) and is the ratio of moisture remaining in the load compared to the bone dry mass of the test load (which is nominally the rated capacity / 1.08).

Energy Star Australia

The US Energy Star has been adopted by several countries, also by Australia. The Energy Star mark is awarded to the top 25% most energy efficient products; inter alia to washing machines. (Australian, State and Territory and New Zealand Governments 2014a)

Water

Water Efficiency Labelling and Standards (WELS) scheme

WELS is the Australia's water efficiency labelling scheme that requires certain products to be registered and labelled with their water efficiency in accordance with the standard set under the national Water Efficiency Labelling and Standards Act 2005. The WELS label replaces a prior voluntary water conservation rating 'AAAAA' label endorsed by the Water Services Association of Australia. The water-using WELS products are inter alia washing machines, including combination washer/dryers. (Australian, State and Territory Governments 2014b)

The standard that sets out the criteria for rating the water efficiency and/or performance of each WELS product type is the Australian and New Zealand Standard AS/NZS6400:2005 Water-efficient products - Rating and labelling. This standard is the basis for the star ratings and water consumption and flow displayed on the WELS label.

Testing of washing machines: The average total water consumption for washing machines is determined by testing three models on a programme recommended to wash a normally soiled cotton load at the rated load capacity of the machine. The water efficiency rating is determined by using a formula derived from the total water consumption. Other tests performed include soil removal, water extraction, severity of wash and rinse performance. These tests have performance thresholds which must be met in order for the product to be registered and labelled. (Australian, State and Territory Governments 2014a)

Combination washer/dryer machines may use water to dry loads. Since 1 November 2011 it has been mandatory for combination washer/dryers registered after that date to carry a WELS label stating the water usage of the dryer function.

Minimum Water efficiency Standards (WES)

Washing machines also have minimum water efficiency standards (WES): Washing machines with a capacity of 5 kg or more must rate at least 3 stars, while those with a capacity of less than 5 kg must rate at least 2.5 stars (Australian, State and Territory Governments 2014b). The minimum Water Efficiency Standard (WES) for washing machines came into effect on 1 November 2011.

1.2.4.6. Latin America (LATAM)

For LATAM, vertical-axis (VA type) machines still are the majority of the markets either with an agitator or an impeller. Semiautomatic (or manual washing machines) where consumer has to make part of the cycle are a huge part of the market from Mexico to Brazil, so energy efficiency requirements have been established to regulate this type of washing. Front loader (horizontal-axis, HA) washers have larger market only in Argentina. In general, these are more expensive and consumers notice cycle time is longer.

As in many other regions LATAM strive to get more efficient products, sometimes in a voluntary way such as via an Eco-label type of program. The concept of high efficiency has been growing into consumer minds recently, especially in countries like Mexico (for its closeness to Canada and US markets).

The following Table 1.21 shows legislation in place in Latin America (i.e. Minimum Energy Performance Standards or comparative labels).

Table 1.21: Latin America legislation (Minimum Energy Performance Standards or comparative labels) for washing machines and washer-dryers; source: (Ecofys 2014)

Country	Minimum Energy Performance Standards	Comparative Labels
Argentina	Mandatory Minimum Energy Performance Standards for clothes washers; status: entered into force (2013)	Mandatory Comparative Label for clothes washers; status: entered into force – no activity (2010)
Brazil	---	Mandatory Comparative Label for clothes washers; status: under revision (2005)
Mexico	Mandatory Minimum Energy Performance Standards for clothes washers; status: entered into force - no activity – (2013)	Mandatory Comparative Label for clothes washers; status: entered into force - no activity – (2013)

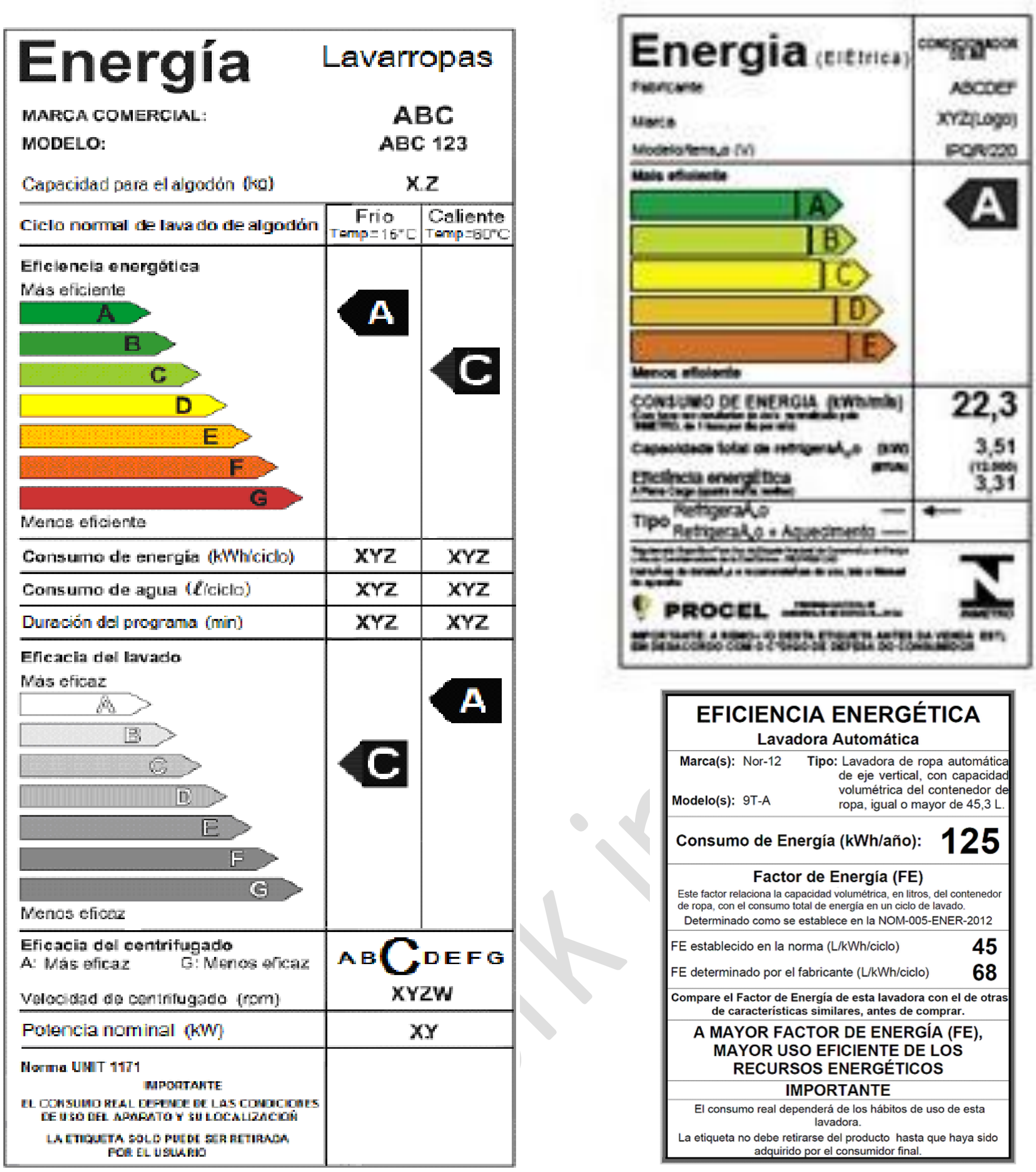


Figure 1-7 Labelling examples in Latin America (left: Argentina & Uruguay; above right: Brazil; below right: Mexico)

In general, more efficient washers have no special recognition and promotion in Latin America. Just in Brazil and in Mexico there is an eco-label that informs somehow that the product is more efficient.

As in many other geographic regions, methodologies have been explored and evaluated to provide a suitable way to measure and report energy efficiency values. Free commerce trades also play a big role when deciding which standards each country is going to follow. The general decision profile for the continent is shown in Figure 1-8.

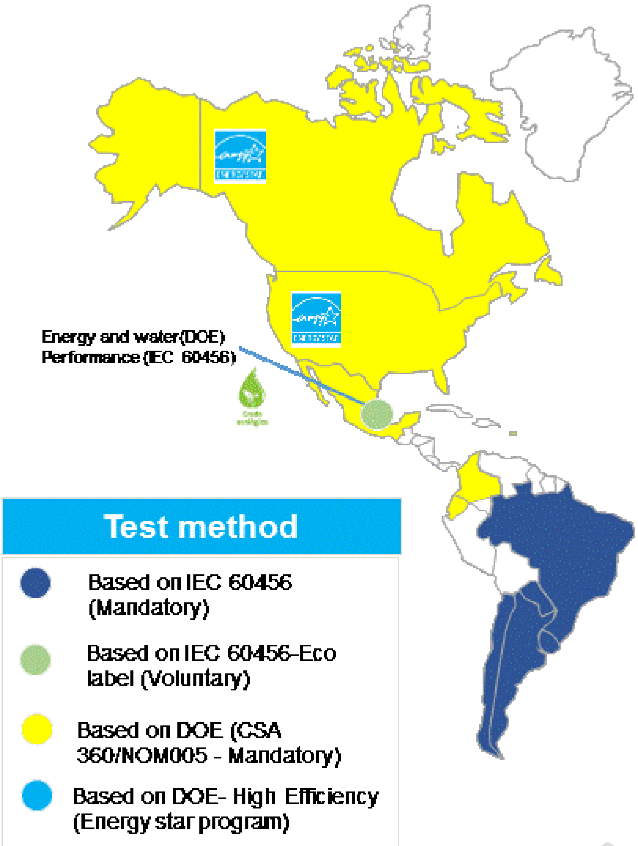


Figure 1-8 **Energy efficiency Washing Machine Standards in Latin America**

Generally speaking, some areas can be identified for the America's energy efficiency legislation:

1 North America region (in yellow) based on DOE methodology, measuring water and energy consumption (with some slight differences). This region includes countries that have recognized laboratories and similar certification processes: Canada, US, Mexico, Ecuador and Colombia

2 Central America region (in white) where there are several schemes in place since there are countries under CB-scheme (Worldwide System for Conformity Testing and Certification of Electrotechnical Equipment and Components (IECEE)) or that have no evaluation infrastructure in place but accept the certificates from other countries based on Trade agreements. Examples are Guatemala, Honduras, Belize, El Salvador and Nicaragua.

3 Open markets: several methodologies are suitable to be approved for commercialization. Example of this could be Costa Rica, which has no testing capabilities and due to Free Trade Agreements the country will accept Energy Efficiency certificates from US, Mexico, Europe and so on.

4 Venezuela: regulations are particular for the country.

<u>Regulations and limits</u>

Basically there are two methodologies in place, DOE-based and IEC-based. However for each group (even within members of each group we have differences) there are some differences on which parameters are included, as shown in Table 1.22.

Table 1.22 Washing machine energy efficiency comparison in Latin America

	DOE based	IEC 60456 based and used edition (ed)	
Countries included	Mexico, Central America, Colombia	South America Argentina 4^{th} ed Uruguay 4^{th} ed Brazil 3^{rd} ed Chile 5^{th} ed	Mexico 5^{th} ed (Eco label only)
Parameters included	MEF (no standby) WF (only for Eco label in Mexico)	Washing performance Cotton 20° cycle, Cotton 40° cycle (Argentina only)	Washing performance Cotton 20° cycle
Semi-automatic Washing Machine included	Yes	Yes (except Chile)	No
Product Qualification	Compliance value	A to G range	Compliance value
Exceptions		Brazil test also WM w/heater inc Uruguay use 15° water intake	Only report washing efficiency

In general, automatic washing machines limits do not differentiate between horizontal axis (HA) versus vertical axis (VA) machines. Of course on labelling it is clearly stated which type of machine is evaluated so the consumer will have the information.

<u>Future work in LATAM</u>

South America countries have a common standardization body as part of Mercosur Trade agreement. Copant, the Panamerican Standards Commission approved last year the publication of an Energy efficiency Washing Machine labelling where the established test method is the IEC 60456 5^{th} edition.

It is expected that in the near future all the region will be harmonized on the same edition.

1.2.4.7. Other world regions and/or countries

(Ecofys 2014) has conducted a comprehensive study ("Impacts of the EU's Ecodesign and Energy/Tyre Labelling Legislation on Third Jurisdictions") gathering considerable detailed information on equipment energy efficiency standards and labelling programmes in place in forty eight countries outside the EU. According to this study, for washing machines following countries have Minimum Energy Performance Standards or comparative labelling schemes, besides those listed in the sections before:

Table 1.23: Third-country legislation (Minimum Energy Performance Standards or comparative labels) for washing machines and washer-dryers; source: (Ecofys 2014)

Country	Minimum Energy Performance Standards	Comparative Labels (e.g. energy and environmental labels)
Egypt	Mandatory Minimum Energy Performance Standards for clothes washers; status: under revision (2006)	Mandatory Comparative Label for clothes washers; status: entered into force – no activity (2003)
Jordan	Mandatory Minimum Energy Performance Standards for clothes washers; status: under development (2014)	Mandatory Comparative Label for clothes washers; status: development completed – under revision (2012)
	---	Mandatory Comparative Label for washer-dryer; status: development completed - pending implementation

Country	Minimum Energy Performance Standards	Comparative Labels (e.g. energy and environmental labels)
		(2013)
Russia	Voluntary Minimum Energy Performance Standards for clothes washers; status: under consideration for development	Comparative label for clothes washers; status: ---
South Africa	Mandatory Minimum Energy Performance Standard for washing machines; status: under development	Voluntary Comparative Label for clothes washers; status: adopted (2012)
	---	Voluntary Comparative Label for washer-dryer; status: adopted (2012)
Tunisia	---	Mandatory Comparative Label for clothes washers; status: under consideration for development
Turkey	Mandatory Minimum Energy Performance Standards for clothes washers; status: entered into force – no activity – (2011)	Mandatory Comparative Label for clothes washers; status: entered into force – no activity (2012)
	---	Mandatory Comparative Label for washer-dryer; status: entered into force – no activity (2002)

1.2.5. Testing and market surveillance

The project Atlete II is a EU-funded project (see www.atlete.eu) that had as main objective was to check the compliance of washing machines to with the relevant provisions of EU Energy Labelling and Ecodesign legislation. MSA were involved in its execution. Specific results concerning market distribution of appliances are presented in Chapter 3. Below, some conclusions related to the testing and market surveillance are presented:

- A Pan-EU compliance verification exercise can be carried out in a systematic, effective and cost-efficient way.
- An effective, accurate and timely procedure for compliance verification has been defined that creates a stable framework for all stakeholders and supports market surveillance by national MSA.
- The project has re-assessed the importance and need for Step 2 in the EU verification procedure for Energy Label and Ecodesign legislation.
- Laboratory testing is re-confirmed as both technically feasible and economically sustainable. It also, paradoxically, appears to be the "easiest" phase of the entire procedure.

..In addition, the project has offered MSAs qualified and independent product checks and test results, reducing the burden and the use of the MSAs' own resources for national market surveillance actions. The project has shown that pan-European check activities can help tackle (and in most cases resolve through voluntary remedy actions) non-compliance cases before delivering the final results to each MSA. These checks contribute to keep alive the awareness of manufacturers concerning the fact that their products can be controlled (although not sanctioned) by third parties.

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The involvement of laboratories has been fundamental for the project. It has helped improve the template for the reporting of results, from the first draft to the final version, and for the discussion about the identification of e.g. standard programmes on the front of a machine. In addition, laboratories recognized the importance of meeting each other, exchanging experiences and commenting on the test results and elements of the regulations which were unclear.

1.3. Legislation and standards on material resource efficiency

The Ecodesign Directive 2009/125/EC in Annex I, Part 1.3 defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to (European Parliament 2009), this includes inter alia

- *Ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, complexity of tools necessary for disassembly, use of component and material coding standards for the identification of components and materials suitable for reuse and recycling (including marking of plastic parts in accordance with ISO standards), use of easily recyclable materials, easy access to valuable and other recyclable components and materials; easy access to components and materials containing hazardous substances;*
- *Incorporation of used components;*
- *Avoidance of technical solutions detrimental to reuse and recycling of components and whole appliances;*

This section identifies and provides an overview of legislation, standards, and labels in the EU, Member States and at third-country level for the products in scope with focus on resources use and material efficiency.

1.3.1. Legislation on hazardous materials, material resource efficiency and end-of-life aspects

Note: This section only presents resource related legislation for washing machines and washer-dryers. Legislation related to ecodesign, energy efficiency and other performance criteria are presented separately in section 1.2.1.

1.3.1.1. EU RoHS Directive 2011/65/EU

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2011/65/EU (commonly referred to as RoHS 2) restricts the use of certain hazardous substances in electrical and electronic equipment to be sold in the EU. (European Parliament 2011)

Directive 2011/65/EU replaces Directive 2002/95/EC (commonly referred to as RoHS 1), which entered into force on the 1st of July 2006. RoHS 2 entered into force on 21 July 2011 and has led to the repeal of RoHS 1 on the 3rd of January 2013. The RoHS-Directive **restricts the presence of the substances** listed in Annex II of the Directive, currently including the following substances:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- Polybrominated biphenyls (PBB)
- Polybrominated diphenyl ether (PDBE)

The RoHS-Directive limits the presence of these substances in electrical and electronic equipment to be placed on the Union market, to concentrations not exceeding 0.1% by weight of homogenous material. For Cadmium the threshold level is at 0.01%.

Exemptions from these provisions are only possible, provided that the availability of an exemption does not weaken the environmental and health protection afforded by Regulation 1907/2006/EC (commonly referred to as REACH, cf. section 1.3.1.3), and that at least one of the following conditions is fulfilled:

- Substitution is not possible from a scientific and technical point of view;
- The reliability of substitutes is not ensured;
- The negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the benefits;

Decisions on exemptions and on their duration may also take into consideration the following aspects, though it is understood that these do not suffice on their own to justify an exemption:

- The availability of substitutes;
- Socio-economic impacts of substitution;
- Impacts on innovation; and
- Life-cycle thinking on the overall impact of an exemption;

Applications for granting, renewing or revoking exemptions have to be submitted to the European Commission in accordance with Annex V of the Directive, are required to include among others a justification including comprehensive information on the substance-application and possible substitutes. All applications undergo a technical analysis as well as a stakeholder consultation.

In general, applications exempted from the restriction are listed in Annex III of the RoHS Directive. As most of the exemptions are very specific, it is not possible to generalise certain topics for household appliances. Possible exemptions might be for example lead in various alloys (steal, copper, aluminium) probably being relevant for housings, though depending on the applied housing materials, as well as other components for which such alloys are in use. Theoretically, another example of exemptions might be CFL backlight systems if still being used in displays of washing machines/washer dryers, although it is assumed that most displays have been shifted to LED backlight systems.

During the preparation of RoHS 2, an **amendment of the list of restricted substances** in Annex II was discussed. Preparatory studies, in particular the review of restricted substances under RoHS (Groß et al. 2008), revealed that further relevant hazardous substances are used in EEE. According to Recital 10 of RoHS 2 in particular the risks to human health and the environment arising from the use of the following substances were to be considered as a priority for the first review:

- Hexabromocyclododecane (HBCDD)
- Bis (2- ethylhexyl) phthalate (DEHP)
- Butyl benzyl phthalate (BBP)
- Dibutyl phthalate (DBP)

RoHS 2 sets the rules for amending the list of restricted substances in Article 6(1). A review and amendment of Annex II was to be performed and considered by the Commission before 22 July 2014, and is to be considered periodically thereafter. In preparation of the 2014 review, the Austrian Umweltbundesamt GmbH (AUBA) conducted a first study in 2012-2014. Among others, the outcomes of this study included a **24 entry priority substance list** (see Table 1.24), and detailed dossiers for the four substances prioritised already in RoHS 2, Recital 10. Further details can be found under this link: http://www.umweltbundesamt.at/rohs2.

Table 1.24: Substances with priority as indicated by the Austrian Umweltbundesamt GmbH (excluding the four substances listed in Directive 2011/65/EU, Recital 10)

Substances	CAS-No	EC-No
Highest priority		
Diisobutylphthalate (DIBP)*	84-69-5	201-553-2
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	204-118-5
Dibromo-neopentyl-glycol	3296-90-0	221-967-7
2,3-dibromo-1-propanol (Dibromo-propanol)	96-13-9	202-480-9
Second highest priority		
Antimontrioxid	1309-64-4	215-175-0
Diethyl phthalate (DEP)	84-66-2	201-550-6
Tetrabromobisphenol A	79-94-7	201-236-9
MCCP (medium chained chlorinated paraffins), C14 – C17: alkanes, C14-17, chloro;	85535-85-9	287-477-0
Third highest priority		
Polyvinylchloride (PVC)	9002-86-2	-
Fourth highest priority		
Nickel sulphate	7786-81-4	232-104-9
Nickel bis(sulfamidate); Nickel sulfamate	13770-89-3	237-396-1
Beryllium metal	7440-41-7	231-150-7
Beryllium oxide (BeO)	1304-56-9	215-133-1
Indium phosphide	22398-80-7	244-959-5
Fifth highest priority		
Di-arsenic pentoxide; (i.e. Arsenic pentoxide; Arsenic oxide)	1303-28-2	215-116-9
Di-arsenic trioxide	1327-53-3	215-481-4
Cobalt dichloride	7646-79-9	231-589-4
Cobalt sulphate	10124-43-3	233-334-2
Sixth highest priority		
Cobalt metal	7440-48-4	231-158-0
4-Nonylphenol (branched and linear)	84852-15-3 25154-52-3	284-325-5 246-672-0

* This substance was reviewed by Öko-Institut; for more information, please refer to the Substance specific Dossier compiled by (Gensch et al. 2014).

AUBA recommended adding HBCDD (brominated flame retardant), DEHP, BBP and DBP (three phthalate plasticisers), to Annex II of RoHS. The study also showed that in some cases a selective ban of a substance from a larger substance group might drive industry towards the use of a problematic alternative from the very same group (e.g. substituting one phthalate plasticiser for another). An assessment of the phthalate diisobutylphthalat (DIBP) was thus carried out by Öko-Institut (Gensch et al. 2014), recommending its addition to Annex II together with the other three phthalates. Decisions as to the addition of these five substances to Annex II of RoHS 2 are still pending. The 24 entry priority substance list prepared by AUBA (excluding the 5 substances listed above) has also been developed by Öko-Institut to include quantitative usage data and is understood to provide a further basis for the EU COM to assess the need to amend the substances listed in Annex II in the future.

Once new substances are added to Annex II of RoHS, it is assumed that a transition period shall be provided for stakeholders to establish compliance of their products and components with the consequential new RoHS substance restrictions. Where substitutes are available, this shall mean that such alternatives are to be implemented in the redesign and manufacture of EEE to be made available on the Union market by the end of the transition period. Where substitutes are not sufficiently developed, exemptions may be applied for, on the basis of the criteria listed above.

(Dalhammar et al. 2014) see interlinkages between RoHS and the Ecodesign Directive; the latter might complement the rules in the RoHS Directive through setting additional rules for chemicals for certain product groups when this would be required to stimulate recycling and contribute to cleaner materials streams. However, this might probably require first developing methodologies within the MEErP.

1.3.1.2. EU WEEE Directive 2012/19/EU

The Directive on waste electrical and electronic equipment (WEEE) 2012/19/EU (commonly referred to as WEEE-Directive) regulates the separate collection, treatment and recycling of end-of-life electrical and electronic equipment. The Directive 2012/19/EU replaces Directive 2002/96/EC of 27 January 2003, which entered into force on 1st of July 2006. Amongst others, Directive 2012/19/EU requires member states to achieve quantitative collection targets (e.g. 65% of the average weight of EEE placed on the market in the three preceding years). It also requires Member States to ensure that producers provide for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE (Article 12).

The WEEE-Directive classifies EEE in various categories. In this system, household washing machines are classified under category 1 “Large household appliances”. Nevertheless, this classification is under transition and will follow a new system from the 15th of August 2018 onwards. Under this new system, washing machines and washer-dryers might not be classified in one single category, but instead fall under the following of the six new categories:

- Category 4: Large equipment (any external dimension more than 50 cm); this category will generally apply to household washing machines and washer-dryers;
- Category 5: Small equipment (no external dimension more than 50 cm); this category might apply to few very small washing machines or washer-dryers;
- Category 1: Temperature exchange equipment; this category might apply to washer-dryers and washing machines with heat pumps;
- Category 2: Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2; this category might apply to washing machines and washer-dryers in case of having a large control panel.

Annex V of the Directive also contains minimum targets for recovery and recycling. For the initial category 1 equipment (large household appliances), these targets are 80% for recovery and 75% for recycling until 14^{th} August 2015. From 15^{th} of August 2015, these targets will be raised to 85% for recovery and 80% for recycling. From 15^{th} August 2018, the targets are split to the new categories: 85% recovery and 80% recycling for categories 1 and 4; 80% recovery and 70% recycling for category 2, and 75% recovery and 55% recycling for category 5.

Furthermore, Annex VII of the Directive specifies substances, mixtures and components that have to be removed from any collected WEEE for selective treatment. Regarding household washing machines and washer-dryers, the following components might be of relevance:

As a minimum the following substances, mixtures and components have to be removed from any separately collected WEEE:

- Today's appliances < 20 years old:
  - Printed circuit boards of devices if the surface of the printed circuit board is greater than 10 square centimetres
  - Plastic containing brominated flame retardants: enclosures of power electronics, and electronic components like casting compound of transformers, capacitors and PCBs contain brominated flame retardants (e.g. Tetrabrombisphenyl A, TBBA).
  - Gas discharge lamps: might be in backlight units of LCD control panels, if not realized with LED
  - External electric cables
  - Components containing refractory ceramic fibres as described in Commission Directive 97/69/EC of 5 December 1997 adapting to technical progress for the 23rd time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances: Theoretically these might be in insulation materials of large household appliances; in general, however, they are made of bitumen sheets.
- Future appliances:
  - Chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC) or hydrofluorocarbons (HFC), hydrocarbons (HC): washing machines with heat pump
  - Liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimetres and all those back-lighted with gas discharge lamps: today's control panel displays are slightly smaller than 100 cm^2
- Possibly in historical appliances > 20 years old:
  - Polychlorinated biphenyls (PCB) containing capacitors in accordance with Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT): might be found in capacitors of motors
  - Mercury containing components, such as switches or backlighting lamps: might be found in fill level switches
  - Asbestos waste and components which contain asbestos: might be in the ducts of heating elements
  - Electrolyte capacitors containing substances of concern (height > 25 mm, diameter > 25 mm or proportionately similar volume): might be found in capacitors of motors

(Dalhammar et al. 2014) see interlinkages between WEEE and the Ecodesign Directive; the latter might complement the horizontal rules in the WEEE Directive through implementing measures for a design of products that better enables recycling of certain components and materials. In this context, section (11) of the WEEE Directive 2012/19/EU clearly states "*Ecodesign requirements facilitating the re-use, dismantling and recovery of WEEE should be laid down in the framework of measures implementing Directive 2009/125/EC. In order to optimise re-use and recovery through product design, the whole life cycle of the product should be taken into account.*"

1.3.1.3. EU REACH Regulation 1907/2006/EC

The European chemicals regulation REACH 1907/2006/EC entered into force on 1st of June 2007. Under the REACH Regulation, certain substances that may have serious and often irreversible effects on human health and the environment can be identified as Substances of Very High Concern (SVHCs). If identified, the substance is added to the Candidate List, which includes candidate substances for possible inclusion in the Authorisation List (Annex XIV). Those SVHC that are included in Annex XIV become finally subject to authorisation. By this procedure REACH aims at ensuring that the risks resulting from the use of SVHCs are controlled and that the substances are replaced where possible.

In this regard, REACH also introduced new obligations concerning general information requirements on substances in articles. Producers and importers of articles that contain substances of very high concern (SVHC) included in the candidate list, will be required to notify these to the Agency (ECHA) if both of the following conditions are met:

- The substance is present in those articles in quantities totalling over 1 t/y per producer or importer;
- The substance is present in those articles above a concentration of 0.1% weight by weight (w/w).

Notification will not be required in case the SVHC has already been registered for this use by any other registrant (Article 7(6)), or exposure to humans or environment can be excluded (Article 7(3)).

In addition, Article 33(1) requires producers and importers of articles containing more than 0.1% w/w of an SVHC included in the candidate list, to provide sufficient information to allow safe handling and use of the article to its recipients. As a minimum, the name of the substance is to be communicated.

The provisions of Article 33(1) apply regardless of the total amount of the SVHC used by that actor (no tonnage threshold) and regardless of a registration of that use. Furthermore, this information has to be communicated to consumers, on request, free of charge and within 45 days (Article 33(2)).

The above mentioned Candidate list is updated regularly (two to three times a year). At present (April 2015), 161 substances are on the list. Several of these substances can be present in household washing machines and washer-dryers, e.g. plasticisers in seals.

(Dalhammar et al. 2014) see interlinkages between REACH and the Ecodesign Directive: Recyclers are not included as stakeholders that have a right to information about chemicals in articles in REACH Art. 33. As both the WEEE and REACH rules are sometimes considered inadequate in providing to recyclers the information on toxic components needed for improving recycling, (Dalhammar et al. 2014) see potential for setting implementing measures under the Ecodesign Directive as a complementary action. This could be for example identification of chemicals that can be a barrier to recycling. Ecodesign implementing measures should, when possible, address such chemicals through banning or setting limits for their content. Another option would be to mandate information about the content through implementing measures; this information might then be used e.g. in public purchasing schemes to reward front-runners, or by recyclers in some cases.

1.3.1.4. EU CLP Regulation 1272/2008/EC

The Regulation (EC) No 1272/2008 of the European Parliament and the Council of 16 December 2008 on the classification and packaging of substances and mixtures entered into force on 20 January 2009.

The purpose of the so called CLP-Regulation is to identify hazardous chemicals and to inform their users about particular threats with the help of standard symbols and phrases on the packaging labels and through safety data sheets. The purpose of the globally harmonised system (UN-GHS) is to make the level of protection of human health and the environment more uniform, transparent and comparable as well as to simplify free movement of chemical substances, mixtures and certain specific articles within the European Union.

Substances had to be classified until 1 December 2010 pursuant to Directive 67/548/EEC and mixtures until 1 June 2015 pursuant to Directive 1999/45/EC. Differing from this provision, the classification, labelling and packaging of substances and preparation may already be used before 1 December 2010 and 1 June 2015 in accordance with the provisions of the CLP/GHS-Regulation. After these dates the provisions of the CLP-Regulation are mandatory. The REACH-Regulation (cf. section 1.3.1.3) is complemented by the CLP-Regulation.

1.3.1.5. EU F-Gas Regulation 517/2014/EU

The revised F-Gas Regulation (EU) No 517/2014 (European Parliament 2014) has been published on May 20 2014 in the Official Journal of the European Union. The text, which repeals the 2006-F-Gas Regulation, applies since 2015. The objective of this Regulation is to protect the environment by reducing emissions of fluorinated greenhouse gases.

This regulation applies to washing machines and washer-dryers in case they are using a heat pump system based on fluorinated hydrocarbons like the frequently applied refrigerant R134a. Accordingly, this regulation:

(a) establishes rules on containment, use, recovery and destruction of fluorinated greenhouse gases, and on related ancillary measures;

(b) imposes conditions on the placing on the market of specific products and equipment that contain, or whose functioning relies upon, fluorinated greenhouse gases;

(c) imposes conditions on specific uses of fluorinated greenhouse gases; and

(d) establishes quantitative limits for the placing on the market of hydrofluorocarbons.

Inter alia, there is a requirement that products and equipment that contain, or whose functioning relies upon, fluorinated greenhouse gases shall not be placed on the market unless they are labelled. The label required shall indicate the following information:

- a reference that the product or equipment contains fluorinated greenhouse gases or that its functioning relies upon such gases;
- the accepted industry designation for the fluorinated greenhouse gases concerned or, if no such designation is available, the chemical name;
- from 1 January 2017, the quantity expressed in weight and in CO_2-equivalent of fluorinated greenhouse gases contained in the product or equipment, or the quantity of fluorinated greenhouse gases for which the equipment is designed, and the global warming potential of those gases.

Further, the regulation specifies certain types of equipment to be banned from being placed on the EU market from certain dates. Washing and dishwashing appliances with heat pump technology applied are not listed under the prohibited products. Further, according to (AREA 2014) bans will not apply to Ecodesign equipment that has less lifecycle CO_2-equivalent emissions than equivalent equipment that meets Ecodesign requirements and does not contain HFCs. The conditions for such an exception would be as follows (AREA 2014):

(1.) The equipment falls under Ecodesign requirements, i.e. an Ecodesign measure has been adopted for the equipment in question.
(2.) It is explicitly established in the Ecodesign that the equipment, due to higher energy efficiency, has lifecycle CO_2-equivalent emissions lower than equivalent equipment which meets all relevant Ecodesign requirements and does not contain HFCs. However, currently none of the adopted ecodesign standards contain such statement.

The new regulation also includes a phase-down scheme according to which the quantity of HFCs placed on the EU market will gradually decrease between 2015 and 2030. Although the new regulation does not name the alternative refrigerants, Ammonia (NH_3), Carbone Dioxide (CO_2), Hydrocarbons (HCs) and Hydrofluoroolefine (HFOs) are the main fluids affected. It is expected that the combination of the phase-down and the planned bans will result in an increase in use of alternative refrigerants and technologies to HFCs.

Some stakeholders have pointed out that the F-gas Regulation 517/2014 established constraints for the choice of cooling agents that might potentially be used in heat pumps part of washing machines/washer-dryers.

1.3.1.6. EU Detergents Regulation 648/2004/EC

EU detergents regulation 648/2004 (European Parliament 2004) stipulates the biodegradability of surfactants in detergents. The regulation introduced harmonized labelling requirements of detergents: The labelling comprises a labelling scheme on the packaging that includes the labelling of fragrance allergens. Besides, a detailed ingredient list has to be published at the internet. Manufacturers must hold additional information on the detergents such as ingredient datasheet and safety tests at the disposal of the Member States' competent authorities and medical personnel in cases of accidents.

The latest amendment of regulation 648/2004, regulation 259/2012 (European Parliament 2012) concerned the limitations on the content of phosphates and of other phosphorus compounds in consumer laundry detergents. Phosphate acts as water-softeners and thereby prevents the deposition of lime scale; it dissolves grease and keep it suspended in the washing water. On the other hand, phosphates cause algae to grow at the expense of other aquatic life, which is commonly named eutrophication.

In consumer laundry detergents, the total phosphorous content limit is set at 0.5 grams phosphorous in the detergent to be used in the main cycle of the washing process for a standard washing machine load. The phosphate limitation was applicable by 30 June 2013. Many member states had already implemented measures to reduce phosphate in laundry detergents before 2013. (European Commission 2007)

As substitute to phosphate in laundry detergents zeolites (aluminosilicates) are used, mainly zeolite A; zeolite-based detergents need a higher concentration of polycarboxylates and phosphonates as additional water softener (co-builder). (European Commission 2007)

The European Chemical regulation No. 1907/2006 (REACH regulation, cf. section 1.3.1.3) stipulates the registration and evaluation of the substances in the detergents. Under REACH, manufacturers have to how the sub-stance can be safely used, and they must communicate the risk management measures along the supply chain. The final detergents are considered mixtures under REACH. Also the Classification, Labelling and Packaging (CLP) regulation (cf. section 1.3.1.4) is applicable for detergents and their ingredients. The CLP regulation ensures that the hazards presented by chemicals are clearly communicated to workers and consumers in the European Union through classification and labelling of chemicals.

1.3.1.7. EU Ecodesign Regulation 1194/2012/EU on directional lamps, light emitting diode lamps and related equipment

The Ecodesign Regulation 1194/2012 sets specific functionality requirements which include different functionality parameters on the lifetime of lamps (European Commission 2012):

- Lamp survival factor at 6,000 h (for LED lamps only). Lamp survival factor (LSF) means the defined fraction of the total number of lamps that continue to operate at a given time under defined conditions and switching frequency. Test procedure: The test shall end when the required number of hours is met, or when more than two lamps fail, whichever occurs first. Compliance: a maximum of two out of every 20 lamps in the test batch may fail before the required number of hours. Non-compliance: otherwise.
- Number of switching cycles before failure. Test procedure: The test shall end when the required number of switching cycles is reached, or when more than one out of every 20 lamps in the

test batch have reached the end of their life, whichever occurs first. Compliance: at least 19 of every 20 lamps in the batch have no failure after the required number of switching cycles is reached. Non-compliance: otherwise.

- Premature failure rate which means when a lamp reaches the end of its life after a period in operation which is less than the rated life time stated in the technical documentation. Test procedure: The test shall end when the required number of hours is met, or when more than one lamp fails, whichever occurs first. Compliance: a maximum of one out of every 20 lamps in the test batch fails before the required number of hours. Non-compliance: otherwise.
- Rated lamp lifetime in hours at 50% lamp survival. 'Lamp lifetime' means the period of operating time after which the fraction of the total number of lamps which continue to operate corresponds to the lamp survival factor of the lamp under defined conditions and switching frequency. For LED lamps, lamp lifetime means the operating time between the start of their use and the moment when only 50% of the total number of lamps survive or when the average lumen maintenance of the batch falls below 70%, whichever occurs first
- Product information requirements to be visibly displayed to end-users prior to their purchase on the packaging and on free access websites: Nominal lifetime of the lamp in hours (no longer than the rated lifetime); number of switching cycles before premature failure

1.3.1.8. EU Ecodesign Regulation 666/2013/EU on vacuum cleaners

The Ecodesign Regulation on vacuum cleaners sets specific requirements on durability from 1 September 2017 (European Commission 2013):

- Durability of the hose: The hose, if any, shall be durable so that it is still useable after 40,000 oscillations under strain. Measurement and test method: The hose shall be considered useable after 40,000 oscillations under strain if it is not visibly damaged after those oscillations. Strain shall be applied by means of a weight of 2.5 kg.
- Operational motor life-time: The operational motor lifetime shall be greater than or equal to 500 hours. Measurement and test method: The vacuum cleaner shall run with a half-loaded dust receptacle intermittently with periods of 14 minutes and 30 seconds on and 30 seconds off. Dust receptacle and filters shall be replaced at appropriate time intervals. The test may be discontinued after 500 hours and shall be discontinued after 600 hours. The total run-time shall be recorded and included in the technical documentation. Air flow, vacuum and input power shall be determined at appropriate intervals and values shall, along with the operational motor lifetime, be included in the technical documentation.

According to (Bundgaard et al. 2015), implementing these specific requirements on resource efficiency was enabled by the existence of measurement and test standards so that the requirements can be monitored when the product are put on the market.

Further, the Ecodesign Regulationon vacuum cleaners sets information requirements on resource efficiency from 1 September 2017 (European Commission 2013):

The technical documentation and a part for professionals of the free access websites of manufacturers, their authorised representatives, or importers shall contain the following elements:

- Information relevant for non-destructive disassembly for maintenance purpose, in particular in relation to the hose, suction, inlet, motor, casing and cable.
- Information relevant for dismantling, in particular in relation to the motor and any batteries, recycling, recovery and disposal at end-of-life.

1.3.1.9. Draft EU Ecodesign Regulation on electronic displays

End of 2014, a Consultation Forum meeting with regard to possible Ecodesign and Energy Labelling requirements for electronic displays has taken place. In this context, the European Commission provided draft proposals for the Ecodesign and Energy Label Regulations on electronic displays as well as related explanatory notes. The draft Ecodesign Regulation includes a comprehensive set of end-of-life requirements.

Note: The following information presented is taken from the documents that have been published so far and are still under discussion; thus they will be refined at a later project stage to take into account the latest versions of the documents available.

.According to the explanatory notes of the possible Ecodesign and Energy Labelling requirements for electronic displays (European Commission 2014b),

> *"The proposed measure sets specific requirements for manufacturers to (1) disclose information relevant for disassembly, recycling and/or recovery at end-of-life, (2) mark plastic parts, (3) declare the recyclability rate of plastic parts, and (4) label for mercury and presence of brominated flame retardants (BFR). These requirements are devised to help recyclers to better comply with the WEEE Directive (2012/19/EU) by providing information relevant for the depollution, disassembling and/or shredding operations. These requirements are in line with the approach taken in the Ecodesign regulations that were adopted so far and with the Commission Communication "Towards a circular economy: a zero waste programme for Europe" aimed at establishing a common and coherent EU framework to promote the circular economy. The proposed requirements should result in marginal costs to manufacturers with possibly relevant cost reduction and improved efficiency for the recycling industry."*

Following end-of-life requirements were proposed for electronic displays (European Commission 2014a):

- Design for recovery of electronic displays
- Marking of plastic parts of electronic displays
- Declaration of the recyclability index for plastic parts
- Mercury free logo
- Brominated Fire retardants logo
- Documentation for recycling at end of life of displays

<u>Design for recovery of electronic displays</u>

Manufacturers shall ensure that electronic displays are designed so that the following four types of components (when present) can be dismantled:

- Printed circuit boards assembly (larger than 10 cm^2);
- Thin-film-transistor liquid-crystal display (larger than 100 cm^2);
- PMMA board;
- Mercury containing backlighting lamps;

This shall be ensured by:

- Documenting the sequence of dismantling operations needed to access the targeted components, including for each of these operations: type of operation, type and number of fastening technique(s) to be unlocked, and tool(s) required;
- Describing the design strategies / innovations implemented to facilitate the disassembly, recycling and/or recovery of the electronic display;
- Providing a video showing the dismantling operations and the indicative time needed to extract the targeted components.

<u>Marking of plastic parts of electronic displays</u>

1. Plastic parts larger than 25g, other than the Polymethyl Methacrylate Board (PMMA) and display optical plastics, shall be marked by specifying the type of plastic using the symbols as specified in EN 11469 and EN 1043, set between the marks “>” and “<”. The marking shall be legible and located in a visible position.

Exemptions are made in the following cases:

(i) Where the marking would impact on performance or functionality of the plastic part

(ii) Where marking is technically not possible due to the production methods; or

(iii) Where the marking could cause defect rates under quality inspection, leading to unnecessary wastage of materials

Each exemption shall be justified in the ‘end-of-life report’.

2. Plastic parts larger than 25g, other than the PMMA board and display optical plastics, containing Brominated Fire Retardants (BFR) shall be marked in the following way:

(i) >x-FR-y<

where:

x= plastic polymer

FR = Fire Retardant

y= brominated fire retardant coding, according to EN 1043.

3. Plastic parts larger than 25g, other than the Polymethyl Methacrylate board (PMMA) and display optical plastics may include information related to the presence of fillers and fire retardants other than BFR in plastic parts. When the information is added voluntarily, this shall be presented in the following way:

(i) the presence of fillers as: 'x-y'

where:

x = plastic polymer

y = abbreviated term for the fillers.

(ii) the presence of fire retardant in plastic parts as: 'x-FR-y'

where:

x= plastic polymer

FR = Fire retardant

y= type of the fire retardant coding.

<u>Declaration of the recyclability index for plastic parts</u>

The recyclability index of plastic parts (heavier than 25g) in electronic displays shall be determined in accordance with the following equation:

$$R_{plastic} = \frac{\sum(m_i \times RCR_i)}{m_{tot}} \times 100 \qquad [\%]$$

Where:

$R_{plastic}$ = recyclability index of plastic parts [%]

m_i = mass of the ith plastic part heavier than 25g

m_{tot} = total mass of plastic parts heavier than 25g

RCR_i = recyclability rate of the ith plastic part heavier than 25g [%] as specified in the table.

Plastic parts lighter than 25g, Printed Circuit Boards (PCB), wiring and speakers are excluded from the calculation.

The manufacturer shall declare in the instruction booklet for users the value of the recyclability index of plastic parts (heavier than 25g) in the electronic display. The manufacturer shall illustrate in the 'end-of-life report' the calculation of the recyclability index for plastic parts ($R_{plastic}$) based on some generic default values set for assessing the recyclability rate of plastics (RCR_i).

Table 1.25: Recyclability rate of plastics (RCR_i); source (European Commission 2014a)

Material	Recyclability rate
Acrylonitrile Butadiene Styrene (ABS)	94%
Acrylonitrile Butadiene Styrene (ABS) with any additives	94%
High impact polystyrene (HIPS)	94%
High impact polystyrene (HIPS) with any additive	94%
Polyamide (PA)	94%
Polycarbonate (PC)	94%
Polycarbonate/ Acrylonitrile Butadiene Styrene (PC-ABS)	94%
Polycarbonate/Acrylonitrile Butadiene Styrene (PC-ABS) with any additives	94%
Polymethyl methacrylate (PMMA)	94%
Polypropylene (PP)	94%
Polypropylene (PP) with natural fibres	0%
Polypropylene (PP) with other additive	94%
Co-injected plastics	0%
Other plastics	0%

If the manufacturer has evidence that the recyclability rate is actually higher (e.g. based on tests) then the manufacturer can use the determined recyclability rate.

Mercury free logo

Electronic displays shall be labelled with the "Mercury inside" or the "Mercury free" logo. The logo shall be immediately and clearly visible on the back of the electronic display without the removal of a cover. The logo shall be in the form of the following graphic.

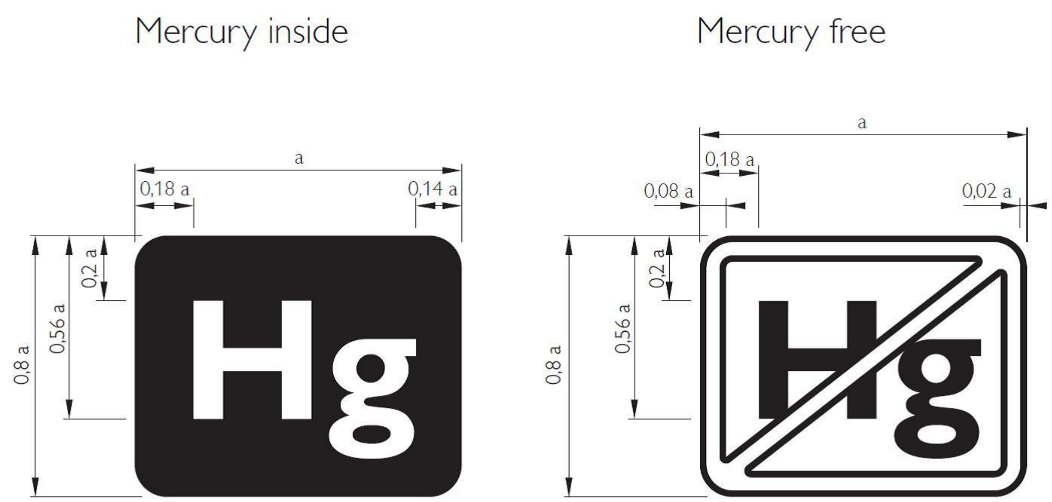


Figure 1-9 **Mercury free logo as proposed in the draft Ecodesign Regulationfor displays; source (European Commission 2014a)**

The dimension of “a” shall be greater than 9 mm and the typeface to be used is ‘Gill Sans serif’. The logo shall be visible, durable, legible and indelible.

Brominated Fire retardants logo

Electronic displays having plastic parts larger than 25g (other than PMMA board and display optical plastics) containing Brominated Fire Retardants (BFR) shall be labelled with the "BFR plastics inside" logo. Electronic displays with plastic parts larger than 25g (other than PMMA board and display optical plastics) not containing BFR shall be labelled with the “BFR-free plastics" logo.

The logo shall be immediately and clearly visible on the back of the electronic display without the removal of a cover. The logo shall be in the form of the following graphic.

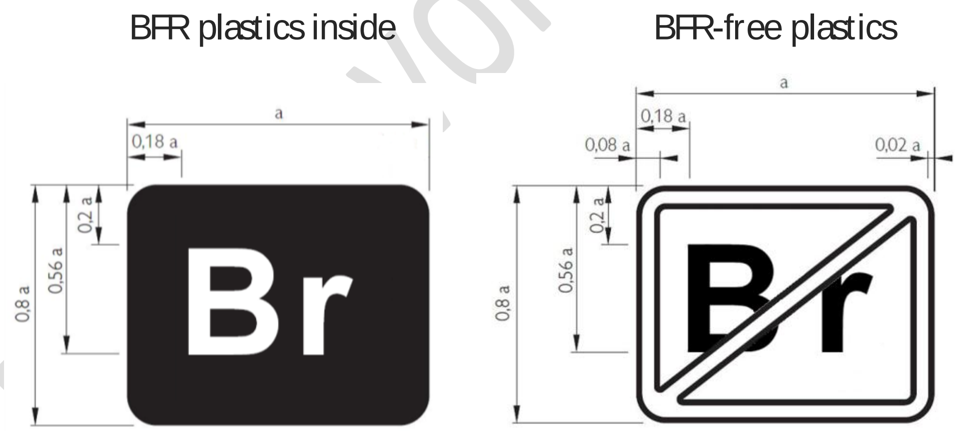


Figure 1-10 **Brominated fire retardants logo as proposed in the draft Ecodesign Regulationfor displays; source (European Commission 2014a)**

The dimension of “a” shall be greater than 9 mm and the typeface to be used is ‘Gill Sans serif’. The logo shall be visible, durable, legible and indelible.

Documentation for recycling at end of life of displays

From 24 months after the publication of the Regulation in the Official Journal of the European Union, manufacturers, and/or importers in the European Union shall provide the following product information on every equivalent electronic display model in a freely accessible websites and kept available for 10 years from the day of the last model placed on the market:

- An 'end-of-life report' containing information relevant for disassembly, recycling and/or recovery at end-of-life. The report shall include at least the following:
  - the exploded diagram of the product labelling the targeted components defined, when present, together with a documentation of the sequence of the dismantling operations needed to access to these components. Each of these operations shall be described in terms of type of operation (e.g. unscrewing, removing, levering, positioning), type and number of fastening techniques to be unlocked (e.g. M3 screw, snap-fit) and tool(s) required;
  - the description of the design strategies / innovations implemented to facilitate disassembly, recycling and/or recovery of the displays;
  - the rationale for each exemption, if some plastic parts are not marked as set out;
  - the declared value of the recyclability index for plastic parts larger than 25 g, accompanied by a description of the calculations (including at least: the list of the plastic parts; their material composition; the considered recyclability rates for each plastic type, plus a justification in case the values differ from the ones presented.
- A video showing the dismantling operations and the indicative time needed to extract the four types of targeted components, when present.

The value of the 'recyclability index of plastic parts' in the electronic display shall be declared in the instruction booklet for users.

The following generic measurement methods were proposed, accompanied with a standardization request of the European Commission to the European standardization organisations (ESOs) to develop generic methodologies related to material efficiency, such as durability, reusability, recyclability and recoverability (cf. section 1.3.3.2):

- <u>Extraction of key components</u>: Measurements of the extraction time of key components shall be made using a reliable, accurate and reproducible measurement procedure, which takes into account the generally recognised state of the art measurement methods, including the provision by manufacturers (through e.g. DVD, website) of the information necessary for the measurement, such as: technical documentation illustrating the dismantling sequence and a supporting video-recording that shows the compliance to the requirement.
- <u>Measurements of marking of plastic parts of electronic displays</u>: Measurements of marking of plastic shall be made using a reliable, accurate and reproducible measurement procedure, which takes into account the generally recognised state of the art measurement methods.
- <u>Minimum recyclability rate index for certain plastic parts</u>: Measurements of minimum recyclability rate index shall be made using harmonised standards, the reference numbers of which have been published in the Official Journal of the European Union, or using other reliable, accurate and reproducible methods which take into account the generally recognised state of the art, and produce results deemed to be of low uncertainty.
- <u>Mercury free logo</u>: Measurements and checks of backlighting systems of electronic displays for mercury content shall be made using harmonised standards, the reference numbers of which have been published in the Official Journal of the European Union, or using other reliable, accurate and reproducible methods which take into account the generally recognised state of the art, and produce results deemed to be of low uncertainty.

1.3.1.10. Review of Regulation 327/2011 with regard to ecodesign requirements for fans

Currently, the Ecodesign Regulation 327/2011 with regard to ecodesign requirements for fans is under revision. The working document presented to stakeholders relating to a meeting of the Ecodesign Consultation Forum on the review of the Regulation 327/2011 on fans on 30 April 2015 includes information requirements for the use of permanent magnet motors for fans:

- Manufacturers shall indicate the total weight per fan of the permanent magnets, if any, used in the motor, in kg with 2 digit precision.

To the knowledge of the authors, this is the first and only regulation which implements marking criteria for permanent magnets and might be a model for other regulations.

The related explanatory notes further explain that the use of Rare Earth Elements (REE) in Electronically Commutating (EC) motors which are used e.g. in fans are expected to be become a noticeable part of the waste stream. Most types contain permanent magnets with on average 18% Neodymium and smaller fractions of other REE. As these REE are regarded as ‘critical raw materials’ due to their ever increasing prices and dependence on supply from a single country it may be useful to indicated the weight of the magnets on the nameplate of the fan.

Discussions at the Consultation Forum meeting, however, proposed to change the requirement into information about the type of rare earths the motor is composed of rather than the weight of the permanent magnets.

1.3.1.11. National legislation: France

Decree n° 2014-1482 of 9 December 2014 regarding information and supply requirements for spare parts which are essential for the use of a good

On 9 December 2014 the French government published a decree in France’s Official Journal that puts into effect Article L111-3 of the Consumption Law (Code de la consommation, Version consolidée au 22 mars 2015, Art. L111-3). According to this article, French retailers will have to inform consumers about the availability of spare parts for products. The article requires manufacturers and importers to inform vendors how long spare parts that are essential for the use of a product will continue to be produced. This can be done either by specifying the period of availability or the final date. The vendor is then required to inform the buyer. The information is required to be displayed “in a visible manner” before a purchase is made and to be confirmed in writing after the purchase. Manufacturers will have to deliver the parts needed to make repairs to vendors or repair enterprises within two months. The rules apply to products placed on the market since March 2015. (French Government 2014)

Draft legislation against planned obsolescence

Further, in France the legislative project concerning the energy transition for green growth has been adopted in first reading by the national assembly on October 14th, 2014. It is currently in the Senate for first reading. Various amendments within this legislative project deal with planned obsolescence, among them article 22b (new) which introduces in the Code de la Consommation (Consumption Law), Art. L. 213-4-1, the following definition of planned obsolescence (French Administration 2014):

I – “Planned obsolescence means all techniques by which a placer on the market aims, especially by product design, at purposefully shortening the lifetime or the potential time of use of this product in order to increase the rate of replacement.”

II – “Specifically, these techniques can include the purposeful introduction of a defect, fragility, a programmed or premature stop, a technical limitation, an impossibility to repair or an incompatibility.”

Further, under the existing Article L213-1 of the Codes de la Consommation which lists diverse facts of consumer deception being penalised with 2 years' imprisonment or 300,000 Euro fine, another criminal offence shall be included: - „be it an intentionally reduced lifetime of a product at the design stage". (French Senat 2014)

On 11 March 2015, the act has gone into a committee for a second reading in the parliament, with a first report of the committee provided on 16 April 2015. After that, further sessions in the parliament and the senate will follow, before the law will be finally put into effect by the president. The version which has gone into the parliament redefined Art. L 213-4-1 as follows: „Programmed obsolescence is defined by each manoeuvre through which the lifetime of a good is knowingly reduced since its design stage, thereby limiting its usage time for business model reasons. It is punished by two years prison and 300.000 EUR fine." (French Parliament 2015)

Further, a new Article L-110-1-2 paragraph II 1a shall be included into the environmental law (code de l'environnement), which defines as one target of the national waste management policy „to fight planned obsolescence of products by means of consumer information. Voluntary experiments may be conducted with a display of product lifetime in order to promote extended usage time of manufactured products by means of consumer information. They will allow putting in place standards shared by economic actors of industrial sectors who are concerned with the notion of lifetime".

1.3.2. Ecolabels and other voluntary schemes – focus resource criteria

<u>Note</u>: This section only presents resource related criteria of European ecolabels existing for washing machines and washer-dryers. Energy and performance related criteria are presented separately in section 1.2.3.

1.3.2.1. Nordic countries: Nordic ecolabelling of white goods

In September 2014, version 5.0 of the Nordic Ecolabelling requirements for white goods (refrigerators and freezers, dishwashers, washing machines and tumble dryers) has been published, valid from 20 June 2013 to 30 June 2017. Gas-powered appliances and washer-dryers are not in the scope of this criteria document. (Nordic Ecolabelling 2014)

The following resource related criteria apply to washing machines:

Table 1.26: Nordic ecolabelling resource related criteria for washing machines; source: (Nordic Ecolabelling 2014)

Criteria category	Requirements
Manufacture – product requirements for washing machines	
Description of manufacturing process and materials	Summary of all parts (type, materials); manufacturing process including different stages, including production technology, cleaning technology for surface treatment and metal plating of parts; name and location of factories for final assembly of core components (e.g. drum, pipework etc.); subcontractors for production of core components and for surface treatment and metal plating
Chemical products, classification	List of chemicals used in final assembly; safety data sheets for the chemical products
Chemical substances	Certain substances prohibited to be actively added to the chemical products named in the criterion above (such as cleaning products, paints, lacquers, adhesives, sealants used in final assembly and surface treatment)

Criteria category	Requirements
Metal plating of parts	Metals may not be plated with cadmium, chromium, nickel, zinc or alloys of these. Exceptional cases are described as well as plating processes ensuring the greatest possible recovery of the chemical products.
Marking of plastic parts	Plastic parts that weight 50 grams or more must be marking in accordance with ISO 11469. (Cables and plastic parts with a smooth surface of less than 200 mm^2 are excluded from the requirement).
Flame retardants in plastic and rubber parts	Certain halogenated organic flame retardants and other flame retardants with certain risk phrases are not allowed to be added. An exemption from the latter requirement may be given for halogenated flame retardants in cases where these are required for electrical or fire safety reasons under the Low Voltage Directive 73/23/EEC or standard EN 60335-1; printed circuit boards PCBs; plastic and rubber parts weighing < 25 grams that are integral to electronic parts
Phthalates	Certain phthalates listed in the criteria document must not be added to plastic or rubber materials. The following are exempted from the requirement: Printed circuit boards PCBs; plastic and rubber parts weighing < 25 g that are integral to electronic parts
Antibacterial properties	Chemicals or additives (including nano materials such as silver ions, nano silver, nano gold and nano copper) that are added to create an antibacterial or disinfectant surface, in or on the product or to be released during the use of the product, must not be used.
Packaging	It must be possible to recycle or reuse the materials in the packaging and transport protection. Chlorine based plastics and biocide treated/impregnated timber must not be used in the packaging.
Waste	The manufacturer must sort different types of waste that arise from the production of the white good, for example glass waste, plastics and metals. A waste plan is to be included, listing waste fractions and a description of how the waste will be handled (e.g. recycling, landfill and incineration) and who will deal with the waste.
Requirements on customer information for washing machines	
Installation and user instructions for washing machines	Inter alia • Information on adaptions of detergent dosing necessary with regard to the water hardness, type of items, size and soiling of load
Warranties	The manufacturer has to provide a warranty that the washing machine will work for at least two years. The warranty is to apply from the day that the machine is delivered to the customer.
Replacement parts	The availability of replacement parts shall be guaranteed for 10 years from the time that production ceases.
Quality and regulatory requirements for washing machines (excerpt)	
Quality of the white good	The licensee must guarantee that the quality of the Nordic Ecolabelled washing machine is maintained throughout the validity period of the licence. Verification: Procedures for collating and, where necessary, dealing with claims and complaints regarding the quality of the Nordic Ecolabelled white goods.

1.3.2.2. Germany: Blue Angel Environmental Label for Household Washing Machines (RAL-UZ 137)

Basic criteria for the award of the German environmental label “Blue Angel” for household washing machines have been published in January 2013 and they will expire in December 2015.

The detailed resource related criteria are as follows (Ral gGmbH 2013b):

Spare Parts Provision

The applicant undertakes to make sure that the provision of spare parts for appliance repair is guaranteed for at least 10 years following the termination of production and that the customer is informed about this guaranteed availability of spare parts, e.g. by means of corresponding notes in the product manual.

Spare parts are those parts which, typically, may break down within the scope of the ordinary use of a product - whereas those parts which normally exceed the average life of the product are not to be considered as spare parts.

Also, the applicant undertakes to provide an after-sales services or hire a company to do on-site repair work at customer's premises. The product manual shall include information on the above requirements.

Material Requirements for the Plastics used in Housing and Housing Parts

The plastics must not contain as constituents any substances classified as

- carcinogenic in category 1 or 2 according to Table 3.2 of Annex VI to Regulation (EC) No 1272/2008,
- mutagenic in category 1 or 2 according to Table 3.2 of Annex VI to Regulation (EC) No 1272/2008
- toxic to reproduction in category 1 or 2 according to Table 3.2 of Annex VI to Regulation (EC) No 1272/2008
- being of very high concern for other reasons according to the criteria of Annex XIII to the REACH Regulation, provided that they have been included in the List (so-called "Candidate List) set up in accordance with REACH, Article 59, paragraph 1.

Halogenated polymers shall not be permitted. Neither may halogenated organic compounds be added as flame retardants. Moreover, no flame retardants may be added which are classified pursuant to Table 3.1 or 3.2 in Annex VI to Regulation (EC) 1272/2008 as very toxic to aquatic organisms with long-term adverse effect and assigned the Hazard Statement H 410 or Risk Statement R 50/53.

The following shall be exempt from this rule:

- Process-related, technically unavoidable impurities;
- Fluoroorganic additives (as, for example, anti-dripping agents) used to improve the physical properties of plastics, provided that they do not exceed 0.5 weight percent;
- Plastic parts less than 25 grams in mass.

Insulation Materials

If fibrous insulation materials are used, such as mineral, glass or rock wool, the applicant shall present a test report showing that the carcinogenicity index (C_I) of the products concerned is ≥ 40 and, hence, the material need not be classified as carcinogenic or suspected of causing cancer in accordance with the classification scheme of TRGS 905. Ceramic mineral fibres, i.e. glassy (silicate) fibres with an alkali metal oxide and earth alkali metal oxide content (Na_2O + K_2O+ CaO + MgO + BaO) of less than or equal to 18 weight percent may not be used.

Systems using Biocidal Silver

The use of systems using biocidal silver shall not be permitted.

Recyclable and Easy-to-Maintain Design

The appliance shall be so designed as to allow quick and easy disassembly with a view to facilitating repair and separation of valuable components and materials. This means that:

- It must be possible to separate the connections concerned by the use of ordinary tools and the points must be easily accessible,
- Plastics should consist of only one polymer or plastic parts greater than 25 g in mass must be marked according to ISO 11469 to allow for a sorting of plastics by type and
- Disassembly instructions must be made available to end-of-life recyclers or treatment facilities in order to recover as many valuable resources as possible.

Consumer Information with regard to resource efficiency

The energy, water and detergent consumption of washing machines greatly depends on the user behaviour (above all, by the user's way of loading and cleaning program selection). The operating instructions/product manual as well as manufacturer's website shall at least include the following basic user information/instructions:

- Instructions for cleaning and care of the appliance (e.g. regular cleaning of the lint filter, use of the detergent depending on soiling and water hardness);
- Information on the 10-year provision of spare parts as well as a contact address/phone number for information on where to obtain spare parts for the appliance.

1.3.2.3. EU: Draft Commission Decision establishing the criteria for the award of the EU Ecolabel for personal, notebook and tablet computers

Currently, the EU Ecolabel criteria for "Personal, notebook and tablet computers" are under revision with the final draft of the EU Ecolabel criteria published to be voted in the Regulatory Committee on 17 April 2015.

The criteria include rather detailed requirements on the product lifetime extension (such as durability testing for portable computers, rechargeable battery quality and lifetime, data storage drive reliability and protection, as well as upgradeability and repairability). Further, the requirements on design, material selection and end-of-life management (material selection and compatibility with recycling as well as design for dismantling and recycling) have been updated and detailed. Finally, a new criterion on sourcing of 'conflict-free' minerals has been introduced.

Although the product categories of personal, notebook and tablet computers are not directly comparable to large household appliances, this approach shall be listed as most current example for defining durability and end-of-life criteria which might be partly applicable also to other electrical and electronic equipment.

In the following, the proposed criteria are listed detailed (European Commission 2015b):

Criteria on product lifetime extension of personal, notebook and tablet computers

- Durability testing of portable computers (mainly based on test procedures of IEC 60068)
  - Mandatory durability test specification for notebook computers:
  - Resistance to shock
  - Resistance to vibration
  - Accidental drop
  - Additional durability test specifications for notebook computers
  - Temperature stress
  - Screen resilience
  - Water spill ingress

  - Keyboard lifespan
  - Screen hinge lifespan (Specification: The screen shall be fully opened and then closed 20,000 times. Functional requirement: The screen shall then be inspected for any loss of stability and hinge integrity.)
  - Mandatory durability test specification for tablet and two-in-one notebook computers
  - Accidential drop
  - Screen resilience
- Rechargeable battery quality and lifetime (not relevant for large household appliances)
- Data storage drive reliability and protection (not relevant for large household appliances)
- Upgradeability and Repairability: For the purpose of upgrading older components or undertaking repairs and replacements of worn out components or parts, the following criteria shall be fulfilled:
  - <u>Design for upgrade and repair</u>: The following components of computers shall be easily accessible and exchangeable by the use of universal tools (i.e. widely used commercially available tools such as a screwdriver, spatula, plier, or tweezers):
  - Data storage (HDD, SSD or eMMC),
  - Memory (RAM),
  - Screen assembly and LCD backlight units (where integrated),
  - Keyboard and track pad (where used)
  - <u>Rechargeable battery replacement</u>: The rechargeable battery pack shall be easy to extract by one person (either a non-professional user or a professional repair service provider) according to the steps defined below. Rechargeable batteries shall not be glued or soldered into a product and there shall be no metal tapes, adhesive strips or cables that prevent access in order to extract the battery. In addition, the following requirements and definitions of the ease of extraction shall apply:
  - For notebooks and portable all-in-one computers it shall be possible to extract the rechargeable battery manually without tools;
  - For sub-notebooks it shall be possible to extract the rechargeable battery in a maximum of three steps using a screwdriver;
  - For tablets and two-in-one notebooks it shall be possible to extract the rechargeable battery in a maximum of four steps using a screwdriver and spudger.
  - Simple instructions on how the rechargeable battery packs are to be removed shall be marked on the base cover of the product or provided in the user instructions.
  - <u>Repair manual</u>: The applicant shall provide clear disassembly and repair instructions (e.g. hard or electronic copy, video) to enable a non-destructive disassembly of products for the purpose of replacing key components or parts for upgrades or repairs. This shall be made publicly available or by entering the products unique serial number on a webpage. Additionally, a diagram shall be provided on the inside of the casing of stationary computers showing the location of the components listed above can be accessed and exchanged. For portable computers a diagram showing the location of the battery, data storage drives and memory shall be made available in pre-installed user instructions and via the manufacturer's website for a period of at least five years.

- Repair Service / Information: Information should be included in the user instructions or on the manufacturer's website to let the user know where to go to obtain professional repairs and servicing of the computer, including contact details. During the guarantee period referred to above this may be limited to the applicant's Authorised Service Providers.
- Availability of spare parts: The applicant shall ensure that original or backwardly compatible spare parts, including rechargeable batteries (if applicable), are publicly available for at least five years following the end of production for the model.
- Commercial Guarantee: The applicant shall provide at no additional cost a minimum of a three year guarantee effective from purchase of the product during which time they shall ensure the goods are in conformity with the contract of sale. This guarantee shall include a service agreement with a pick-up and return option for the consumer. This guarantee shall be provided without prejudice to the legal obligations of the manufacturer and seller under national law.

Criteria on design, material selection and end-of-life management of personal, notebook and tablet computers

- Material selection and recyclability
  - Improving the recyclability of plastic casings, enclosures and bezels: Parts shall not contain molded-in or glued-on metal inserts unless they can be removed with commonly available tools. Disassembly instructions shall show how to remove them; for parts with a weight greater than 25 grams for tablet computers and 100 grams for all other computers, the following treatments and additives shall not result in recycled resin with a >25% reduction in the notched izod impact when tested according to ISO 180:
  - Paints and coatings
  - Flame retardants and their synergists
  - Existing test results for recycled resin shall be accepted provided that the recycled resin is derived from the same input material as described above.
  - Material information to facilitate recycling: Plastic parts with a mass greater than 25 grams for tablet computers and 100 grams for all other computers shall be marked in accordance with ISO 11469 and ISO 1043, sections 1-4. The markings shall be large enough and located in a visible position in order to be easily identified. Exemptions are made in the following cases:
  - Printed circuit boards, Polymethyl Methacrylate Board (PMMA) and display optical plastics forming part of display units;
  - Where the marking would impact on the performance or functionality of the plastic part;
  - Where the marking is technically not possible due to the production method; or
  - Where the marking causes defect rates under quality inspection, leading to an avoidable wastage of materials.
  - Where parts cannot be marked because there is not enough appropriate surface area available for the marking to be of a legible size to be identified by a recycling operator.
  - Minimum recycled plastic content: The product shall contain on average a minimum 10% content post-consumer recycled plastic measured as a percentage of the total

plastic (by weight) in the product excluding Printed Wiring Boards and display optical plastics. Where the recycled content is greater than 25% a declaration may be made in the text box accompanying the Ecolabel. Tablets, subnotebooks, two-in-one notebooks and products with a metal casing are exempt from this sub-criterion.

- Design for dismantling and recycling:
  For recycling purposes computers shall be designed so that target components and parts can be easily extracted from the product. A disassembly test shall be carried out according to the test procedure in Appendix 1 to the Decision. The test shall record the number of steps required and the associated tools and actions required to extract the target components and parts identified under the following points.
  - The following target components and parts, as applicable to the product, shall be extracted during the disassembly test:
  - All products: Printed Wiring Boards relating to computing functions >10 cm^2
  - Stationary computer products: Internal Power Supply Unit; HDD drives
  - Portable computer products: Rechargeable battery
  - Displays (where integrated into the product enclosure): Printed Circuit Boards >10 cm^2; Thin Film Transistor unit and film conductors in display units >100 cm^2; LED backlight units
  - At least two of the following target components and parts, selected as applicable to the product, shall also be extracted during the test, following-on in the test from those above:
  - HDD drive (portable products)
  - Optical drives (where included)
  - Printed circuit boards ≤ 10 cm^2 and > 5 cm^2
  - Speaker units (notebooks, integrated desktops and portable all-in-one computers)
  - Polymethyl Methacrylate (PMMA) film light guide (where the screen size is >100 cm^2)

The test procedure, i.e. protocol for a product disassembly test, inter alia specifies following aspects:

- Operating conditions for the extraction:
  - Personnel: The test shall be carried out by one person.
  - Tools for extraction: The extraction operations shall be performed using manual or power-driven standard commercially available tools (i.e. pliers, screw-drivers, cutters and hammers as defined by ISO 5742, ISO 1174, ISO 15601).
  - Extraction sequence: The extraction sequence shall be documented and, where the test is to be carried out by a third party, information provided to those carrying out the extraction.
- Recording of the test conditions and steps
  - Documentation of steps: The individual steps in the extraction sequence shall be documented and the tools associated with each step shall be specified.
  - Recording media: Photos shall be taken and a video recorded of the extraction of the components. The video and photos shall enable clear identification of the steps in the extraction sequence.

Criteria on sourcing of 'conflict-free' minerals

The applicant shall support the responsible sourcing of tin, tantalum, tungsten and their ores and gold from conflict-affected and high-risk areas by:

- Conducting due diligence in line with the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, and
- Promoting responsible mineral production and trade for the identified minerals used in components of the product in accordance with OECD guidance within conflict-affected and high-risk areas.

1.3.2.4. Asian Ecolabel criteria with regard to material and resource efficiency

China (Mainland) – China Environmental Labelling

The following resource-related criteria are required by the China Environmental Labelling:

- The requirement on lifetime of machines shall comply with the provisions of GB/T 4288-2003 Grade A.
- Environmental design of products:
  - Exchangeability, upgradeability design
  - The products should have modular structure.
  - Detachment and module exchange of the products should be done with conventional tools
  - Design of the product should take modular upgradeability and exchangeability into consideration
  - Plastics and metals used in the products should be 90% (by weight) recyclable technically.
  - In the product, independent plastic components should be made from one type of polymer (homopolymer or copolymer) or from recycled plastics
  - Products shall not contain metals that could not be separated from plastic (>25g)
  - Except plastic with <25g weight or <200mm^2 area, plastic components should be marked according to ISO 11469
- Regarding reuse and recycling, the manufacturers should recover and recycle waste products or components by free as well as reuse them.
- Hazardous substances
  - Components which contain hazardous substances must be marked and easily be found and detached.
  - Regarding plastic parts:
  - Plastic parts weighing over 25g shall not contain lead or cadmium added artificially.
  - Plastic parts weighing over 25g shall not contain flame retardants containing polybrominated biphenyls (PBBs), polybrominated diphenylethers (PBDEs) and chlorophenol
  - Any plastic component exceeding 25g in products could contain maximum 5% organofluoride
  - Any of the following softeners shall not be used in plastic component exceeding 25g (this requirement takes not account of recycled components): Diisononylphthalate

(DINP); Di-n-octylphthalate (DNOP); Di(2-ethylhexyl)phthalate (DEHP); Diisodecylphthalate (DIDP); Butylbenzylphthalate (BBP); Dibutylphthalate (DBP)

  - Packing materials: No CFCs, HCFC, 1,1,1-Trichloroethane or carbon tetrachloride shall be used in the production of packing materials and packing materials themselves.

- Production:
  - CFCs, HCFC, 1,1,1-Trichloroethane or carbon tetrachloride is not allowed to be used in the production of products
  - CFCs, HCFC, 1,1,1-Trichloroethane or carbon tetrachloride is not allowed to be used as cleaning agent in producing process of printed circuit boards

China (Hong Kong) – The Hong Kong Green Label Scheme

The following resource-related criteria are required by the Hong Kong Green Label Scheme:

- Plastic parts shall have no lead or cadmium added by the manufacturer and plastic parts weighing over 25g shall not contain flame retardants containing polybrominated biphenyls (PBBs), polybrominated diphenylethers (PBDEs) and chloroparaffins with 10-13 carbon atoms per molecule and chlorine content of greater than 50% by weight.
- Surface Treatment: Paints shall not contain pigments or additives based on cadmium, lead, chromium, mercury or their compounds. Metals shall not be coated with cadmium, chromium, nickel or their compounds.
- The product shall have clear volumetric markings on the detergent dispenser to allow adjustment according to degree of soiling.
- Packing requirements: Packaging materials shall not contain chlorine-based plastics. General packaging requirements according to the Hong Kong labelling criteria for packaging materials.

China (Taiwan) – Green Mark

- The following resource-related criteria on materials, accessories and components are required by the Taiwanese Green Mark:For the product's surface coating material, its content of cadmium, lead, hexavalent chromium, and mercury shall be below the regulatory limits.
- The product shall meet the requirements of ISO 11469, in labelling all major plastic components weighing more than 25 g in prominent areas to indicate the composition code.
- Product's plastic parts weighing more than 25 g shall meet the following requirements:
- Content of cadmium, lead, hexavalent chromium and mercury shall be below the regulatory limit. If recycled materials are used in the plastic components, or safety regulations require the addition of glass fibre to the components located in the high temperature area, the lead content of such components shall be less than 20 ppm.
- Content of the following flame-retardants shall be below the regulatory limit:
- Polybrominated biphenyls (PBBs);
- Polybrominated diphenylethers (PBDEs): monobrominated diphenylether, dibrominated diphenylether, tribrominated diphenylether, tetrabrominated diphenylether, pentabrominated diphenylether, hexabrominated diphenylether, heptabrominated diphenylether, octabrominated diphenylether, nanobrominated diphenylether, decabrominated diphenylether; and
- Chloroparaffins with 10-13 carbon atoms per molecule and chlorine content of greater than 50% by weight.

Korea Ecolabel

The following resource-related criteria are required by the Korean Ecolabel:

- Use of chemical substances
- Recycling capability of product during the recycling or disposal stage of production process: Marking on each part of synthetic resin used for the product; material requirements for shock-absorbing materials in packaging; establishment, implementation and operation of a collecting and recycling system of products to be disposed

1.3.2.5. Ecolabels and other voluntary initiatives regarding the use of detergents

Ecolabel for detergents

The EU Ecolabel criteria for laundry detergents were adopted in 2011 (Commission Decision 2011/264/EU). The aim of these criteria documents was to promote laundry detergents that corresponded to the best 10-20 % of the products available on the Community market in terms of environmental performance considering the whole life-cycle of production, use and disposal. These criteria are due to expire in 2016. Currently, these criteria are under review (for more details, cf. http://susproc.jrc.ec.europa.eu/detergents/index.html).

The “Preliminary report for the revision of ecological criteria for laundry detergents” building the basis for revision of European Ecolabel criteria for laundry detergents also provides an extensive overview of other European national as well as international voluntary labelling schemes and standards for laundry detergents including their detailed requirements, cf. (JRC IPTS 2014b), p. 18-46.

PEF process: Development of product environmental footprint category rules (PEFCRs) for “Heavy Duty Liquid Laundry Detergents (HDLLD) for Machine Wash”

The European Commission, working closely with the Joint Research Centre, has developed a proposed methodology for the calculation of the environmental footprint of products. In the spring of 2013, the Commission launched a call for pilots to test this methodology (over the period 2013-2016) with specific product sectors, in order to develop workable product environmental footprint category rules (PEFCRs), test the verification objectives and test different communication options. The International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) was selected in October 2013 to lead one of the pilot studies, focusing on household liquid laundry detergents. The procedure for the development of a PEFCR according to the “Guidance for the implementation of the EU PEF during the EF pilot phase” considers a number of steps (A.I.S.E. [n.d.]):

- Definition of PEF product category and scope of the PEFCR documents
- Definition of the product “model” to analyse based on representative product(s)
- Screening of the Product Environmental Footprint (PEF)
- Draft PEFCR
- PEFCR supporting studies
- Confirmation of the benchmark(s) and determination of performance classes
- Final PEFCR

In April 2015, the Technical Secretariat of the PEF pilot project on “Heavy Duty Liquid Laundry Detergents (HDLLD) for machine wash” provided a first draft PEFCR together with a PEF screening report to stakeholders which can be downloaded under (European Commission 2015c).

The draft PEFCR (A.I.S.E. 2015) provides rules for the product category “Heavy Duty Liquid Laundry Detergents (HDLLD) for Machine Wash,” including 100% Liquid tablets (unit-dose). Other products such as

"Light Duty Liquid Laundry Detergents", "Powder Laundry Detergents" and "Powder Tablets" are part of the same category; but they were not chosen to be covered by the PEFCR, since the different product types vary in their functional units. However, A.I.S.E. plans to evaluate these other categories in order to assess if and how to apply the HDLLD PEFCR also to these categories.

According to (A.I.S.E. 2015), the unit of analysis for the HDLLD Product Category was chosen to be the following (based on or in conformance with the Detergent Regulation (EC 648/2004)): "Wash 4.5 kg of dry fabric with the recommended dosage for

- a 4.5 kg load;
- normally soiled fabric;
- with a medium water hardness;
- in a 6 kg capacity machine wash at 75% loading."

The standard use scenario calculations were chosen to be based on the following data (A.I.S.E. 2015):

- Specific dosage recommended to the consumer (in ml): 75 ml
- Specific location of the consumer (country scale)
- Wash temperature: 40°C
- Water consumption: 50 litres/wash
- Wash electricity consumption based on the following formula developed by A.I.S.E. ("A.I.S.E. laundry energy model 2014").

$$\textbf{Electricity consumption (kWh)} = \mathbf{b[0]} + \mathbf{b[1]} \times \textbf{washing temperature (°C)}$$ **Equation 1-10**

with b[0] = -0,1342 and b[1] = 0,0193

According to (A.I.S.E. 2015), the equation is based on fundamental thermodynamic principles. In this assessment, the sum is made of the mechanical energy for a wash (drum rotation, spinning) plus the amount of energy consumed in the water heating cycle, as a function of temperature. The efficiency of the washing machine is neglected. Other parameters required for the calculation are the amount of water assumed to be heated (21 l/wash); the average seasonal inlet water temperature for a series of countries (average = 12.98 °C); the specific heat capacity of water.

Based on variations in consumer habits, the following parameters at the use stage can be varied: Product dosing; wash temperature; and water used by the machine.

This is the last update at May 2015. Additional information on the project can be found on: www.aise.eu/pef.

The A.I.S.E. Charter for Sustainable Cleaning

The A.I.S.E. Charter for Sustainable Cleaning (see: http://www.sustainable-cleaning.com/en.home.orb) is a voluntary initiative of the European cleaning and maintenance products industry established since 2005 sets high level standard to drive sustainable progress and standard in the detergent industry. More than 200 companies have joined the project, representing over 95% of the total production output for Europe. The Charter stipulates a set of Charter Sustainability Procedures for companies to implement in their management systems. It also defines a set of key performance indicators (KPIs) linked to the sustainability procedures and covering the whole lifecycle. Companies signed up to the Charter must report annually on these KPIs to measure their progress towards sustainable cleaning. The data collected is independently verified by an international audit firm.

Since 2010, the Charter also incorporates a product dimension, enabling companies to offer sustainability assurance for individual products, by complying with Charter Advanced Sustainability Profiles (ASPs). The Advanced Sustainability Profiles cover following aspects: Ingredient's safety (if applicable), product formulation, packaging weight and recycled content as well as end-user information.

Products which meet the requirements of these ASPs may then use a differentiated 'ASP' logo on pack which signifies not only that the manufacturer is committed to certain sustainability processes at the manufacturing level, but also that the product itself meets certain advanced sustainability criteria. ASPs are specific to product categories. The following criteria for laundry detergents exist.

Criteria for household Solid Laundry Detergents (including tablets)

The following requirements in each of these domains (i.e. product formulation, packaging and end-use information) should be fulfilled in order to reach Advanced Sustainability Profile (ASP) status (A.I.S.E. 2012):

Table 1.27: Advanced Sustainability Profile (ASP) requirements for household Solid Laundry Detergents (including tablets); source (A.I.S.E. 2012)

Criteria category	Requirements
Product formulation	Pass successfully Environmental Safety Check (ESC) on all ingredients AND Dosage g/job(*): ≤ 75 g AND Dosage ml/job(*): ≤ 115 ml (*) job (i.e. washing cycle): following the Detergent Regulation EC 648/2004 the "standard washing machine loads are 4,5 kg dry fabric for heavy-duty detergents and 2,5 kg dry fabric for low-duty detergents"
Overall packaging weight	Total (primary + secondary but excluding tertiary) packaging g/job: ≤ 6.5 g
Board packaging – recycled content	Minimum requirement: ≥ 60 % OR Where 100% of the board used is certified made from fibre sourced from sustainable forests under an endorsed certification standard such as FSC, SFI or PEFC: no minimum.
Materials other than board – recycled content	No minimum, but any recycled plastic content may be excluded from the calculation of overall packaging weight per job
Wash temperature	Ability to wash at ≤ 30° C indicated on pack
End user information	End-user info on-pack: Laundry Cleanright (former Washright) Panel Safe Use tips
Performance	Evidence has to be provided (in case of external verification organised by A.I.S.E.) that the product has been performance tested and reached a level acceptable to consumers consistent with claims made.

Criteria for household Liquid Laundry Detergents Products

The following requirements in each of these domains (i.e. product formulation, packaging and end-use information) should be fulfilled in order to reach Advanced Sustainability Profile (ASP) status (A.I.S.E. 2011b):

Table 1.28: Advanced Sustainability Profile (ASP) requirements for household Liquid Laundry Detergents; source (A.I.S.E. 2011b)

Criteria category	Requirements
Product formulation	Pass successfully Environmental Safety Check (ESC) on all ingredients AND Dosage ml/job*: ≤ 75ml (*job: following the Detergent Regulation EC 648/2004 the "standard washing machine loads are 4,5 kg dry fabric for heavy-duty detergents and 2,5 kg dry fabric for low-duty detergents")
Packaging weight per job	Total (primary + secondary but excluding tertiary) packaging g/job: ≤ 7.0 g
Packaging – recycled content	Primary packaging: No minimum, but any recycled plastic content is excluded from calculation of packaging weight per job Secondary packaging: Board: ≥ 60%
Wash temperature	Ability to wash at ≤ 30° C indicated on pack
End user information	End-user info on-pack: Washright panel or alternative
Performance	Evidence has to be provided (in case of external verification organised by A.I.S.E.) that the product has been performance tested and reached a level acceptable to consumers consistent with claims made.

<u>Criteria for household Fabric Conditioners</u>

The following requirements in each of these domains (i.e. product formulation, packaging and end-use information) should be fulfilled in order to reach Advanced Sustainability Profile (ASP) status (A.I.S.E. 2011a):

Table 1.29: Advanced Sustainability Profile (ASP) requirements for household Fabric Conditioners; source (A.I.S.E. 2011a)

Criteria category	Requirements
Product formulation	Pass successfully Environmental Safety Check (ESC) on all ingredients AND Dosage ml/job*: ≤ 35ml (*job: following the Detergent Regulation EC 648/2004 the "standard washing machine loads are 4,5 kg dry fabric for heavy-duty detergents and 2,5 kg dry fabric for low-duty detergents")
Packaging weight per job	Total (primary + secondary but excluding tertiary) packaging g/job: ≤ 4g
Packaging – recycled content	Primary packaging: No minimum, but any recycled plastic content is excluded from calculation of packaging weight per job Secondary packaging: Board: ≥ 60%
End user information	End-user info on-pack: Washright panel or alternative
Performance	Evidence has to be provided (in case of external verification organised by A.I.S.E.) that the product has been performance tested and reached a level acceptable to consumers consistent with claims made.

The products also carry on a voluntary basis some best use advice to promote the sustainable use of detergents (dosage, low temperature washing, filling of the machine etc.) whether laundry or automatic dishwashing detergents, which are featured on all packs of products (see: http://www.aise.eu/library/artwork.aspx; www.cleanright.eu).

A.I.S.E. "Product Resource Efficiency Projects"

All over Europe, powder detergents are becoming more concentrated, meaning that according to A.I.S.E. there are less raw materials and less packaging needed, which leads to less waste and reduced CO_2 emissions from transport. This voluntary industry initiative shall inform consumers to pay careful attention to the new dosing instructions, as they will need to use less detergent from now on for the same washing.

<u>Product Resource Efficiency Project for Laundry Powder Detergents "PREP-P3"</u>:

The product scope covers Heavy Duty Low Suds (HDLS) powder detergents used for household laundry. Participating companies commit:

- To compact / concentrate their laundry powder detergents, reaching a recommended dosage ≤75 g/wash and ≤115 ml/wash for a normal washing machine load, delivering at least the same performance as before
- To optimize the usage of packing materials, committing to a reduction by ensuring a high fill level, remaining at least overall in line with current filling levels. In particular, for individual rigid containers, effective filling ratios should continue to be no less than 70% of the maximum filling ratio
- To communicate to consumers about the correct use of compact products through on-pack communication, using the A.I.S.E. non-branded material

By end of June 2014 participating companies must have started "placing on the market" the new products with the on-pack communication material and must have stopped producing pre-PREP products.

<u>Product Resource Efficiency Project for liquid Fabric Conditioners "PREP-FC"</u>:

The product scope covers Liquid Fabric Conditioners (FC) used for household laundry. Participating companies commit:

- To concentrate their liquid Fabric Conditioners, reaching a recommended dosage ≤35 ml/wash for a normal washing machine load, delivering at least the same performance as before
- To optimize the usage of packing materials, committing to a reduction by ensuring a high fill level, at least overall in line with current filling levels
- To communicate to consumers about the correct use of concentrated products through on-pack communication, using the A.I.S.E. non-branded material

By end of June 2014 participating companies must have started "placing on the market" the new products with the on-pack communication material and must have stopped producing pre-PREP products.

Multi-stakeholder campaign called "I prefer 30°"

Recently, a specific multi-stakeholder campaign called "I prefer 30°" (for laundry low temperature washing) has been conducted, in a multi-stakeholder way, as it is opened to retailers, appliance manufacturers, fashion manufacturers/retailers, authorities, NGOs and other corporate supporters. The aim is to raise awareness of the benefits and support consumers in lowering their wash temperatures.

More information can be available via www.iprefer30.eu

1.3.3. Test standards

In the following, an overview of existing test standards and measurement methods for resource efficiency with regard to the aspects durability (maintenance, repair, re-use) and recyclability is given.

<u>Note</u>: This section only presents resource related standards for washing machines and washer-dryers. Standards related to ecodesign, energy efficiency and other performance criteria are presented separately in section 1.2.2.

1.3.3.1. Durability

According to stakeholder feedback, there exist only few standards originally designed for durability purposes.

Austrian standard ONR 192102:2014 on durable, repair-friendly designed electrical and electronic appliances

ONR 192102:2014-10-01 with regard to a label of excellence for durable, repair-friendly designed electrical and electronic appliances replaces ONR 192102 from 2006 (Sustainability label for electric and electronic appliances designed for easy repair (white and brown goods)).

Manufacturers of electrical and electronic equipment, who intend to mark their products with a label for repair-friendly designed appliances, have to test their products according to the requirements of ONR 192102 verifying compliance with a test report. According to (Ricardo-AEA 2014b), this standard suggests a labelling system with three levels of achievement (good, very good, excellent) based mostly upon reparability criteria. The standard includes white goods (such as washing machines). The aim is to consider reparability to ensure products are not discarded sooner than is necessary as the result of a fault or inability to repair a fault.

The in total 40 criteria for white goods are split into mandatory criteria and other criteria for which a certain scoring can be achieved. To comply, products have to fulfil all mandatory requirements and achieve a minimum number of scores for common criteria and for service documentation.

The types of requirements include criteria such as accessibility of components, ease of disassembly, use of standard components, achievable service life (at least 10 years for white goods), availability of spare parts (at least 10 years after the last production batch), facilitation of regular maintenance, and further service information (inter alia free access for all repair facilities (not only authorized repairers) to repair-specific information). Each requirement is underpinned with some examples of realisation; however, no specific testing procedures and techniques are detailed.

British PAS 141 re-use standard

The PAS 141 specification has been developed by British Standards Institution (BSI) to increase the re-use of electrical and electronic equipment and to ensure that they are tested and repaired to a minimum level. The British non-for-profit company WRAP has developed a set of protocols based on industry experience highlighting tests and procedures to be carried out. The product protocols form a baseline for electrical product assessment and repair for re-use and can be used as a guideline to product assessment and testing (WRAP [n.d.]e).

The PAS 141 Protocol Product Guide for washing machines, tumble dryers and washer/dryers developed by WRAP describes a series of minimum tests that should be performed on those domestic-use appliances when the product shall be considered functional or fit for re-use for auditing purposes. No specific testing procedures and techniques are described as the protocol shall be applied as widely as possible. (WRAP 2013b)

According to (WRAP 2013b), the PAS 141 protocol refers only to domestic-use machines that use water as the primary cleaning solution and includes top- and front-loading washing machines, washer/dryers and tumble dryers, as opposed to dry cleaning machines (which use alternative cleaning fluids) or ultra-sonic cleaners. It excludes twin-tub machines, which are rarely available.

The following components of a washing machine, tumble dryer or washer/dryer shall undergo a visual inspection, safety or function test:

Table 1.30: PAS 141 Protocol Product Guide for washing machines, tumble dryers and washer/dryers (Source: adapted (WRAP 2013b))

Component	Test
Hoses, trims, connector, seals	Visual inspection of condition and for damage
Door or lid hinges and handles and soap trays	Visual inspection of condition
Feet / wheels	Visual inspection of absence or damage
Knobs, switches, and fixings	Visual inspection of absence or damage
Cabinet and back panel	Visual inspection of condition
Plug and lead cables	Safety test regarding condition and connection
Motor	Function test
Drum / spider	Function test of bearings (in place and secure)
Door - locking and unlocking	Function test
Hoses, connectors, seals	Function test for leakage
Programmes	Function test
Internal components, pressure switches, modules and wiring	Presence and function test
Thermostat and heating element	Function test
Detergent dispenser	Function test
Rinse cycle, drain operation, spin operation, drying cycle (including sensor drying, if available)	Function test
Delayed start	Function test
Outlet pipe, sump hose	Function test regarding damage or leaks
Filter	Presence and function test
Timer	Function test
Condenser system	Function test

Durability test standards and measurement methods applied in EU Ecodesign and Ecolabel regulations

In some existing EU Ecodesign regulations requirements with regard to the durability of products or components are specified. The according test procedures are detailed in sections 1.3.1.7 to 1.3.1.9.

<u>International IEC 60068-1 ed7.0 Environmental testing</u>

The test procedures described in this IEC standard are used as reference in the draft EU Ecolabel criteria for "Personal, notebook and tablet computers" with regard to durability testing of portable computers (cf. section 1.3.2.3).

IEC 60068-1:2013 includes a series of methods for environmental testing along with their appropriate severities, and prescribes various atmospheric conditions for measurements and tests designed to assess the ability of specimens to perform under expected conditions of transportation, storage and all aspects of operational use. Although primarily intended for electro-technical products, this standard is not restricted to them and may be used in other fields where desired. The IEC 60068 series consists of:

- IEC 60068-1 – General and guidance, which deals with generalities;
- IEC 60068-2 – Tests – which publishes particular tests separately for different applications;
- IEC 60068-3 – Supporting documentation and guidance, which deals with background information on a family of tests. The families of tests comprising Part 2 of the IEC 60068 series are designated by the following upper-case letters:
  - A: Cold
  - B: Dry heat
  - C: Damp heat (steady-state)
  - D: Damp heat (cyclic)
  - E: Impact (for example shock and rough handling shocks)
  - F: Vibration
  - G: Acceleration (steady state)
  - H: (Awaiting allocation; originally allotted to storage tests)
  - J: Mould growth
  - K: Corrosive atmospheres (for example salt mist)
  - L: Dust and sand
  - M: Air pressure (high or low)
  - N: Change of temperature
  - P: (Awaiting allocation; originally allotted to “flammability”)
  - Q: Sealing (including panel sealing, container sealing and protection against ingress and leakage of fluid)
  - R: Water (for example rain, dripping water)
  - S: Radiation (for example solar, but excluding electromagnetic)
  - T: Soldering (including resistance to heat from soldering)
  - U: Robustness of terminations (of components)
  - V: (Awaiting allocation; originally allocated to “acoustic noise” but “vibration, acoustically induced” will now be Test Fg, one of the “vibration” family of tests.
  - W: (Awaiting allocation)
  - Y: (Awaiting allocation)

Product endurance tests of consumer test magazines (Stiftung Warentest)

Besides tests for durability of components (focus mostly on safety), no widely established test standards for the durability of whole products with regard to their functional quality exist. Some consumer test magazines have developed their own endurance tests. For example, Stiftung Warentest developed and carried out durability tests for washing machines and washer dryers in the last years.

- For washing machines, three machines of each model in the test are run in total 1,840 cycles in different programmes with practice-oriented load and usual heavy duty detergents;

this shall correspond to a lifetime of around 10 years with 3.5 wash cycles per week. (Stiftung Warentest 2013)

- For washer-dryers, three machines of each model in the test are run in total 1,430 cycles in different programmes with practice-oriented load and usual heavy duty detergents; thereof 360 cycles in the programme “wash-dry colour, cupboard dry”; this shall correspond to a lifetime of around 8 years with 3.5 wash cycles per week. (Stiftung Warentest 2012b)

Safety standards for products and components, indirectly addressing durability

There are some standards which are related to the safety of products and components and seem to address quality and/or durability of those components at least indirectly.

For example, EN 60335 addresses product safety; EN 60335 Part 1 defines general safety requirements on household and similar electrical appliances, whereas Part 2 is divided into specific sub-parts each containing appropriate appliance specific safety requirements inter alia for washing machines:

Table 1.31: Examples of safety standards for household and similar electrical appliances and their indirect requirements for quality and durability of components to comply with product safety

Standard	Component	Requirement
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, Annex C	Engine	Ageing-check for engines (in device-specific parts are modifications possible)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 25	Power supply and external cables	(In device-specific parts are modifications possible regarding the number of operating cycles)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014; section 23	Inner cables	The flexible part is being moved with 30 bends per minute backwards and forwards, so that the conductor is bended by the feasible biggest angle, enabled with this construction. The number of bends accounts: • 10,000 for conductors, which are bended during proper use • 100 for conductors, which are bended during users-maintenance (In device-specific parts are modifications possible, concerning the number of bends)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for switches: IEC 61058-1	Components: Switches	Number of operating cycles have to add up to at least 10,000
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for regulation- and control systems is IEC 60730-1	Components: Regulation and control systems	Minimum number of required operating cycles for example • for temperature controllers: 10,000; • for operating temperature limiter – 1,000 (In device-specific parts are modifications possible regarding the number of operating cycles)
Household and similar electrical appliances - Safety - Part 2-7: Particular requirements for washing machines	Lid- and door locking systems	Lid or door undergo 10,000 operating cycles (13,000 operating cycles for appliances with drying function) consisting of opening and

Standard	Component	Requirement
(IEC 60335-2-7:2008, modified + A1:2011, modified); EN 60335-2-7:2010 + A1:2013 + A11:2013		closing (opening-angle, opening-speed and force are well defined).
Household and similar electrical appliances - Safety - Part 2-7: Particular requirements for washing machines (IEC 60335-2-7:2008, modified + A1:2011, modified); EN 60335-2-7:2010 + A1:2013 + A11:2013)	Firmness of lid and door	Test with rubber-hemisphere (diameter 70 mm; defined hardness, attached to a cylinder with 20 kg mass) is dropped to the centre of the lid and the door from a height of 1 metre; to be repeated three times.; furthermore, the lid shall have enough firmness to resist deformation
ISO 6804:2009	Rubber and plastics inlet hoses and hose assemblies for washing-machines	Requirements for three types of rubber or plastics inlet hoses and hose assemblies for washing-machines and dishwashers connected to the domestic water supply at a pressure not exceeding 1 MPa (10 bar). It is applicable to the following types of hose: • Type 1: rubber hoses for unheated water supply (maximum temperature 70 °C). • Type 2: rubber hoses for heated water supply (maximum temperature 90 °C). • Type 3: plastics hoses for unheated water supply (maximum temperature 60 °C). The standard foresees performance requirements for finished hoses, such as bending tests, flexing tests, resistance to kinking, resistance to hydrostatic pressure after ageing resistance to ozone or weathering, resistance to hydraulic-pressure impulse test, adhesion and mechanical resistance of thermoplastics coupling nuts.

According to stakeholder feedback via questionnaire (JRC IPTS 2015a), however, those existing safety and endurance / performance standards cannot directly be translated into durability standards. The standards are used by companies to test the safety of their appliances under endurance tests and extreme conditions to ensure consumers' safety during functioning of the appliance, but also in case of incident (stress tests to ensure that people do not get hurt). This is especially true for safety standards to measure components for failure. According to the stakeholder's feedback, methods for testing failed components have no relation to component durability, although they might be a good starting point for standardisation organisations' investigations in starting up standardisation work for testing durability of appliances and/or components. In this context, the safety standards would have to be checked for details of the testing conditions to make sure that they are applicable for an alternative purpose. Furthermore, the pass/fail criteria would need to be completely redefined.

(Ricardo-AEA 2014b) argue in the same direction, that the adoption of the EN 60335 test requirements into an Ecodesign Regulation would not affect the durability performance of appliances since these requirements should already be achieved and declared for LVD compliance. However, they could be the basis of tests, potentially with higher minimum standard pass requirements.

(Ardente & Talens Peirò 2015) conducted a survey in the websites which revealed that several manufacturers of household dishwashers claim to perform durability tests on sample of devices before putting them in the market. Tests are generally based on intensive use under pre-set conditions, in order to simulate the total number of washing cycles during lifetime. (Ardente & Talens Peirò 2015) propose these manufacturers' procedures to be potentially translated into standardised procedures. It is assumed, that also manufacturers of household washing machines and washer-dryers perform such durability tests on sample of devices before putting them in the market.

1.3.3.2. Recyclability and end-of-life treatment of electrical and electronic equipment

EN 50574: Collection, logistics and treatment requirements for end-of-life household appliances containing volatile fluorocarbons of volatile hydrocarbons

Washing machines and washer dryers, if operated with heat pump, should be covered by standard EN 50574. Discarded appliances covered by this European Standard will have been deposited at a collection facility as domestic WEEE.

Standard EN 50574 was prepared by CENELEC's Technical Committee 111X / Working Group 04, "Environment - End of life requirements for household appliances containing volatile fluorinated substances or volatile hydrocarbons" and published in 2012. It defines requirements for the end of life handling, transportation, storage, sorting and treatment of WEEE household appliances containing volatile fluorocarbons, volatile hydrocarbons, or both; as well as requirements for monitoring and reporting. Furthermore, this European standard only applies to WEEE household appliances that use heat-transfer media other than water e.g. refrigerators, freezers, heat pump tumble dryers, de-humidifiers and portable air conditioners.

The standard describes requirements for the removal of volatile fluorocarbons and volatile hydrocarbons. These substances can be found as refrigerant in the refrigerating system (partly dissolved in the oil) and as blowing agent in the insulating foam of discarded household appliances.

Further, Annex D of the standard includes sorting requirements for heat pump tumble dryers based on instructions for identifying tumble dryers containing fluorinated refrigerants. According to the European F-gas Regulation (cf. section 1.3.1.5) and the WEEE Directive (cf. section 1.3.1.2), volatile fluorinated hydrocarbons (VFCs) have to be removed when recycling appliances. Special treatment plants are required to recycle appliances containing VFCs. To achieve the right treatment for heat pump tumble dryers with VFCs it is therefore necessary to ensure identification and correct sorting of these appliances. The following procedure should be used to facilitate this identification: Marking according to the requirements of the F-gas Regulation. The information is usually printed on a separate label, placed on the back of the machine with a text declaring that the appliance contains fluorinated gases that are covered by the Kyoto protocol. Or it could be included in the main rating plate. Other ways of identification, if the information is not provided via F-gas label or the main rating plate is the existence of a compressor and a heat exchanger which can be seen when opening the device.

These requirements shall also be applicable to other household appliances if operated with heat pumps, such as washing machines and washer dryers.

TS 50574-2: Collection, logistics & treatment requirements for end-of-life household appliances containing volatile fluorocarbons or volatile hydrocarbons - Part 2: Specification for de-pollution

This Technical Specification, published in November 2014, is intended to support EN 50574:2012 (see above) by providing further normative requirements for the measurement of de-pollution for treatment of end-of-life household appliances containing volatile fluorocarbons or volatile hydrocarbons. Any characteristic numbers and target values within this technical specification are based on evidence gathered by technical experts over a time period of more than two years when performing test according to EN 50574:2012.

EN 50574:2012 gives the responsible take-back parties the task of defining target values (e.g. for treatment, and minimum masses of volatile fluorocarbons or volatile hydrocarbons to be recovered). This Technical Specification provides applicable target values, characteristic numbers, sampling and analysis procedures, as well as monitoring and reporting requirements. Furthermore the Technical Specification provides validation methodologies for tests and the daily business of the treatment plants as defined in EN 50574:2012.

European Commission's Mandate M/518 for standardisation in the field of Waste Electrical and Electronic Equipment (WEEE)

According to (CENELEC n.d.), mandates, also called standardization requests are the mechanism by which the European Commission (EC) and the EFTA Secretariat request the European Standards Organizations (ESOs) to develop and adopt European standards in support of European policies and legislation. This mechanism evolves through several steps: Sending a provisional draft mandate, a draft mandate and finally a mandate for acceptance to CENELEC. The Technical Board Members are invited (not) to accept the given mandate, with or without restrictions, based on the Technical Body and CENELEC feedback. In case of acceptance of the mandate, the Technical Body is entrusted with the task of starting expected standardization work within CENELEC.

In January 2013, the European Commission has sent Mandate M/518 to the European standardisation organisations with the purpose to develop one or more European standard(s) for the treatment (including recovery, recycling and preparing for re-use) of waste electrical and electronic equipment, reflecting the state of the art. The European standard(s) requested by this mandate shall assist relevant treatment operators in fulfilling the requirements of the WEEE Directive. (European Commission 2013b)

EN 50625 standard series: Collection, logistics & treatment requirements for WEEE

CENELEC, through its Technical Committee 'Environment' (CLC/TC 111X), is leading the development of standards (and other deliverables) that will support the implementation of the EU Directive on Waste Electrical and Electronic Equipment. These standards, which are being developed in response to a request issued by the European Commission (EC M/518, see section above), cover various aspects of the treatment of electronic waste (including collection, treatment requirements, de-pollution and preparing for re-use). TC111X works on standards related to the environment and set up Working Group 6 for the EN 50625 series.

According to (SENS/Swico/SLRS 2014), the general standard EN 50625-1 (Collection, logistics & treatment requirements for WEEE - Part 1: General treatment requirements) came into force recently. On 20 December 2013 the voting of the European National Committees on the general WEEE treatment standard EN 50625 resulted in the acceptance of the standard which was finally published in March 2014. It establishes the basis for the standards to follow for individual categories of equipment, such as lamps, monitors and photovoltaic panels. These more specific standards will contain references to the general standard, and together they will form the EN 50625 series. Additionally, an associated Technical Specification TS 50625-3-1 for de-pollution (general) has been developed in 2014.

The standard on general treatment requirements includes on the one hand administrative and organisational requirements for the treatment operator and the treatment facility such as management, infrastructural pre-conditions, training and monitoring. On the other hand, technical requirements regarding the handling of WEEE, the storage of WEEE prior to treatment, the de-pollution process, the determination of recycling and recovery targets and documentation requirements. The technical specification further details different methodologies for monitoring of de-pollution.

According to (SENS/Swico/SLRS 2014), the technical specifications are just as binding as the standards themselves, except that they contain limit values and target values as well as instructions for taking samples of material and specific details for performing tests.

Besides Part 1 on general treatment requirements, further parts are under development:

- EN 50625-2-1: Treatment requirements for lamps plus associated Technical Specification for de-pollution TS 50625-3-2
- EN 50625-2-2: Treatment requirements for WEEE containing CRTs and flat panel displays plus associated Technical Specification for de-pollution TS 50625-3-3
- EN 50625-2-3: Treatment requirements for WEEE containing volatile fluorocarbons or volatile hydrocarbons; according to stakeholder feedback, this standard has currently a draft status and is planned to replace EN 50574:2012. Also for this standard, an associated Technical Specification for de-pollution (TS 50625-3-4) will be developed. According to stakeholder feedback, the draft is not yet available, however, will replace TS 50574-2:2014 when adopted.
- EN 50625-2-4: Treatment requirements for WEEE for photovoltaic panels plus associated Technical Specification for de-pollution TS 50625-3-5.

Additionally to these 5 standards and corresponding Technical Specifications (TS), three further TS shall be developed covering horizontal matters:

- TS 50625-4: Specification for the collection and logistics associated with WEEE
- TS 50625-5: Specification for the end processing of WEEE fractions – copper and precious metals
- TS 50625-6: Report on the alignment between Directive 2012/19/EU and EN 50625 series standards

For household washing machines and washer-dryers, especially the standard and technical specification regarding the treatment of WEEE containing refrigerants would be applicable in case of appliances operated with heat pumps. If in future, appliances would be equipped with control panels greater than 100 cm^2, also EN 50625-2-2 and TS 50625-3-3 would apply. Precious metals, for which the technical specification TS 50625-5 is planned, can be found for example in PWBs, containing palladium, silver and gold, and in permanent magnet motors of washing machines and washer-dryers.

Whereas the standards and according technical specifications define requirements regarding the removal and further treatment of certain substances, mixtures and components such that they are contained as an identifiable stream or part of a stream by the end of the treatment process, they do not specify requirements for better identification or ease of dismantling of those components to facilitate the end-of-life treatment process itself.

EN 50614 (under preparation): Requirements for the preparation for re-use of waste electrical and electronic equipment

The Technical Committee CLC/TC 111X, Working Group 7 started the preparation of such a standard in March 2014 which shall be completed in December 2015.

European Commission's draft Mandate M/529 with regard to ecodesign requirements on material efficiency

The European Commission addressed in January 2015 a standardization request to the European standardization organisations (ESOs) to develop generic methodologies related to material efficiency, such as durability, reusability, recyclability and recoverability. Related aspects, such as upgradeability, reversible disassembly time, end of life dismantling time, part mass or value, calculation of recycled and re-used content in products, or other relevant characteristics relevant for the product groups under consideration, were asked to be included if appropriate. The request covered the following generic standards to be developed (European Commission 2015a):

a) Reusability / recyclability / recoverability (RRR) indexes by mass

b) Reusability / recyclability / recoverability (RRR) indexes by environmental impact

c) Durability of products or some of their key components

d) Measuring the time for the reversible disassembly, substitution and re-assembly of key components of products

e) Measuring the dismantling time of products (or of its components) at end-of-life

The standardization request was rejected by ESOs. According to (ECOS, EE and UK SNS 2015), the standardisation organisations rejected the Commission's initial mandate on the grounds that it was too prescriptive on the above listed requirements asked for and also the inability to fully develop the methods within the proposed timescale.

It is expected that the European Commission will specify a new standardization request taking into account the reasons for such a rejection and hand in the revised mandate to the ESOs again. The European Commission is currently working on a new draft horizontal mandate. However, it should be highlighted that once the request is accepted, the process of developing such standards could take up to or even more than three years.

IEC/TR 62635: Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment

The Technical Report IEC/TR 62635:2012 ed1.0 (IEC 2012) provides a methodology for information exchange involving EEE manufacturers and recyclers, and for calculating the recyclability and recoverability rates to

- provide information to recyclers to enable appropriate and optimized end-of-life treatment operations,
- provide sufficient information to characterize activities at end-of-life treatment facilities in order to enable manufacturers to implement effective environmental conscious design (ECD),
- evaluate the recyclability and recoverability rates based on product attributes and reflecting real end-of-life practices.

Furthermore this technical report includes:

- criteria to describe EoL treatment scenarios;
- criteria to determine product parts that might require removal before material separation and related information to be provided by manufacturers (location and material composition);
- a format for information describing EoL scenarios and the results of EoL treatment activities;
- a method for calculating the recyclability and recoverability rate of EEE. The calculation is limited to EoL treatment and does not cover collection. The recyclability rate is expressed as a percentage of the mass of the product that can be recycled or reused, whereas the recoverability rate in addition includes a portion derived from energy recovery. This techncial report can be applied to all electrical and electronic equipment;
- some example data corresponding to identified scenarios.

IEC/TC 111 PT 62824: Guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

Further, under the IEC Technical Committee 111, Project Team 62824 has been established to provide guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

ISO 11469: Plastics - Generic identification and marking of plastics products

This International Standard, published in 2000, specifies a system of uniform marking of products that have been fabricated from plastics materials. The marking system is intended to help identify plastics products for subsequent decisions concerning handling, waste recovery or disposal. Generic identification of the plastics is provided by the symbols and abbreviated terms given in ISO 1043, parts 1 to 4:

- ISO 1043-1, Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics.
- ISO 1043-2, Plastics — Symbols and abbreviated terms — Part 2: Fillers and reinforcing materials.
- ISO 1043-3, Plastics — Symbols and abbreviated terms — Part 3: Plasticizers.
- ISO 1043-4, Plastics — Symbols and abbreviated terms — Part 4: Flame retardants.

The standard includes requirements on the marking system and the method of marking. The marking system is subdivided into marking of products, of single-constituent products, of polymer blends or alloys, and of compositions with special additives (fillers or reinforcing agents, plasticizers, flame retardants and products with two or more components difficult to separate).

The standard is often referred to in ecolabels containing requirements on resource efficiency and end-of-life treatment of appliances.

British standard BS 8887: Design for Manufacture, assembly, disassembly and end-of-life processing ("MADE")

The British Standards Institution has developed a design for manufacture standards series BS 8887 (Design for Manufacture, Assembly, Disassembly and End-of-life processing MADE) first in 2006. The series contains of following sub-standards:

- BS 8887-1: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 1: General concepts, process and requirements (01 February 2012, superseding BS 8887-1:2006)
- BS 8887-2: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 2: Terms and definitions (01 July 2014)
- BS 8887-211: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 211: Specification for reworking and remarketing of computing hardware (31 August 2012). This sector-specific standard focuses on the information and communication technology sector and created to provide the vocabulary and procedures for 'remarketed products', i.e. products that cannot be sold as new. It is planned to develop a generic remarketing standard for use by all sectors, using BS 8887-211 as a template (BSI Group n.d.).
- BS 8887-220: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 220: The process of remanufacture – specification. It outlines the steps required to change a used product into an 'as-new' product, with at least equivalent performance and warranty of a comparable new replacement product (BSI Group n.d.).

- BS 8887-240: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 240: Reconditioning (March 2011)

According to (BSI Group n.d.),

> *In 2012, BS 8887-1 was put forward to the ISO and it has been accepted onto the work programme of the ISO committee with responsibility for technical product documentation. A new working group is being set up, which will be led by the UK, and work to convert BS 8887-1 into an international standard.*

The international standard BS ISO 8887-1 Design for manufacture, assembly, disassembly and end-of-life processing (MADE) Part 1: General concepts, process and requirements is currently in development, by the BSI committee TDW/4 'Technical Product Realization' being responsible.

1.3.3.3. Test standards regarding the use of detergents

Basically, the performance standard EN 60456 defines a test procedure for measuring the washing performance of the washing machine under a certain reference detergent (cf. section 1.2.2.1).

For testing the performance of detergents themselves, according to (Center for Testmaterials BV n.d.), there have been numerous of test methods which were used for detergent testing. In the last few years there was more movement towards standardisation and consensus. The two main exponents from that are: the AISE-protocol and the Ecolabel-standard which are moving closer together. Especially the AISE-protocol is a base standard that means it leaves a lot of room to add other stains or test materials as well, so that you can better incorporate the protocol into your own protocols. Both protocols incorporate a section on colour management as well.

A.I.S.E. Minimum protocol for comparative detergent performance testing

A.I.S.E., the International Association for Soaps, Detergents and Maintenance Products, developed the first detergent test protocol in 2009 and updated it in 2013. The protocol aims at advising test institutes and consumer organisation about the minimum set of tests for assessing the performance of detergents across Europe, independent from the country under test. The A.I.S.E. working group "Detergent Testing" has published the "Minimum protocol for comparative detergent performance testing" for Heavy Duty, Colour Save and Light Duty Detergents and Stain Removers.

The test protocol includes minimum requirements – free to exceed those but not lower them, and can be adapted to different countries/regions, differences in wash habits, wash temperatures, recommended dosages, etc. Inter alia, the test protocol defines parameter like dosage, soil donator, stain set, dyes for dye transfer inhibition, dyes for colour maintenance, the test execution, statistical evaluation or requirements to the communication of results prior to publication.

For example, dosages should be based on manufacturers' recommendation. Regarding the wash temperature, the temperature that is most relevant in the country shall be selected; different temperatures may be used if justified by product category. In most countries this is 40°C for generalist detergents.

The protocol has been developed based on experts' knowledge of major companies manufacturing such products, after a thorough review of existing test protocols used in western Europe and of existing internal company data. For more information, please refer to

http://www.aise.eu/our-activities/standards-and-industry-guidelines/detergent-test-protocol.aspx

EU Ecolabel Performance Test for Laundry Detergents

In June 2014, the final draft of a revised EU Ecolabel Performance Test for Laundry Detergents has been published. (European Commission 2014c)

The test protocol serves as a prove to show compliance with Criterion 6 – Washing performance (fitness for use) of the Commission Decision establishing EU Ecolabel criteria for Laundry Detergents. It detailed describes the test criteria, materials and conditions (such as water hardness, water inlet temperature, ballast load, stains set, soil, dosage, number of cycles etc.), the methods and test procedures including evaluation of stain removal, basic degree of whiteness, colour maintenance and dye transfer inhibition.

Nordic Ecolabel Performance Test (fitness for use)

The Scandinavian Ecolabel "Nordic Swan" labels products which are environmentally friendly and "fit for use". Beside an ecological evaluation of the ingredients, the product must proof its performance in a so called Nordic Ecolabel Performance Test (fitness for use). The Test is detailed described in Appendix 6 (Nordic Ecolabel Performance Test (fitness for use)) of the Nordic Ecolabelling of Laundry detergents and stain removers, Version 7.7 (Nordic Ecolabelling 2011).

The performance test is categorised into four different parts for Heavy-Duty detergents, Low-duty detergents, Stain removers with subsequent wash and Stain removers without subsequent wash. It clearly defines parameters such as washing machines and wash programmes, water quality, materials, the test procedure, evaluation and sets limit values.

Others

Further own or adapted test protocols for performance testing of laundry detergents are applied for example by consumer testing magazines like Que Choisir, Stiftung Warentest, Which? Consumentenbond, Test Achat, AFISE. The report of the EU project MarketWatch "Approaches and priority parameters tested by consumer associations and independent organisations performing tests on energy-using products" provides an overview of the current activities of consumer associations and independent endorsement organisations in Europe with respect to the testing of energy-using products. It is based on a survey conducted among the MarketWatch project partners and their partners/members.

The report is available on:

http://www.market-watch.eu/wp-content/uploads/2014/01/MW_NGO-approaches.pdf

1.3.4. Other studies on material resource efficiency

1.3.4.1. Study "Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency" by Bundgaard et al.

In their study "Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency", (Bundgaard et al. 2015) reviewed 23 currently adopted implementing measures and voluntary agreements under the Ecodesign Directive, criteria for resource efficiency in voluntary instruments such as ecolabels and Green Public Procurement as well as recent Commission projects with regard to implementation of resource efficiency aspects into the ecodesign directive.

In the study, Bundgaard et al. generally include under "resource efficiency" the following measures:

- Reducing materials and energy use in the entire life cycle of products (mining of materials, production / use / final disposal of the product)
- Improving possibilities for maintenance and repair (e.g. guidelines)
- Ensuring re-use or redistribution, i.e. multiple use cycles.
- Increasing the potential for remanufacturing or refurbishment of the product, i.e. multiple use cycles (e.g. improving reparability, access to spare parts)

- Improving recyclability of materials used in the product

The review of existing instruments revealed that resource efficiency is already widely applied in voluntary instruments covering energy related products. The instruments include following criteria which were also assessed by the study team with regard to their transferability to the Ecodesign Directive (Bundgaard et al. 2015):

Declaration and threshold of RRR ratio (reusability, recyclability and recoverability)

According to (Bundgaard et al. 2015), transferring declaration and threshold requirements with regard to RRR ratio to the implementing measures and voluntary agreements of the Ecodesign Directive first needs a common methodology to be developed on how to calculate the RRR ratio for products and materials to verify the requirements based on technical information provided by the producers.

However, setting requirements for the RRR ratio of the material or the product only reflects the theoretical potential and will not ensure that the materials or products are in fact reused, recycled or recovered which depends on the infrastructure for collection and treatment and the technologies available.

In case of future requirements to RRR ratio it is recommended to make them according to the waste hierarchy, by prioritising reuse before recycling and recycling before recovery.

Declaration and/or threshold of recycled content

According to (Bundgaard et al. 2015), setting criteria for the threshold of recycled materials can help create a market for these materials. The environmental benefits of using recycled materials would depend on the type of material. However, before transferring these requirements to the Ecodesign Directive, it is important to assess if producers of recycled materials can satisfy increased demands on the market that a requirement would create. A possibility could be to begin by setting declaration requirements and then tightening them continuously by setting threshold requirements.

If setting criteria for recycled materials, however, first reliable technologies for an analytical assessment of the recycled content in the products would be needed to enable verification and market surveillance.

Bill of materials (BOMs)

BOMs are an important source of information to conduct LCAs, assess the product's recyclability, recoverability and recycled content and identify priority resources in the product to ensure their reuse and recycling; all of these activities are basis for other requirements to improve resource efficiency.

However, (Bundgaard et al. 2015) conclude that due to the complexity of the supply chain of electronic and electrical equipment, a mandatory requirement on providing BOMs would be challenging to comply especially for small producers, as they might not have the ability to force these requirements on to their larger suppliers. Further, the implementation of such a requirement might first need the setup of a system that can ensure the companies' property rights, e.g. with regard to the use of rare metals.

Identification of plastic components

Marking of plastic components according to ISO 11469, at least the main ones, shall help recyclers identifying different plastic types and parts to ensure correct handling during waste recovery or disposal, especially when the plastic parts are manually sorted. Also, the visual marking of plastics parts according to certain ISO standards might be quite easy to verify visually by market surveillance authorities when dismantling the product.

On the other hand, there are certain drawbacks shown by the literature research of (Bundgaard et al. 2015): A certain percentage of the labels were found to be incorrect and, mainly, for automatic sorting systems the ISO labels had no effect as these systems sort according to the plastic's mechanical, optical and electrostatic properties.

Thus, (Bundgaard et al. 2015) recommend that before setting criteria for visual marking of plastics in the Ecodesign Directive it should be further examined to what extent the waste is manually sorted for the product group in question, and how the future waste treatment of the product might look like. Furthermore, alternative marking methods should be examined, which could be applied for example in automatic sorting systems.

Contamination of materials / plastics

Requirements regarding contamination of materials are relevant for the recyclability, as the potential for recycling is reduced if incompatible materials are combined, e.g. painting, coating or metallizing large plastic parts making them not compatible with recycling. Depending on the specific requirement, it could be verified visually.

Mono-materials

Using compatible or a reduced number of plastics can improve the recyclability of e.g. thermoplastics, as a mixture of different polymers or a contamination of the plastic fractions can significantly decrease the plastics properties and thereby the use of the recycled materials.

(Bundgaard et al. 2015) recommend that setting these types of requirements should be supplemented with a dialogue with the stakeholders from the recycling industry to ensure the effectiveness of these types of requirements which depends on the recycling system that the products enter into.

Efficient use of materials during the use phase

For washing machines, the Ecodesign Regulation 1015/2010 sets specific ecodesign requirements with regard to the water consumption. For dishwashers, no such requirement is yet in place. According to (Bundgaard et al. 2015) an example of ecodesign requirements within this category could be to set a requirement to an automatic detergent dosing system for washing machines avoiding over-dosage and overconsumption of detergents.

Easy disassembly

Easy or manual disassembly can help improve reparability and upgradability of the product improving the durability of the product. Criteria might be detailed with regard to the components to be separated, the type of connections or the tools to be used.

Regarding end-of-life treatment, (Bundgaard et al. 2015) conclude that it is not possible based on the finding of their study to assess whether or not requirements for manual disassembly will improve the recyclability and recoverability of electrical and electronic equipment in the future. This is due to the reason that manual disassembly in the waste treatment process of electrical and electronic equipment (EEE) is increasingly being replaced by automatic or destructive disassembly in many developed countries which questions if requirements for easy or manual disassembly will improve the recyclability and recoverability of EEE if they are fed into an automatic or destructive disassembly system. However, manual disassembly is still performed when economically feasible, e.g. components or materials containing valuable resources, or when regulations such as the WEEE Directive require it, e.g. for components containing hazardous substances. Requirements in addition to manual disassembly might target automatic or destructive disassembly.

Durability requirements (incl. extended warranty, upgradability and repair, spare parts, modularity)

All criteria strive to extend the lifetime of the product thereby preventing electronic waste. Durability is also related to the previous category disassembly, where criteria targeting easy disassembly for repair and upgradability were included.

The length of the warranty should be product specific and it is also strongly related to the availability of spare parts, which is also an issue for reparability. Determining how long spare parts should be taking into account both economic and resource efficiency aspects: On one hand components should be available to enable repair, but on the other hand the risk is that a too large inventory of components will be out-dated and never utilized. Modular design and easy disassembly enable upgrading and repair and are thus prerequisites for lifetime extension. Upgradability can potentially reduce the frequency of replacement against the background of rapid technological product developments.

(Bundgaard et al. 2015) conclude that durability should be included as possible resource efficiency requirements in the Ecodesign Directive, also due to the requirements being possibly verifiable by market surveillance authorities. However, it is important to ensure that prolonging the lifetime of the product is the environmentally best solution in a life cycle perspective, e.g. that possible environmental benefits are not evened out by increased energy consumption of the older product compared to a new more energy efficient product.

<u>Waste from manufacturing</u>

By including requirements to the manufacturing, the scope would be expanded from a product focus towards a production focus which is applicable to the Ecodesign Directive which mainly sets requirements to the design of the product, however targeting the environmental performance of the entire product life cycle. Therefore, design requirements to the product that might improve the manufacturing process would be highly relevant. However, as many electronic products are produced outside Europe, it might be difficult to enforce these criteria. (Bundgaard et al. 2015)

<u>Further requirements</u>

Further requirements on hazardous substances, take-back schemes and packaging identified in voluntary instruments such as ecolabels are not recommended to be transferred to the Ecodesign Directive as there are rather large overlaps with existing legislations such as REACH and RoHS, WEEE and the European Directive on packaging and packaging waste.

<u>Information requirements related to resource efficiency</u>

With regard to information and specific requirements targeting resource efficiency in ecodesign, (Bundgaard et al. 2015) recommend in their study following:

- Information relevant for disassembly, recycling or disposal at end-of-life:
  - Relevant for end-users to know how to correctly dispose the product at its end-of-life
  - Relevant for recyclers to know how to disassemble and recycle the products in the best possible way, for example to ensure that hazardous substances are removed and treated correctly. It is suggested that such information could be made more easily available, by embedding it in the product in e.g. a RFID to benefit the recyclers more compared to information provided on webpages or in user instructions. Furthermore, it could be specified in the Directive which type of information the recyclers may need. This could be done in close collaboration with the recyclers to ensure that the information is indeed relevant for their processes.
- Information and specific requirements on easy disassembly:
  - Relevant for consumers / repair facilities to help improving maintenance and repairs. Generic information requirements for non-destructive disassembly for maintenance could be supplemented by requirements for the producers to make repair and service manuals public. It may also be relevant to set specific requirements to easy disassembly of the product for maintenance purposes.
  - Relevant for recyclers to help improving end-of-life treatment, for example the removal of certain components which have to be treated separately in accordance with the WEEE Directive (batteries, heat pumps etc.).

- Information and specific requirements on durability (e.g. on lifetime of the product as for lamps, or for components, such as minimum loading cycles for batteries in computers)
  - Relevant for consumers to enable them selecting the most durable product
- Information requirements on hazardous substances, precious metals or rare earths
  - Relevant for recyclers to a) avoid contamination of the materials when they are recycled or b) ensure a more optimal recovery of precious materials. As stated above, also for these information it is suggested to make it more easily available, by embedding it in the product in e.g. a RFID.
- Information requirements with regard to resource consumption in the use phase
  - Relevant for consumers: e.g. to stipulate consumers choosing the most efficient programmes in terms of energy and water consumption and the best suitable detergents.

1.3.4.2. Study "Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP)" by BIO Intelligence Service

(BIO Intelligence Service 2013) conducted a study to clarify the implications of material efficiency from the pragmatic perspective of its practical application for ecodesign purposes, and the elaboration of recommendations for the MEErP methodology (Part 1); and undertook an update of the MEErP methodology and its component EcoReport tool, to include the necessary means for better analysing material efficiency in MEErP (Part 2). Part 2 also contains a guidance document for analysing material efficiency in ErP; as well as an updated version of the EcoReport Tool and a report of the test of the updated methodology on two case studies.

The project identified from available evidence the most significant parameters regarding material efficiency that may be used in MEErP, in order to analyse the environmental impacts of ErP, and assessed their suitability and robustness for Ecodesign purposes, together with associated information parameters.

The parameters selected as most suitable were:

- Recyclability benefit ratio, describing the "potential output" for future recycling, based on a formula considering the recyclable mass per material and its recycling rate and a downcycling index. It implies that it is possible to assess the potential benefits of recyclable plastic parts in a product (as metals are already commonly recycled to a large extent). However, due to data constraints only data on recyclability benefit rate for bulk and technical plastic is included.
- Recycled content, describing the "input" of materials with origin on waste, based on new data sets for materials. The dataset makes it possible to model products with recycled material as input material. However, again due to data constraints, only data on paper, PVC, PET and HDPE has been included as additional material inputs in the EcoReport Tool.
- Lifetime, a mechanism to display impacts not only as a total over the whole lifespan, but also per year of use, allowing an easier comparison of products with different lifetimes or analysing the effect of lifetime extension. The product lifetime can refer to:
  - The technical lifetime is the time that a product is designed to last to fulfil its primary function (technical lifetime).
  - The actual time in service is the time the product is used by the consumer (service lifetime). The actual time in service is not a typical parameter in industry and depends more on the user than on the manufacturers of the product design.

- Critical raw materials, a tool to analyse products including critical raw materials to display differences between different product designs and improvement options.

The key end result of this project is the proposal of new features in the MEErP, enabling further analyses of material efficiency aspects in products. These shall be fully functional and ready to be used in future Ecodesign preparatory studies. However, (Bundgaard et al. 2015) conclude in their study:

> *The MEErP methodology has not been changed significantly. The alterations made to the EcoReport Tool are minor and to some extent updates of existing elements. Hence, despite the good intentions to include material efficiency into MEErP, the current update and expansion of MEErP will properly not be enough to ensure a focus on material efficiency in future implementing measures and voluntary agreements.*

The study by VHK "Resource efficiency requirements in Ecodesign: Review of practical and legal implications" (2014) provides some additional insights on this. Due to time constraints, it has not been possible to analyse it, but the conclusions will be presented in the next update of the present study.

1.3.4.3. Study "The durability of products" by Ricardo-AEA

Ricardo-AEA, in collaboration with Sustainability Management at Scuola Superiore Sant'Anna di Pisa (SuM) and Intertek, has been commissioned by the European Commission – DG Environment to conduct a study on the durability of products. The purpose of the study is to identify two priority products and develop a methodology for measuring their durability. The study also aims to estimate the benefits and costs of more durable products. The outputs from this work can then be used in relevant product policies. (Ricardo-AEA 2014a)

Within the durability study, the authors undertook a literature analysis to develop an appropriate definition of durability. For example, the Ecodesign Directive 2009/125/EC in Annex I, Part 1.3 defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to (European Parliament 2009), this includes inter alia

> *"Extension of lifetime as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability."*

The following definition has been developed by (Ricardo-AEA 2014a) proposed to be potentially also applied to other policy interventions in Europe aimed at improved durability of products.

> *"Durability is the ability of a product to perform its function at the anticipated performance level over a given period (number of cycles – uses – hours in use), under the expected conditions of use and under foreseeable actions.*
>
> *Performing the recommended regular servicing, maintenance, and replacement activities as specified by the manufacturer will help to ensure that a product achieves its intended lifetime."*

The authors further discussed the possibility of creating an extended definition of durability that encompasses repair, design for repair and remanufacturing, and that such an extended definition of durability could be developed for inclusion within for example the EU Ecolabel and GPP criteria requirements.

> *"A product to maintain its functions over time and the degree to which it is repairable before it becomes obsolete."…. "In other words, a product should not cease to function after relatively little usage and its reparability should not be hindered by its design."*

It is thus worth considering that, within this context, extended durability is the aim to extend the life of a product past its first life by ensuring a product can be easily repaired, upgraded, remanufactured and, at end of life, dismantled and recycled.

Beyond the above definitions on durability, (Ricardo-AEA 2014a) listed the following definitions for a number of relevant terms:

- Design for durability: considering the product's longevity, reparability and maintainability; considering environmental improvements emerging from new technologies (ISO/TR 14062 2002).
- Operating time: average time frame during which the product is supposed to be used. Operating time can be derived from product statistics or from estimating models.
- Extension of operating time: estimated time frame extension of the operating time that can be achieved due to specific design and maintenance actions.

Within the study of (Ricardo-AEA 2014a), domestic refrigerators and freezers, and ovens were selected for further analysis. The selection is based on the assumption, that they might also be applicable to other products with similar components. For washing machines and washer dryers the study results are expected to be transferable to a large extent as following components are similar:

- Outer casing
- Pumps
- Filters
- Heating elements
- Mechanical elements such as hinges and catches
- Electronics, including controls and displays

1.3.4.4. Study "Investigation into the repairability of Domestic Washing Machines, Dishwashers and Fridges" by RReuse

The Reuse and Recycling EU Social Enterprises network (RREUSE) is a European umbrella organisation for national and regional networks of social enterprises with re-use, repair and recycling activities. They cover 42,000 Full Time Equivalent (FTE) employees and over 200,000 volunteers working throughout 22 member organisations across 12 EU Member States.

In 2013, RReuse has conducted an investigation into some of the main obstacles its members encounter when repairing products, inter alia for washing machines and dishwashers, to provide part of the basis for setting requirements within implementing measures to improve the reparability of products, and thus their material and resource efficiency. Based on a questionnaire sent out through their network, the findings are answers from 9 individual reuse and repair centres from four national networks of social enterprises namely AERESS (Spain), Repanet (Austria), Réseau Envie (France) and the Furniture Reuse Network (UK). (RReuse 2013)

The results of the study with regard to specific obstacles for repair and maintenance of washing machines can be found in section 3.3.2. Examples of common causes of break downs as well as suggestions for product design to help improve reparability of washing machines are provided in section 4.2.5.2.

Based on the study results, the following horizontal measures within Ecodesign Implementing Measures are suggested by (RReuse 2013):

- The product should be able to be disassembled non-destructively into individual components and parts without the need for special proprietary tools to do this. If special tools are required however, these must be readily and freely available to all approved reuse and repair centres/networks (not just to the after sales service providers of the manufacturers).

- The availability of replacement parts must be guaranteed for a minimum period of 10 years following the last product batch. Critical spare part components should be available at a reasonable price.
- Free of charge access to repair service documentation of the after sales service providers of the manufacturers for all reuse and repair centres, not only those of the after sales service providers, together with any relevant fault diagnostic software and hardware.
- Simplification of specific components and potential standardisation of certain components across different brands would significantly increase the efficiency of repair as it would allow greater interoperability of components across different machines

1.3.4.5. "Study on Socioeconomic impacts of increased reparability" by BIO by Deloitte

Currently, DG Environment has commissioned a study to BIO by Deloitte to analyse the socioeconomic impacts of increased reparability. (Bio by Deloitte 2015)

With this study, DG Environment strives to gather information about the mechanisms of the solutions in order to increase reparability. To assess the viability of the requirements, they must be tested in order to measure the benefits of their impacts on economic growth, job creation and resource efficiency under the perspective of the Roadmap to a Resource Efficient Europe and the Green Employment Plan. Thus, within the study case studies on possible reparability requirements are performed on 4 product groups (domestic washing machine, dishwasher, coffee machine and vacuum cleaner) in order to get a global and complementary vision of the repair sector. These case studies enhance the mechanisms barriers and drivers in the perspective of their potential integration of generic or product-specific requirements in product policy instruments (either mandatory or voluntary). The operational objectives of the project are stated as follows:

- Perform case studies on four product groups;
- Review existing barriers and identify suitable reparability requirements;
- Quantify the job creation, economic and resource-savings potential of the selected reparability requirement policy scenario and its individual elements, including impact on SMEs;
- Describe the characteristics of possible job creation potential in terms of skills requirements, private/public, entrepreneurship and self-employment, entry to labour market and global mobility; and
- Describe mechanisms under which such a policy framework would develop in a scientifically sound way building on empirical studies, literature studies or economic modelling or others as best suited.

Each case study is performed in order to assess the job creation potential, the resource savings potential and the net cost and benefits for society. The results are compared in order to identify an EU policy scenario.

In April 2015 a first questionnaire has been sent out to stakeholders. For domestic washing machines, (Bio by Deloitte 2015) ask about the importance of certain barriers to repair:

- Availability of technical documentation, diagnosis software
- Availability of spare parts
- Cost of spare parts
- Labour cost
- Difficulty of access and replacement of control boards

- Non-replaceable components (e.g. ball bearings, door hinges, drum casing)
- Low consumer awareness about repair possibilities

Additionally, stakeholders have been asked about their opinion regarding possible reparability requirements and their effectiveness to increase the repair of products by being voluntary or mandatory tools (Bio by Deloitte 2015):

- Provision of instructions for troubleshooting, diagnosis software, diagrams of the Printed Circuit Board
- Ensure accessibility in the switched on position for the purpose of troubleshooting during the repair work
- Ensure accessibility to inner parts (e.g. large and easily accessible back and top covers, cable lengths, space for mounting, screw orientation, scale of design)
- Ensure the possibility of breaking down the product (e.g. components can be tested separately)
- Provision of information relevant for disassembly (e.g. instructions, break down plan
- Avoidance of non-reversible adhesives
- Ensure the separation of the connections by a limited number of ordinary tools
- Ensure the possibility to exchange or upgrade critical components (e.g. ball bearings, door hinges)
- Use of standardised designs to allow compatibility of spare parts
- Ensure the availability of compatible spare parts for a determined period of time
- Offer to consumers an optional extension of warranty time at purchase
- Provision of information to consumers about reparability in product Energy Labels, brochures, etc. (e.g. similar to Austrian rating Standard ONR 192102).

The project is currently on-going and expected to be concluded by the end of summer 2015. The results and conclusions will be included in a revised version of this preparatory study, also in the context of other research results on reuse and reparability (cf. sections 3.3 and 4.2.5).

1.3.4.6. Study "Addressing resource efficiency through the Ecodesign Directive. Case study on electric motors" by Dalhammar et al.

(Dalhammar et al. 2014) conducted a case study in 2012 on the potential inclusion of permanent magnet (PM) motors in the Ecodesign Regulation for electric motors. The objective was to see how the Ecodesign Directive could promote eco-innovation for resource use in PM motors, and to:

- Investigate what kind of requirements related to resource use of rare earth elements (REE) are of relevance for permanent magnet electric motors, and
- Obtain input from experts on the feasibility of outlined potential requirements, and the most important drivers for eco-innovations.

Against the background of increased demand for REE, combined with global supply imbalances and unavailable post-consumer recycling options for REE, their substitution in the magnets is currently being investigated in several pilot projects. Replacing REEs with other materials however can come with a performance loss in the PM motor (i.e. reduced energy efficiency due to a reduced energy density in the magnet and more material use). Therefore, increasing the recyclability of PMs is of interest, if technically and economically feasible at the point in time of interest, as it could provide a stable supply of REEs and thus, enhances their continued use to achieve more energy-efficient motors.

Based on interviews with material experts, (Dalhammar et al. 2014) outline potential implementing measures facilitating recycling of REE.

- Generic requirements that producers should show how they take design for recycling into account in the design process.
- Design for dismantling, e.g. modularisation; or preventing that permanent magnets are for instance covered by plastic, which would ease recycling practices.
- BOMs providing information about key materials and their positions to promote future recycling (when new technologies may allow for profitable recycling if the motors are easy to disassemble).
- Additional information to recyclers that are relevant for allowing cost-effective recycling.
- Take-back obligation; it might provide incentives to design a motor from which materials can more easily be recycled.

(Dalhammar et al. 2014) conclude that it appears as if a more developed set of requirements cannot be set under the Ecodesign Directive until pilot projects and ongoing research have provided more insights on the technical and economic viability of REE recycling. The long-time scales involved (i.e. time before the motors are at the EoL stage) however mean that future recycling options and associated costs and benefits are rather uncertain compared to products with shorter life spans, e.g. laptops or cell phones.

1.3.4.7. Further studies with regard to resource efficiency as possible Ecodesign measures

The following studies will be analysed during the further course of the project:

- Study "Integration of resource efficiency and waste management criteria in European product policies. Case-study washing machine" by JRC IES
- VHK study "Resource efficiency requirements in Ecodesign: Review of practical and legal implications". (2014).

1.4. Summary and discussion: scope, legislation and standardisation

1.4.1. Preliminary product scope and definitions

Based on the previous analysis of existing scopes and definitions, stakeholder feedback related to the scope as well as the analysis of market data and trends (cf Task 2), the following preliminary product scope and definitions are proposed for the revision of the ecodesign and energy label Regulations for household washing machines and washer-dryers. These definitions and scope proposal shall be discussed at the first stakeholder meeting.

1.4.1.1. Proposal for a product scope

Current scope of the Ecodesign Regulation 1015/2010 for household washing machines:

> *This Regulation establishes ecodesign requirements for the placing on the market of electric mains-operated household washing machines and electric mains-operated household washing machines that can also be powered by batteries, including those sold for non-household use and built-in household washing machines.*

The Energy Label Regulation 1061/2010 has the same scope.

Please note that the existing energy labelling and ecodesign regulations exclude washer-dryers (defined as *'household combined washer-driers'*) from their scope:

Proposal for a revised scope of the ecodesign Regulation for household washing machines and washer-dryers (to be discussed):

> *This Regulation establishes Ecodesign requirements for the placing on the market of electric mains-operated household washing machines and household washer-dryers.*

The energy labelling Regulation would have the same scope, as follows:

> *This Regulation establishes requirements for the labelling of and the provision of supplementary product information on electric mains-operated household washing machines and household washer-dryers.*

Rationale:

- It is proposed to add washer-dryers in the scope description since one of the main goals of the revision and since their market relevance is increasing.
- It is proposed to delete 'electric mains-operated household washing machines that can also be powered by batteries' from the scope description. The market research (cf. Task 2) as well as stakeholder feedback reveal indeed that these types of washing machines (and washer-dryers) do not have yet market relevance (no battery-operated household washing machines and washer-dryers were detected; the production volume is estimated to be lower than 200 000 units per year), although they could become more relevant in the future. Theoretically, battery powered household appliances might work as capacity storage in a smart-grid network; however, it is assumed that such power storage would rather be implemented as a central storage system for the whole household with the single appliances still being electric-mains operated.. Moreover, these products should be considered separately as they would need a different amount of energy in case of battery usage, as compared to being operated by electric mains, and they may not reach the same performance levels as traditional machines. The current test standard does not explicitly describe the test procedure for battery driven appliances. If included inside the scope, standards should be improved accordingly.
- It is proposed to remove 'including those *sold* for non-household use' which may cover also household washing machines and washer-dryers being used in a professional context. Section 1.1 defines 'household washing machines and washer-dryers' differentiating them from professional appliances based on their design and intended use as foreseen by manufacturers and according to the provisions of legislative framework (Low Voltage and Machinery Directives).
- It is proposed to delete 'including built-in household washing machines' from the scope description. In general, this sub-type of appliances is already covered by the term 'household washing machine'. According to stakeholders, a separation of standalone and built-in appliances is not needed; also because there is no difference in terms of efficiency and performance and the requirements do not differ between the two sub-categories. 'Built- in' was in the past used as one of the differentiation criteria for professional appliances.
- It is proposed not to include semi-professional washing machines and semi-professional washer-dryers into the future revised scope of the Ecodesign and Energy label Regulations for household appliances. Semi-professional machines clearly differ from household washing machines with regard to several aspects which justify further exclusion from the scope of regulations for household appliances.-Semi-professional washing machines and washer-dryers are handled together with professional appliances in Lot24.

Discussion point 1.1

a) Do you agree with the proposed revised scope? Please explain why / why not.

1.4.1.2. Proposal for definitions

Current definitions of the Ecodesign Regulation 1015/2010 and of the Energy Label Regulation 1061/2010 for household washing machines and washer-dryers:

> *'Household washing machine' means an automatic washing machine which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes.*
>
> *'Built-in household washing machine' means a household washing machine intended to be installed in a cabinet, a prepared recess in a wall or a similar location, requiring furniture finishing.*
>
> *'Automatic washing machine' means a washing machine where the load is fully treated by the machine without the need for user intervention at any point during the programme.*
>
> *'Household combined washer-dryer' means a household washing machine which includes both a spin extraction function and also a means for drying the textiles, usually by heating and tumbling.*

Proposal for revised definitions of the Ecodesign Regulation for household washing machines and washer-dryers:

> *'Household washing machine' means a machine which cleans and rinses textiles by using water, chemical, mechanical and thermal means; which also has a spin extraction function and which is designed in a way principally intended for domestic use as stated by the manufacturer in the Declaration of Conformity (DoC).*
>
> *'Household combined washer-dryer' means a household washing machine which includes both a spin extraction function and also means for drying the textiles by heating and tumbling.*

The revised energy labelling Regulation would have the same definitions,

Rationale:

- 'Built-in washing machines: According to stakeholders, it is not necessary to provide a separate definition for built-in appliances, as this refers to the outer design and envelope of the machines, and there is no difference in terms of technology and performance to e.g. standalone appliances. Already within the current ecodesign and energy labelling Regulations, no further differentiation has been made regarding requirements for built-in and standalone appliances. The inclusion of such definitions is thus redundant for the purpose of these Regulations .A technology neutral approach should be applied as far as possible in the definition of Ecodesign and Energy Label requirements.
- 'Automatic washing machine': According to stakeholders it is not necessary to provide a separate definition as only automatic washing machines are sold in the European market.
  - Semi-automatic washing machines have two tubs, one for washing and the other for drying which needs user intervention to shift the clothes from one tub to the other.

- Automatic / fully automatic washing machines have only one tub in which all functions (washing, rinsing, and spinning) are performed without the need of user intervention to shift clothes. This "automatic" feature of the appliance must not be confused with the “automatic programmes” that a machine may offer.
- Multi-drum washing machine: Recently, such appliances have been introduced into the market. The appliances have two washing drums, which can either work together or separately. It is considered that this kind of appliance would also be covered by the term ‘automatic’ washing machine, as each drum could finish a complete washing process (cf. Chapter 4.1.3.1). However, further analysis might be needed with regard to testing and labelling of performance.

- ‘Household / sold for non-household use’: The “Guidelines on the application of the Low Voltage Directive 2006/95/EC” (European Commission 2007 / modif. 2012) clarify the borderline between the scope of the “Machinery” Directive (European Parliament 2006) and the “Low Voltage” (LVD) Directive (European Parliament 2014) in order to provide greater legal certainty for manufacturers. Whilst it is possible for a consumer to acquire an appliance intended for commercial use or for a commerce to use an appliance intended for consumers, the criterion to be taken into account for determining the intended use is the use intended and stated by the manufacturer of the appliance concerned in the so called “Declaration of Conformity (DoC)” and in the product information/instructions/advertising concerning the product. The statement from the manufacturer in the product information concerning the specific product is the criterion that has to be considered to determine the intended use of the appliance in this case and which Directive (Low Voltage Directive or Machinery Directive) applies. Evidently this must accurately reflect the reasonably foreseeable use of the product. The definitions provided by the guidelines are “Household appliances intended for domestic use” and a description of “domestic use”. Thus, in addition to replacing the current part of the scope “and which is designed to be used principally for non-professional purposes” by the formal definition given in the LVD Directive, it is proposed to align the definition of “household washing machines and washer-dryers” to that of the Low Voltage Directive.
- For the definition of ‘household combined washer dryers’ stakeholder feedback has been taken into account who recommended modifying it by deleting the word and “usually” since the washer-dryer needs to have a device to heat the process air.

1.4.1.3. Further considerations for the revision of the scope

Depending on the techno-economic elements gathered along the elaboration of the study and the consequent proposal of policy measures, further types of appliances and/or definitions might be added during the course of the study (e.g. special purpose products, system approach like ‘renewable energy heated’, ‘smart grid ready (SG ready)’ or others.

Discussion point 1.2

a) Do you agree with the revised definitions? Please explain why / why not.

b) The definition refers to *'drying the textiles by heating and tumbling'*. Is this definition too restrictive about the means of drying – in other words, is there any risk of hindering technical innovation of alternative drying options? Please note that the former definition was *'drying the textiles, usually by heating and tumbling'*.

1.4.2. Legislation and standardisation: energy efficiency and performance

Test standards should produce reliable, repeatable and reproducible results. These include delivering data for the purpose of assigning an Energy Label, and checking if Ecodesign requirements are met. In addition, declarations require verification.

Standardisation bodies and their technical working groups (e.g. CLC/TC 59X/WG 1 for washing machines) are continually working and implementing technical updates to ensure the relevance and appropriateness of test standards and to ensure a level playing field for manufacturers. Some of the testing procedures currently in standards (like low power modes) require currently a testing effort that might not be in line with their added value. Other procedures (like textile care / gentleness of action) are relevant but not used and other relevant parameters (like rinsing performance) are currently missing.

There will always be conflict between the need for reproducibility on the one side, which requires specific test conditions to be met, and the higher variability of user conditions in real life on the other side. These differences will always exist. However, it is neither possible nor necessary for standards to mirror exactly real-life conditions.

Regulation 1061/2010 on energy labelling and Regulation 1015/2010 on ecodesign already foresee an update mechanism 'in light of technological progress' and mention specifically an assessment of verification tolerances, ecodesign requirements on rinsing and spin-drying efficiency and the potential for hot water inlet.

The actual status, need for future standardisation, and international comparability of requirements and standards have also been recently assessed in two studies:

- The Omnibus review. The “Omnibus” Review Study on Cold Appliances, Washing Machines, Dishwashers, Washer-dryers, Lighting, Set-top Boxes and Pumps (Van Holsteijn en Kemna B.V., et al. 2014)
- CLASP/ The Policy Partners (2014) Improving Global Comparability of Appliance Energy Efficiency Standards and Labels

As the market of washing machines and washer –dryers is international, proposals for changes in standards need to check how this will affect trade and international comparability. Differences in standards may introduce competitive advantage to producers or sellers of specific regions. The data presented in this chapter illustrates that many countries worldwide have implemented energy and other environmental requirements for washing machines. Some of them include elements not currently addressed in EU Regulations, e.g.:

- *The US Department of Energy introduced a 5% bonus in the energy star regulation if the product has smart grid connection capability.*
- *The Australian standardisation body has announced its willingness to adopt the IEC rinsing method, which is still under development. The development of a new rinsing method is under way in the US and in the EU (AHAM will adopt a new standard soon; CENELEC is checking whether the same principle can be implemented for EN60456 under the mandate from the EC).*

The study by CLASP (2014) concludes that '*for clothes washers, EU and US MEPS values appear virtually the same'; however, they are not comparable. EU energy tests include a fairly stringent test of wash performance, whereas US tests do not. Wash performance requirements have a substantial impact on energy demand, and since it is not known how wash performance compares between regions, resulting energy performance data may not represent the same functionality”.*

The following issues are proposed for discussion with stakeholders at the first Technical Working Group Meeting.

1.4.2.1. Energy efficiency tested in the most commonly used programmes

Chapters 1 and 3 provide evidence that the standard programmes are currently not always chosen by consumers, because of their long duration and in some cases also for not reaching the indicated temperature of 60 or 40oC.. Additionally, some stakeholders indicate that the standard programmes are not always easy to find and select in the appliances, and that the standard programme indicator (an empty arrow) might not be well understood by all consumers.

The ambition of the ecodesign and energy label Regulations shall be that the programmes which the consumer select most often to wash normally soiled clothes, and thus result in the largest energy consumption in the EU annually, should be the programmes tested for Ecodesign and Energy Labelling.

The most used programmes are at present washing cotton loads at 40 °C and 60 °C., with a trend to a lower temperature range (20-40 °C) enabled by the development of enzyme-based detergents.

In the current Regulation, there is a requirement to define a "standard cotton programme". This has resulted in a split between standard and non-standard cotton programmes for 40 and 60 °C. While some consumers choose the standard programmes, others do not (See Chapter 3), resulting in an overall higher energy use in the EU than if there were only one 60C and one 40C programme per machine.

An option to solve this is to go back to what was requested in mandate M/458/EN (2010) ('European Commission Mandate to CEN, CENELEC and ETSI for Standardisation in the field of household washing machines'): *"to ensure that the prospective harmonised standard(s) includes a procedure that avoids an appliance being programmed to recognise the test cycles, and reacting specifically to them*".

Additionally, when the appliance has default programme selection, it might be requested that the programme tested (40 °C/60 °C) is selected by default by the appliance when the machine is switched on.

Discussion point 1.3

a) Do you agree with the proposal above of eliminating the need of an additional "standard cotton programme", and devising a mechanism for testing the most frequently used programmes for cotton loads at 40 and 60 °C? Please explain why / why not. Please describe alternative mechanisms that could ensure that the most frequently used programmes are the ones tested in relation to the energy label.

b) Do you agree with the proposal above of requesting default programme selection of the programme tested in the standard (40 °C/60 °C) when the appliance has default programme selection capability? Please explain why / why not.

c) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.2. Protocol for testing: full-half-loads, 40 °C/60 °C

The ATLETE testing (see Chapter 2) concludes that the EN60456:2012 is well applicable and it does not yield any technical problems. The protocol of the test standard seems thus fit for the purpose of describing a reproducible, comparable level playing field.

However, following the information on user behaviour described in Chapter 3, some elements of the performance measurement protocol could be changed, as for instance:

- the number of full loads and half loads (see discussion point on capacity below)
- the temperature of the programme(s).

It seems from the data collected that the testing could continue to be based on the 40 and 60 °C cotton programmes, as those are the most widely chosen.

It may be an option to change the 60 °C cotton full programme to a 40 °C cotton full programme and to leave the half load programmes as it is currently (see also discussion on capacity and loads below). In consequence, the total average energy consumption would be lower.

Discussion point 1.4

a) Do you agree with the proposal? Please explain why / why not.

b) Do you have any alternative proposals? Please provide them with a rationale.

c) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.3. Capacity measurement

Currently, the capacity of a washing machine is declared by the manufacturer (the so-called "rated capacity"), as requested in the Ecodesign regulation. However, some stakeholders claim that different capacities can be declared for identical washing machines depending on which country they are sold. Harmonisation could be achieved by requiring the measurement of the capacity according to the already existing standard IEC 60456.

Sales data indicate that the rated capacity of appliances has increased in the last decade, but that the amount of laundry loaded in practice is on average <4kg cotton. The current measurement and calculation methods make use of half loads to address this divergence. However, for a 10 kg machine this means 5 kg and for a 13 kg machine this means 6.5 kg. These half load-capacities resemble more to a fully loaded «normal» washing machine and are in a contrast with the European average load, which is around 3-3.5 kg. This average load shall remain the reference for testing, so that it reasonably reflects real practice. Thus, it seems relevant to discuss if to adapt and increase the share of half-loads in the standard testing.

It is additionally an issue for discussion how to address the testing of automatic load detection programmes, in case these provide an additional energy saving potential. Some stakeholders indicate that there are washing machines on the market which use the same amount of energy and water for a half load as for a full load using the standard programme. It may thus be required that half load tests deliver realistic energy and water saving compared to full load tests. As the correlation of load to energy use is not linear, reference saving rates compared to full load may be required, e.g. 25-30%. As technology progresses, 30-35 % might be achievable.

Additionally, the Standard Annual Energy Consumption (SAEC), which constitutes the denominator for the determination of the Energy Efficiency Index used in the Energy label and Ecodesign regulations, is calculated based on the lowest between the rated capacities "c" declared for the standard 60 °C cotton programme at full load and the standard 40 °C cotton programme at full load. SAEC is calculated in kWh/year (and rounded to two decimal places) according to the formula $SAEC = 47.0 \times c + 51.7$. Apparently, the SAEC calculation is not based on real use conditions and it would be interesting to deepen the fundaments of its determination and to understand if it should be updated and how.

It has also been noticed that US legislation refers to 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.

Discussion point 1.5

a) Do you agree with the diagnosis of capacity measurement differences described above? Please explain why / why not.

b) Do you agree with the proposal of adjusting the share of half-loads based on a quantitative assessment of the average loads (obtained from user surveys) and nominal capacity (from sales data)? Please explain why / why not.

c) How could automatic load detection programmes be dealt with in the test procedure?

d) Would you agree with the introduction of minimum energy saving rates for half-load (e.g. 25%) compared to full load? Please provide your rationale and supporting information. Documentation on the relation between energy consumption and loading of a given appliance would be of much value.

e) Should the formula for the calculation of the SAEC be updated, for instance to reflect real use conditions or the evolution of the market? Please provide the reasons for your answer.

f) Is there any known correlation between the volume of the drum (e.g. as used in the US) and the load of the machine (weight of textiles in kg cotton, as used in the EU)? If so, which one?

g) Have you identified any conflicts related to the metrics (volume vs. weight) that shall be discussed and clarified? Are there any special issues to point out with respect to the trade of European appliances to the US and vice versa?

h) Can the issues above be dealt with in the same way for washing machines as for washer-dyers, or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.4. Inclusion of rinsing performance and measurement of hygiene

Rinsing is reportedly needed to ensure a sufficient elimination of the detergent and soil components from the wash load, which have been lately linked to the development of allergies. The data collected on standardisation activity (also internationally) and on rinsing performance of the most energy-efficient washing machines currently on the European market indicates that it would be advisable to include rinsing performance testing in the testing procedure associated to the ecodesign and energy labelling.

So far, the existing test procedures for rinsing efficiency did not provide sufficient reproducibility and repeatability. A new procedure for measuring the rinsing performance with sufficient reproducibility and repeatability is under investigation within the standardisation working group CLC/TC 59X/SWG 1.8. Some stakeholders indicate that there should be requirements on a minimum of two rinsing cycles in the regulation.

It seems also advisable to pursue alignment with international standardisation (e.g. IEC rinsing method under development). It seems that the US and Australia are following this line in their requirements.

Moreover, IEC59D has decided to limit its standardisation activities for washing machines to the measurement of the microbial contamination reduction on textiles. SC 59D decided to develop a globally acceptable Publicly Available Specification (PAS) to respond to the increase in consumer complaints regarding odour from washed laundry caused by the presence of microorganisms. This IEC/PAS 62958 Ed.1: "Clothes washing machines for household use – Method for measuring the microbial contamination reduction" was published in 2015. There is not much experience and no information on measurement uncertainty on the use of PAS 62958. Nevertheless, this measure may be seen as a complementary measure to the washing performance, as lower wash temperature may affect the microbial contamination reduction on textiles.

Discussion point 1.6

a) Do you agree with the proposal of including rinsing in the standard and the regulations? Please explain why / why not.

b) Do you have any specific suggestions for developing the rinsing method? Please provide your proposal with a rationale.

c) Do you see the need of developing an approach for measuring and reducing the residual microbial contamination of the laundry? Please why and how / why not.

d) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.5. Simplification of low power requirement

Following the prescriptions of Regulation 1275/2008 as amended by Regulation 801/2013/EU on standby, since 2013 washing machines and washer-dryers are equipped with power management systems (e.g. maximum time allowed to switch to the lowest possible consumption of 20 minutes).

This limits substantially the annual energy consumption of standby and off modes (cf. section 1.2.1.2), which contribute minimally (up to 2.5%) to the annual energy consumption calculated according the EN 60456 standard (according to the results of the ATLETE project, it accounts on average for 1.8% of the annual consumption).

A remaining issue of concerns for some stakeholders is that this contribution, despite small, may be sufficient to result in different energy class categorisation of two machines with the same energy consumption for the washing cycle, but different standby mode energy use. It was indeed indicated that low power modes of e.g. 2.5 % of the yearly energy consumption, represent about a fourth of the width of an energy class.

Currently, the testing of low-power modes is judged by manufacturers and testing laboratories as complicated and costly, as it needs special test set-ups to avoid failure rates beyond the measurement tolerances. This may be seen as a barrier for the testing in new laboratories.

The mandatory prescriptions for stand-by in place since 2013 by Regulation (EC) No. 1275/2008 seem to have made to some extent obsolete the measurement of some of the low power conditions required in performance tests for washing machines. Measurement of the energy consumption in low power modes may thus be excluded from the calculation of the EEI used for ecodesign and the energy label.

Alternatively, low power consumption requirements may be included in the Ecodesign regulation, (if not already included in Commission Regulation (EC) No. 1275/2008), e.g. automatic switch-off of the appliance after a certain time.

Discussion point 1.7

a) Do you agree that energy consumption from low power modes barely contributes to the annual energy consumption of washing machines? Please provide the reasons for your answer.

b) Do you see any risks that the energy consumption from low-power modes might increase if not part of the Ecodesign/Energy Label regulations (despite the mandatory prescriptions set for stand-by of Regulation (EC) No. 1275/2008)? For instance, from a legal point of view, the delay-start function does not fall under the Standby Regulation because 'delay start' is not defined as standby mode since it does not last for an indefinite time. Please provide a rationale to your answer.

c) What is your preferred approach for limiting the energy use of low-power modes (e.g. the ‘delay start’ function)? Should they be included in or excluded from the EEI calculation? Should separate ecodesign requirements be foreseen (for instance maximum energy consumption or maximum time duration)? Please provide the reasons for your answer.

d) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.6. Specify consumption values per cycle

As the low power energy consumption has turned out to have quite a small contribution to the annual energy consumption (see above), there seems to be no longer a need to calculate average energy and water consumption on an annual basis. For consumers, consumption values have a similar representativeness if reported per year or per cycle.

On the one hand, a potential buyer can perhaps convert more easily yearly values to potential annual savings in monetary terms. On the other hand, the real annual consumption depends on the household size and on washing habits, and the annual number of washing cycles might deviate from the 220 washing cycles taken as basis for the calculation of the annual energy consumption (see Chapter 3).

Therefore, it is proposed to discuss if it is advisable to change the annual energy and water consumption reported on the label to ‘consumption per cycle’ (i.e. back to the format before EC 1061/2010). Alternatively, if the current annual values are kept, it is proposed to discuss if the number of washing cycles per year shall or not be updated.

Discussion point 1.8

a) Are you in favour of providing information per cycle rather than per year? Please explain why

b) If you are in favour of indicating annual consumption values, which number of washing cycle,s per year you would consider? Please provide the reasons for your answer.

c) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.7. Avoidance of damage to textiles

Energy saving cycles have reduced energy consumption by increasing the program duration. When a 60°C cotton programme achieves 60°C, it is possible to achieve the desired level of cleaning within 60 to 90 minutes. When the wash temperature is lowered to 25 to 35°C it can take three times longer to achieve the same cleaning performance.

The higher the mechanical action on the laundry, the better will generally be the washing performance. However, washing has a mechanical impact on the textile fibres, and it damages it with time. The longer the washing cycle, the more damage occurs. Manufacturers can control this damage not only by shortening the washing time, but also by other actions, like using more water, less spinning, etc.

A measurement of mechanical action has been suggested as one of the possible means for limiting the development and marketing of washing machines that use less energy at the expense of increasing mechanical action with longer cycles and sometimes, higher water use. However, a standardisation mandate would be needed for this. This mandate should foresee also conducting field-tests to check the current performance with regard to mechanical action, and investigate the repeatability and reproducibility of the methods.

Other simpler but more intrusive options are for instance a limitation of the total washing time of the test associated to the labelling. Even simpler, but perhaps not as effective, could be a clear indication of the cycle time in the energy label. Necessary preconditions, as well as possible implications and side effects need to be carefully analysed during the course of the project.

Discussion point 1.9

a) How concerning is in your opinion the textile damage due to mechanical action? Do you have further evidence?

b) Are you in favour of developing formally in a standard a method for the measurement of the mechanical action? If so, please provide indications on how such method could be developed. If not, please explain why.

c) Please provide your opinion and any pros/cons of the following potential additional requirements:

- a limitation of the total washing time of the test associated to the labelling
- a clear indication of the cycle time in the energy label
- compulsory information to the consumers (e.g. in the display) when the programme is chosen.

d) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provides the reasons for your answer.

1.4.2.8. Temperature testing

Recent test of appliances on the market (e.g. ATLETE project, see Chapter 2) concludes that the standard 60°C and 40°C programmes achieve actually maximum temperatures of respectively 35°C and 25°C.

While 5-10 °C differences may not be essential for a customer significant at around 40°C, provided that the washing performance is the same, larger temperature differences can be a problem at about 60°C, as this temperature is normally selected purposefully to address hygiene or specific soiling of textiles. Certain pathogenic microorganisms or soiling is removed indeed only if exposed to this temperature.

Using the standard cotton 60°C programme commonly provided in many washing machines on the market today will provide the complete opposite effect of a hygienic wash – it will incubate pathogens at 35 to 40°C – exactly the temperature at which they multiply most rapidly. Some stakeholders argue in this respect that low temperature standard programmes would normally require running additional regular maintenance cycles at high(e.g. 90°C) temperature to remove bacterial growth, and this should be included in the EEI calculation.

Whilst it is recognised that manufacturers are obliged to include a statement explaining that claimed temperatures may not be achieved in practice, the statement itself is too vague to give the user a proper understanding of the situation.

This issue could be handled for instance through:

- the removal of the standard 60°C cotton programme from the test procedure linked to the Regulations.
- a requirement to declare the maximum temperature (± 2°C) of each programme in the booklet of instructions.
- a requirement to reach a minimum temperature for a certain amount of time for some specific programmes.

The method for temperature testing (e.g. exact placement in the machine , duration of the measurement) shall also be part of the standard.

Some stakeholders have additionally indicated that the availability of cold wash programmes (i.e. 20°C), which is required by the Ecodesign regulation, offer great energy saving potential. However, their performance is not tested, measured and regulated, especially with respect to the washing function.

Discussion point 1.10

a) Please indicate your opinion of the proposals outlined to address the differences between declared and actual temperatures. Please explain why / why not and which would be the practical consequences of such changes.

- removing the standard 60°C cotton programme from the test procedure linked to the Regulations.

- introducing a requirement to declare in the booklet of instructions the maximum temperature (± 2°C) reached in all the programmes.

- requiring a minimum temperature for a certain amount of time for some specific programmes..

b) Could you please provide any hints on how temperature testing (e.g. exact placement in the machine/laundry, duration of the measurement) should be performed? Do you foresee any specific hurdle for this?

c) Are you in favour of requirements for the testing of performance of the cold wash programmes? Should high temperature cycles be included in such test procedure? Please explain why / why not and, if in favour how this could be handled in practice.

d) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.9. Verification of the level of uncertainty of all measured values

As a step in the implementation of any new proposals of revision of the Ecodesign and energy label Regulations, it would be useful that round robin tests (RRT) are being carried out for all new measurement standards. A centralised office for organising and evaluating the round-robin test results may be needed. The results of the RRTs might also be used to establish expanded uncertainty values for all measurements required for energy labelling and ecodesign.

A stakeholder for instance suggests that tolerances could be smaller, about 6%. Industry stakeholders also reported that products are designed to be sure to meet the verification tolerances provided in the relevant standards and regulations.

Discussion point 1.11

a) Could you provide any preliminary indications about the actual uncertainty associated with the measurement of the levels of performance for washing machines and washer-dryers, and how tolerances should be set to reflect such inherent uncertainties?

1.4.2.10. Demand-response enabled appliances

Appliances which offer a demand-response function provide flexibility in the demand side to match the fluctuating energy production forecasted for the future due to the increasing number of wind and solar PV stations. However, this cannot work alone, and it is needed that the distribution system operator, or an aggregator of the smart grid, offers the consumer sufficient incentives to allow the use of the demand-response enabled power capacity. A sufficient large number of appliances need to be in the market before such a system can take off.

It could therefore be useful to support the introduction of demand-response enabled appliances. Requirements to the demand-response function itself can be set up either by standardization or be introduced in the ecodesign or energy label regulation.

Therefore, it is proposed for discussion if support to the demand-response enabled appliances should be introduced, and what is the best tool to set up the general requirements, e.g. user settings, information and capabilities.

Discussion point 1.12

a) Should any general requirements be set to handle the demand-response function (e.g. user settings, information requirements, capabilities, etc) ? Please explain which ones and why.

b) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provide the reasons for your answer.

1.4.2.11. Improvement of rounding methods

Industry operates globally. Thus, rounding has to follow international rules. IEC 59D and CLC 59X standards define rounding by using the methods described in the Rule B of the Annex B.3 of the ISO 80000-1:2009 'Quantities and units - Part 1: General'. These should be applied to the final result of any calculation. European standards and regulations should not differ more than necessary from international standards.

However, the methods described in the European standards and Regulations deviate from this target. Different rounding methods were found, e.g for the water consumption of washing machines where the annual water consumption of a household washing machine is calculated in litres, rounded up to the nearest integer and after that multiplied by the total number of standard cleaning cycles per year (220) (cf clause 3 of Annex II in EC/1015/2010 and clause 2 of annex VII of EC/1061/2010).

This method is different from ISO 80000-1, and implies double rounding, as a rounded-up value is multiplied by 220. Such deviations can lead to differences between the declared values and the values determined during the verification procedure.

Therefore, it is proposed to discuss if the method from ISO 80000-1 is to be prescribed, where rounding up is applied to the final value of any calculation.

Discussion point 1.13

a) Is the rounding of figures an issue of concern? Would the prescription of the method from ISO 80000-1 be a solution to that? Please provide reasons for your answer.

b) Should the same approach be applied also for washer-dyers or are there any differentiations needed? Please provides the reasons for your answer.

1.4.2.12. Performance of washer-dryers

The standard of measuring of performance of household clothes washer-dryers (EN 50229) is currently being updated, to align load definitions with washing machines and tumble-dryer standards.

The energy use test procedure for washer dryer described in the (old) directive on labelling of washer-dryers (Directive 96/60/EC of 1996) overrates the drying function, as it requires drying of 100% of the washed laundry. However, the evidence is that only 25% of the laundry is dried in typical household use (see chapter 3). The current version of the standard does not either reflect user behaviour regarding washing temperature and load amount (only cotton 60°C with rated capacity against low temperature washing mainly with partial loads).

Discussion point 1.14

a) Do you agree or disagree with the diagnosis above? Please explain why / why not.

b) Do you have any specific proposals which would improve the standard under development? Please provide them with your rationale.

1.4.3. Legislation and standardisation: material resource efficiency

Research has shown an increasing number of examples of integration of resource efficiency matters (such as durability, and facilitating end-of-life management of products) into product policy instruments like mandatory ecodesign Regulations or voluntary ecolabels.

While ecolabels such as EU Ecolabel, German Blue Angel or the Nordic Swan already have included a large range of resource-related criteria for quite a long time, the implementation of those criteria into mandatory product-specific Regulations has only started a few years ago (e.g. ecodesign for vacuum cleaners, lamps, displays), apart from general directives or Regulations such as RoHS, REACH or WEEE. This is accompanied by increasing importance of research on the feasibility of implementing resource efficiency aspects into product policies, as reflected different European research studies published within the past two years.

However, it seems that there is still a gap between the already implemented requirements/criteria in product policies, and the ongoing research in this field, which focuses on the effectiveness and impacts of increased product-related resource efficiency. One of the causes of this gap is the absence of sufficient standards which are applicable for testing and measuring resource-related criteria, that hinder a practicable implementation of the criteria (including procedures for verification and market surveillance).

Some stakeholders indicate additionally that any new resource efficiency requirements should be measurable, enforceable, relevant and should not hinder innovation and competitiveness. Any new requirements should have a proven environmental benefit and thus be based on robust data, methodologies and widely recognised standards that confirm this. Standards should be built on a solid foundation to ensure they reflect the technical reality (state of the art). Solid evidence for feasibility, proper measurability and environmental benefit should be taken into account when developing such standards. In the absence of these conditions, any shift from resources in use (energy, water, etc.) towards material efficiency should not be forced artificially.

Some stakeholders find it also confusing that material efficiency and end-of-life requirements, part of the same integrated product policy initiative in the early 2000's although split in the final implementation (ecodesign and energy labelling on one side, RoHS, REACH and WEEE/ELV on the other), are again re-integrated.

There are currently a number of standards related to material efficiency (e.g. safety standards for durability, recycling standards for end-of-life management), but they are primarily developed for other purposes (product safety, management at recycling operations) and are not directly transferrable for increasing resource efficiency in the design phase . For example, the EN 50625 standard series cover various aspects of the treatment of electronic waste (including collection, treatment requirements, de-pollution and preparing for re-use). However, it only deals with the handling of existing (waste) products entering the recycling stream. The European Commission will issue a standardization request to ESO to develop, in an appropriate timeframe, European standards on material efficiency aspects for energy-related products. When available, such standards might be referenced normatively in product or product group related harmonised standards where implementing measures set ecodesign requirements for material efficiency aspects.

However absent harmonized standards for resource efficiency may be, it is still possible to explore resource efficiency aspects in the preparatory study. The ESO horizontal initiative above may if deemed necessary be combined with product-specific standards which could address requirements of design that facilitate end-of-life management and resource efficiency for specific product groups.

For household washing machines and washer-dryers, the presented examples are used as a basis for the discussions. Further research in the following sections (e.g. user behaviour, technical product lifetime, common causes of breakdown, end-of-life behaviour), and especially a more accurate picture of the end-of-life management situation in Europe will enable a better decision on the feasibility and value-added of proposing resource efficiency requirements in the ecodesign and energy label Regulations for household washing machines and washer-dryers.

Discussion point 1.15

a) Which kind of resource or end-of-life requirement do you see most/least feasible for washing machines and washer-dryers? Please explain why.

1.4.4. Additional discussion issues on legislation and standardisation

The following additional discussion issues have been tabled by stakeholders in the written consultation:

1. Washing performance should be separate for each treatment and not an average value. Industry claims that alternative measurement methods have to be developed.
2. It would be an interesting cost-saving option to streamline the existing methods for water preparation (e.g. in dishwashers, washing machines, washer-dryers, professional and household).
3. The tolerances for the EMPA-certificates are too small.
4. 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 <u>or</u> the "standard 40 °C cotton 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.
5. With respect to washer-dryers, the approach for integrating the drying function in the revised ecodesign and energy label requirements has to be discussed. For instance, two separate labels/scales might be needed (1 for the washing function and 1 for the drying function).
6. With respect to the spin-drying efficiency, it is proposed by some stakeholders to introduce a minimum requirement. However this should be assessed also with respect to the market distribution of products in terms of spin-drying efficiency.

Discussion point 1.16

a) Do you have any comment to the additional discussion issues listed above? Please provide any available data to support your view.

2. Task 2: Markets

This chapter provides information on generic economic data, market and stock data, market trends and consumer expenditure for washing machines and washer-dryers. Each of these sections is explained in detail in the following. A summary of the main information is presented at the end of the chapter with some discussion points.

2.1. Generic economic data

This section presents market and economic data based on official European statistics provided by Eurostat concerning production and trade data. Based on these data, the apparent EU-28 consumption of household washing machines including washer-dryers is calculated in section 2.1.3.

It has to be noted, however, that the statistical data have to be interpreted with care as there are some data gaps, especially for the domestic production. However, the statistical analysis can very well complement the general market analysis which is presented in subsequent sections as they do represent the official source for EU policy.

Classification of household washing machines and washer-dryers in Eurostat statistics

Prodcom (EU statistics on the production of manufactured goods, (Eurostat n.d.)) and the European trade statistics (Eurostat 2015a) use different classifications for household washing machines and washer-dryers: The Prodcom category includes clothes washing machines, combined washer-dryers, but also clothes dryers altogether in one single code. In the EU-28 trade statistics, the so called Combined Nomenclature codes (CN8) are used. The trade statistics differentiates by specifying washing machines only and further categorising according to capacity (≤ 6 kg or 6-10 kg) and/or format (front- or top loading).

- Prodcom database: Clothes washing and drying machines, of the household type (Prodcom code 27511300)
- Trade database:
  - Fully-automatic household or laundry-type machines, of a dry-linen capacity ≤ 6 kg: (CN code 84501110)
    - Fully-automatic household or laundry-type front-loading washing machines, of a dry-linen capacity ≤ 6 kg: (CN code 84501111)
    - Fully-automatic household or laundry-type top-loading washing machines, of a dry-linen capacity ≤ 6 kg: (CN code 84501119)
  - Fully-automatic household or laundry-type washing machines, of a dry-linen capacity > 6 kg but ≤ 10 kg: (CN code 84501190) (top and front load)

It is assumed, that these categories of the trade database also include combined washer-dryers (which do not have an own category, but also do not fall under “drying machines” for which other CN codes apply).

Please, note that the presented data may contain some inherent inconsistencies (e.g. when comparing Tables 2-3, 2-4 and 2-5) due to the different nature of the databases, methods used for data collection, and to some limitations existing in such statistics (e.g. precision, completeness). This information and these inconsistencies will be analysed further in the next revision of this document.. Nevertheless, this is only one of the sources considered for describing the market and further input will be taken into due account if available.

2.1.1. EU Production of clothes washing and drying machines of the household type

Volume of EU production of clothes washing and drying machines of the household type

The following table shows the unit volume of household washing machines including washer-dryers in produced in EU Member States and EU28 totals in the years 2007 to 2013 according to (Eurostat 2015a).

According to the Prodcom data, Poland, Italy and Germany are the main Member States (for which data are available) producing 'clothes washing and drying machines', followed by Spain and France. Besides Poland, all other production sites have declining production volume whereas Poland doubled the production between 2007 and 2013. In total, the volume of produced household clothes washing and drying machines in EU28 declined from 27.7 million units in 2007 by 26% to 20.5 million units produced in 2013.

However, it is important to note that data is missing for some producing Member states like Czech Republic or Germany. For UK, for example, production data are available until 2009 only, for Germany production data are not available from 2012 on. This leads to a data gap of around 7 million units in 2013 of the listed production in single Member States compared to the EU 28 totals production volume.

Table 2.1: Volume (number of units) of 'Clothes washing and drying machines, of the household type' produced in the EU28 between 2007 and 2013; source: (Eurostat 2015a)

Declarant	2007	2008	2009	2010	2011	2012	2013
Austria	0	0	0	0	0	0	0
Belgium	0	:	:	:	:	:	:
Bulgaria	0	:	:	:	:	:	:
Croatia	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0
Czech Republic	:	:	:	:	:	:	:
Denmark	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0
Finland	2	:	:	0	0	0	0
France	0	1,659,943	1,424,648	1,377,689	1,067,727	1,220,365	1,007,213
Germany	2,661,139	:	2,574,867	2,419,348	2,477,977	:	:
Greece	0	:	:	:	:	:	:
Hungary	:	:	:	:	:	:	:
Iceland	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0
Italy	9,681,266	8,495,725	5,407,054	5,098,767	4,782,322	4,524,574	4,315,817
Latvia	0	0	0	0	0	0	0
Lituania	0	0	0	0	0	0	0
Luxemburg	0	0	0	0	0	0	0

Declar-ant	2007	2008	2009	2010	2011	2012	2013
Malta	0	0	0	0	0	0	0
Nether-lands	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0
Poland	3,706,613	4,152,683	5,027,864	5,924,203	6,264,679	6,711,326	7,495,935
Portugal	0	0	0	0	0	0	0
Romania	0	:	:	14,701	:	:	:
Slovakia	0	:	:	:	:	:	:
Slovenia	0	:	:	:	:	:	:
Spain	2,470,484	2,002,840	1,689,876	1,272,514	:	1,300,123	1,013,725
Sweden	55,812	:	:	:	:	:	:
United Kingdom	1,477,174	2,538,108	2,244,032	:	:	:	:
EU28 TOTALS	**27,736,546**	**24,812,568**	**21,163,985**	**21,046,139**	**20,645,799**	**20,305,038**	**20,516,768**

":" means data not being available

Value of EU production of clothes washing and drying machines of the household type

The following table provides an overview of the value corresponding to the number of units produced in certain Member States and EU28 totals (cf. Table 2.1). It can be resumed that the total value of produced household washing machines in EU28 declined from 6.4 billion Euros in 2007 by 29% to 4.5 billion Euros in 2013; i.e. the production value decreased slightly more than the production volume.

Table 2.2: Value (in thousand Euros) of 'Clothes washing and drying machines, of the household type' produced in the EU28 between 2007 and 2013; source: (Eurostat 2015a)

Declar-ant	2007	2008	2009	2010	2011	2012	2013
Austria	0	0	0	0	0	0	0
Belgium	0	:	:	:	:	:	:
Bulgaria	0	:	:	:	:	:	:
Croatia	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0
Czech Republic	:	:	:	:	:	:	:
Denmark	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0
Finland	1.254.084	1.375.653	366.121	0	0	0	0
France	0	364.507.000	303.655.000	279.585.000	217.897.000	259.569.000	231.871.000
Germany	1.267.224.082	:	1.238.742.793	1.151.713.896	1.127.944.004	886.774.455	:
Greece	0	:	:	:	:	:	:
Hungary	:	:	:	:	:	:	:
Iceland	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0
Italy	1.866.729.000	1.635.573.000	1.099.828.000	1.071.993.000	989.943.000	951.759.000	899.542.000
Latvia	0	0	0	0	0	0	0
Lituania	0	0	0	0	0	0	0
Luxem-	0	0	0	0	0	0	0

Declar-ant	2007	2008	2009	2010	2011	2012	2013
burg							
Malta	0	0	0	0	0	0	0
Nether-lands	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0
Poland	790.942.649	912.843.541	1.012.044.205	1.182.905.575	1.136.946.755	1.290.793.701	1.391.240.095
Portugal	0	0	0	0	0	0	0
Romania	0	:	:	1.190.633	:	:	:
Slovakia	0	:	:	:	:	:	:
Slovenia	0	:	:	:	:	:	:
Spain	476.001.395	393.598.900	329.556.008	265.978.058	:	285.340.520	225.284.053
Sweden	19.011.470	:	:	:	:	:	:
United Kingdom	206.710.115	434.737.781	389.900.554	:	:	:	:
EU28 TOTALS	**6.372.604.475**	**5.696.900.447**	**4.948.867.062**	**4.890.074.180**	**4.663.341.489**	**4.623.900.016**	**4.526.493.195**

“:” means data not being available

2.1.2. EU imports and exports of clothes washing and drying machines of the household type

The following tables provide an overview of the *value* of exports and imports of clothes washing and drying machines of the household type by Member States for the year 2013. Unfortunately, since 2008 no data with regard to *quantities* of exports and imports is available any more so that the following overviews only represent the MS specific values of exports and imports.

Based on value, Germany, UK and France appear to be the largest importing countries of household clothes washing and drying machines, followed by Italy, Netherlands, Sweden, Spain and Belgium.

A clear trend of rising or declining import values cannot be seen; for many Member States, the values have been more or less stable over the years, for some MS they have been declining (e.g. Sweden, Spain or Netherlands) whereas the value of imports has been increasing for others (e.g. Belgium, Germany or Italy, as well as EU28 totals).

Table 2.3: Value of imports of clothes washing and drying machines of the household type from 2007 to 2013; source: (Eurostat 2015a)

Declarant	2007	2008	2009	2010	2011	2012	2013
Austria	107.859.640	107.658.210	115.979.120	127.402.350	121.206.540	115.218.510	119.229.380
Belgium	171.775.340	174.906.480	178.752.840	192.668.530	191.909.040	211.912.630	211.812.840
Bulgaria	49.164.930	41.246.580	31.094.920	32.425.720	26.100.650	29.461.990	31.309.390
Croatia	32.135.110	27.529.460	21.655.490	23.039.770	22.050.210	20.502.560	22.730.340
Cyprus	12.402.220	12.909.680	10.447.470	9.608.430	9.193.470	7.271.380	5.047.330
Czech Republic	77.157.990	80.712.660	80.967.560	77.314.410	83.233.660	85.979.860	91.479.250
Denmark	119.541.300	110.215.100	97.415.060	98.539.710	103.529.750	97.764.410	97.581.580
Estonia	11.175.840	9.386.070	6.265.920	8.416.690	8.265.820	11.456.360	11.537.130
Finland	101.798.270	92.777.380	61.494.880	65.432.840	70.059.750	65.286.130	59.319.750
France	566.309.800	531.191.420	552.783.200	556.897.430	576.550.160	580.437.220	554.764.620
Germany	800.016.110	786.040.090	782.266.790	914.464.020	924.941.040	943.852.650	914.545.660

Declarant	2007	2008	2009	2010	2011	2012	2013
Greece	98.270.460	103.078.920	93.877.000	86.004.910	65.867.420	51.977.720	57.327.010
Hungary	98.700.230	70.815.940	61.169.320	74.465.340	50.692.000	38.761.250	42.751.120
Ireland	72.826.250	61.996.680	49.694.600	43.806.050	47.571.520	48.238.560	49.890.600
Italy	255.810.230	234.360.790	250.174.420	299.309.970	284.097.020	273.179.260	263.282.570
Latvia	16.150.650	13.035.960	7.572.680	10.400.750	11.630.190	15.021.390	16.567.440
Lituania	28.494.310	21.299.580	11.285.490	15.500.630	15.271.840	18.983.410	21.676.710
Luxemburg	13.032.380	15.846.980	17.203.870	15.366.850	11.981.500	11.193.900	12.277.640
Malta	4.153.660	4.903.630	4.337.740	3.634.640	4.559.050	4.235.330	5.195.060
Netherlands	304.879.330	280.315.610	282.544.330	291.557.800	267.105.290	272.342.390	245.352.590
Poland	228.684.900	193.395.510	144.887.940	146.589.630	165.053.520	166.303.830	156.110.400
Portugal	84.106.330	81.465.980	73.567.940	86.622.370	65.292.260	49.652.840	55.383.950
Romania	96.339.760	98.575.690	58.517.510	63.895.100	58.302.360	61.926.230	66.475.350
Slovakia	42.297.080	34.377.290	26.847.930	29.701.780	34.141.740	37.095.150	30.725.190
Slovenia	18.263.750	18.773.520	17.103.120	19.345.160	19.758.360	17.392.520	18.713.000
Spain	308.663.840	246.592.300	219.158.410	261.233.500	255.864.850	214.170.180	216.672.850
Sweden	245.134.670	226.409.700	224.250.950	209.551.590	202.005.380	209.001.960	218.492.390
United King-dom	505.556.820	499.484.540	519.208.920	558.480.340	613.039.580	642.464.020	672.794.200
EU28 TOTALS	681.833.790	705.407.100	818.403.860	1.008.006.810	1.035.474.150	1.002.704.270	972.250.450

Table 2.4 provides an overview of the export values. Based on value, Poland by far, Italy and Germany appear to be the largest exporting countries of household clothes washing and drying machines, followed by Slovakia, Czech Republic, Spain and Sweden.

A clear trend of rising or declining export values cannot be seen; for many Member States, the values have been more or less stable over the years, for some MS they have been declining (e.g. France, Germany, Italy or UK) whereas the value of exports has been increasing for others (e.g. Czech Republic or Poland). Within EU28 totals, the value of exports has declined significantly from 1.8 billion Euros in 2007 to 0.8 billion Euros in 2013.

Table 2.4: Value of exports of clothes washing and drying machines of the household type from 2007 to 2013; source: (Eurostat 2015a)

Declarant	2007	2008	2009	2010	2011	2012	2013
Austria	7.509.580	6.310.690	6.302.520	11.286.900	11.906.610	10.912.830	12.493.000
Belgium	47.366.140	43.597.000	36.874.530	39.625.020	47.732.400	64.173.050	63.787.000
Bulgaria	3.199.030	2.671.090	3.014.860	5.006.750	3.783.240	3.024.390	2.590.230
Croatia	1.804.460	1.686.370	643.930	770.540	596.090	296.900	541.700
Cyprus	76.230	35.340	7.350	18.140	16.410	4.410	15.130
Czech Rep.	154.798.010	164.420.950	136.957.870	136.731.600	148.938.520	170.879.650	199.598.760
Denmark	11.506.480	11.371.740	9.032.290	7.539.820	9.847.170	21.673.280	18.954.130
Estonia	852.710	799.110	484.470	1.733.210	1.673.000	2.618.940	2.227.420
Finland	59.408.380	45.442.910	9.653.950	2.643.230	2.070.630	781.260	970.390
France	323.679.330	257.699.320	198.166.840	179.114.010	174.779.630	155.953.860	130.089.920
Germany	1.550.471.120	1.327.164.830	1.067.034.750	967.399.990	937.818.410	732.118.300	647.578.070
Greece	6.761.080	7.151.220	6.779.760	6.257.360	7.023.750	6.524.350	5.829.410

Declarant	2007	2008	2009	2010	2011	2012	2013
Hungary	44.468.850	24.421.720	21.477.890	21.272.980	8.499.440	8.964.110	9.945.940
Ireland	2.669.610	2.916.630	1.938.940	1.137.820	1.309.060	2.582.400	3.066.640
Italy	1.533.267.020	1.290.392.720	899.571.400	881.954.450	802.108.670	791.576.780	791.399.880
Latvia	1.419.010	1.860.770	1.965.870	5.731.900	6.458.280	8.293.450	8.965.880
Lituania	5.189.710	2.552.430	2.630.850	5.874.670	6.087.240	7.419.130	8.980.620
Luxemburg	4.503.030	5.973.180	6.749.840	6.214.800	3.872.010	2.645.190	3.698.310
Malta	:	3.970	1.350	170	:	1.450	6.910
Netherlands	65.154.660	74.507.260	47.087.470	77.255.580	67.235.160	72.265.330	67.845.520
Poland	756.202.550	621.666.130	918.957.190	1.133.065.950	1.156.333.880	1.232.965.330	1.355.472.630
Portugal	3.260.290	3.164.330	4.608.450	2.620.760	2.992.030	3.300.570	2.939.270
Romania	594.920	309.390	2.027.710	2.734.350	2.343.840	3.309.370	2.452.550
Slovakia	313.703.870	314.892.940	274.111.440	250.192.210	246.496.770	235.572.350	284.206.930
Slovenia	127.192.490	124.284.820	121.249.390	128.468.440	119.962.970	113.439.670	139.681.190
Spain	269.707.570	216.564.440	174.345.750	158.557.520	204.594.660	265.386.030	193.046.240
Sweden	156.105.110	151.557.520	153.334.700	192.061.390	190.243.600	199.591.340	183.253.200
United Kingdom	173.375.490	110.219.120	77.806.880	85.251.730	96.378.620	87.636.760	96.240.900
EU28 TOTALS	1.847.347.600	1.541.836.330	1.078.843.670	1.009.109.470	957.913.390	879.885.450	830.778.490

2.1.3. Apparent consumption of household washing machines

Apparent consumption of EU Member States generally can be calculated as follows:

Apparent consumption = Production + Imports – Exports

Unfortunately, since 2008 no data with regard to quantities of exports and imports are available. An indirect method of estimation will be used in further phases of drafting of this report to estimate the apparent consumption.

2.1.4. EU sales and Intra/Extra-EU28 trade of household washing machines

The following tables show the Intra- and Extra-EU trade of EU Member States with household washing machines (front-loaders ≤ 6 kg; top-loaders ≤ 6 kg, and machines > 6 but ≤ 10 kg) in 2014 according to (Eurostat 2015b).

The trade data suggest that for nearly all Member States, the Intra-EU trade is greater than the Extra-EU trade. Sales with top-loading washing machines ≤ 6 kg, especially the Extra-EU trade, is rather small compared to the front-loading machines. Slovakia, Poland and France have the largest number of exports from their country to other EU Member States (exports to Intra-EU); France, Germany and Poland also import most of top-loading machines from other EU Member States. Exports to extra-EU countries are very small at all, with France having the largest number of export.

Within the front-loading machines, appliances ≤6 kg and >6 to 10 kg have a comparable trade volume with differences in single Member States. For example, in some countries the trade with the smaller appliances is higher (e.g. Italy, Czech Republic, Slovakia or Poland; in Poland, however exports of appliances >6 – 10 kg to other EU Member States surpass the exports of smaller appliances). In other Member States, the trade with larger appliances is in a similar range or higher (e.g. Germany, Netherlands, France, Greece, or Sweden).

Table 2.5: **Intra- and Extra-EU28 trade of Member States with household washing machines (front-loaders ≤ 6 kg) in 2014; source: (Eurostat 2015b)**

	EU28_EXTRA		EU28_INTRA	
Country	Imports (units)	Exports (units)	Imports (units)	Exports (units)
Austria	19.009	1.584	116.824	38.132
Belgium	65.905	244	0	0
Bulgaria	28.368	508	43.056	4.321
Croatia	22.490	274	19.551	1.046
Cyprus	1.328		7.675	
Czech Republic	39.565	2.503	94.138	20.815
Denmark	9.808	6.027	42.564	8.709
Estonia	2.168	310	13.974	2.012
Finland	2.195	122	25.015	53
France	290.076	19.142	450.657	9.954
Germany	199.567	29.532	517.580	124.147
Greece	34.455	35	23.346	5.474
Hungary	20.054	1.636	63.599	7.351
Ireland	13.602		92.196	4.060
Italy	204.939	262.876	312.598	1.401.295
Latvia	3.981	3.908	17.801	7.208
Lithuania	11.753	5.162	24.446	3.622
Luxembourg			8.354	65
Malta	4.509		2.642	
Netherlands	28.327	564	131.009	35.928
Poland	191.690	243.524	134.594	1.302.757
Portugal	25.277	605	65.937	2.255
Romania	82.557	808	101.707	5.210
Slovakia	7.604	44.012	42.599	625.072
Slovenia	8.418	36.578	5.859	146.457
Spain	320.309	5.304	107.426	24.986
Sweden	53.086	34.045	92.321	44.993
UK	243.378	1.355	885.544	36.817

Table 2.6: **Intra- and Extra-EU28 trade of Member States with household washing machines (top-loaders ≤ 6 kg) in 2014; source: (Eurostat 2015b)**

PARTNER	EU28_EXTRA		EU28_INTRA	
Reporter	Imports (units)	Exports (units)	Imports (units)	Exports (units)
Austria	365	130	9.993	593
Belgium	257	873	0	147
Bulgaria		10	2.913	81
Croatia	133	356	4.585	417

PARTNER	EU28_EXTRA		EU28_INTRA	
Cyprus			43	
Czech Republic		21	50.204	32.265
Denmark	85	71	14.433	59
Estonia	1	709	7.753	292
Finland	73	0	35.338	34
France	27.558	19.883	368.497	102.804
Germany	703	12.736	154.706	15.058
Greece	37		15.828	22
Hungary	0	1.226	58.193	4.638
Ireland			365	1
Italy	2.354	57.189	65.132	89.845
Latvia	9	228	3.674	978
Lithuania	179	1.872	6.625	62
Luxembourg			446	115
Malta			183	
Netherlands	1.467	5	10.048	2.398
Poland	547	53.746	115.285	298.675
Portugal	21	1	509	18
Romania	1	368	19.618	125
Slovakia	1	107.679	13.735	569.887
Slovenia	2	887	2.275	473
Spain	3.309	8.900	23.387	58
Sweden	1.077	18.772	34.866	20.246
UK	62	51	2.344	187

Table 2.7: Intra- and Extra-EU28 trade of Member States with household washing machines (> 6 but ≤ 10 kg) in 2014; source: (Eurostat 2015b)

PARTNER	EU28_EXTRA		EU28_INTRA	
Reporter	Imports (units)	Exports (units)	Imports (units)	Exports (units)
Austria	19.284	1.114	96.587	9.993
Belgium	106.471	1.649	0	134
Bulgaria	11.762	262	27.806	2.078
Croatia	8.786	297	28.185	200
Cyprus	1.084		3.591	
Czech Republic	15.293	2.080	52.287	12.776
Denmark	8.175	1.599	94.465	3.590
Estonia	263	1.555	6.447	496
Finland	9.329	607	73.901	289
France	275.623	4.214	439.486	6.990

PARTNER	EU28_EXTRA		EU28_INTRA	
Germany	176.676	246.283	846.176	601.618
Greece	48.983	534	63.718	6.360
Hungary	9.361	4.389	37.285	9.382
Ireland	5.674		52.511	1.982
Italy	148.648	106.796	210.525	215.483
Latvia	3.991	913	19.087	11.549
Lithuania	1.011	3.428	15.468	608
Luxembourg			18.380	6.710
Malta	2.949	1	3.031	
Netherlands	49.127	309.815	412.940	231.526
Poland	100.145	131.344	83.163	1.977.542
Portugal	23.619	1.239	89.571	1.517
Romania	35.171	50	49.960	2.540
Slovakia	6.343	3.963	20.823	15.972
Slovenia	6.008	139.062	16.875	117.568
Spain	117.521	30.727	249.377	275.758
Sweden	56.418	75.097	287.950	104.417
UK	255.923	633	533.245	27.849

2.2. Market, stock data and trends

Different approaches did allow getting some insight into the market in general, how it developed in the past and how it may develop in future. This picture is provided by a study which was conducted by a consultant under the supervision of the EU and had the task to assess the impacts of already existing ecodesign regulations (2.2.1). The second study did have a detailed look into the market offer of washing machines of years 2012-13 and tested 50 different models of washing machines (2.2.2). Finally, further data were gathered and summarised (2.2.3 ff).

2.2.1. Study “Ecodesign Impact Accounting”

The European Commission has identified a need to systematically monitor and report on the impact of Ecodesign, Energy Labelling, Energy Star and Tyre Labelling measures, including potentially new forthcoming actions, with a view to improve its understanding of the impacts over time as well as its forecasting and reporting capacity. With contract no. ENER/C3/412-2010/FV575-012/12/SI2.657835 DG Energy has contracted Van Holsteijn en Kemna B.V. (VHK) to undertake this exercise. (VHK 2014)

The accounting method developed in this study (ECODESIGN IMPACT ACCOUNTING; Part 1 – status Nov. 2013) provides a practical tool to achieve those goals.

The accounting covers projections for the period 2010-2050, with inputs going as far back as 1990 and earlier. Studies of 33 product groups (including Lot 14 on washing machine and dishwashers) with over 180 base case products were harmonised and complemented to fit the methodology. For the period up to 2025-2030 inputs were derived from the available studies. The period beyond 2025-2030 is an extrapolation of the existing trend without any new measures, i.e. it is not in the scope of this study to develop new policies.

Projections use two scenarios: a ‘business-as-usual’ (BAU) scenario, which represents what was perceived to be the baseline without measures at the moment of the decision making, and an ECO scenario that is derived from the policy scenario in the studies which come closest to the measure taken. The BAU scenario is not a 'freeze' scenario; it is derived from extrapolating historical trends at the time of the preparatory study analysis, including possible ongoing trends in energy efficiency improvement and emission abatement The ECO scenario is the scenario with the impact of known Ecodesign, Energy Labelling, Energy Star, Tyre Label and Voluntary Agreements. Up to 2020-2030 it is derived from Impact Assessment and preparatory study scenarios for the selected/proposed measures. Longer term scenarios are extrapolations of the trends, but do NOT assume that new measures will be introduced (it was not within the study scope to predict new long-term measures). All prices, rates and euro amounts are in 2010 euros, i.e. inflation corrected (at 2%) to 2010.

2.2.1.1. Washing machines

Regarding washing machines, this study reports some increase related to the inclusion of new member states in the late 90's and beginning of the 00's, but foresees a relative constant level for the period from 2015 to 2050 (Figure 2-1) reflecting almost 100% penetration in European households. VHK does not give data on penetration, and uses sales and lifetime information to calculate the stock.

For calculating the expected change in energy consumption and related greenhouse gas emissions the study makes some essential assumptions (Table 2.8). While the size of the washing machine is seen as rather constant after 2020 (in terms of rated capacity and used capacity measured per cycle), the average temperature used for the washing cycle is assumed to drop by about 20 Kelvin between 2020 and 2050 down to about 17 °C in 2050. Taking these basic input parameters and the data about BAU and ECO scenarios from Lot 14 the consumption of washing machine per cycle and per year can be calculated for a washing machine on sale for all years (Figure 2-2).

Using the stock model as developed by (VHK 2014) with the assumption of constant 15 years life time the energy used for a washing machine on stock in all years can be calculated (Figure 2-3). These calculation prognoses a significant difference of the total amount of energy used per year between the BAU and the ECO scenario for about 75 kWh per year. This is mainly caused by the reduction in average wash temperature. Following these calculations for the ECO scenario a total energy consumption for automatic laundry washing in EU is estimated to be at 15 TWh elec. in 2050 causing 8 MtCO2 eq./a greenhouse gas emissions (cf. Figure 2-4 and Figure 2-5). Notably, this is half as high as it is calculated for automatic dishwasher use.

All data are summarised in Table 2.8..

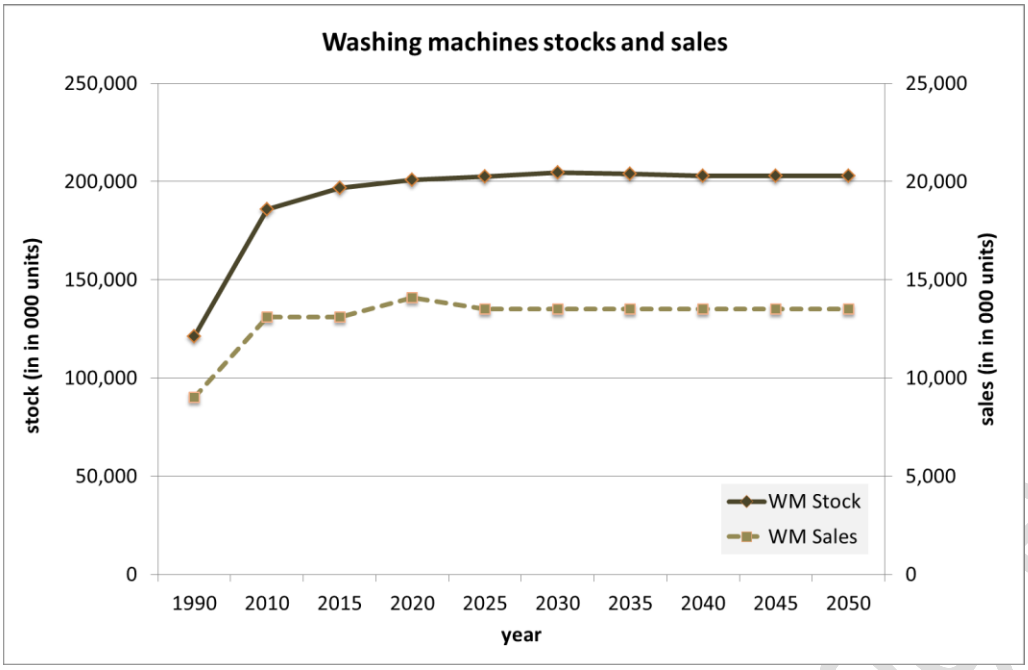


Figure 2-1 **Sales and stock of washing machines in the European market from 1990 to 2050 – please note that the interval 1990-2010 is not represented proportionally in the horizontal axis (data from (VHK 2014))**

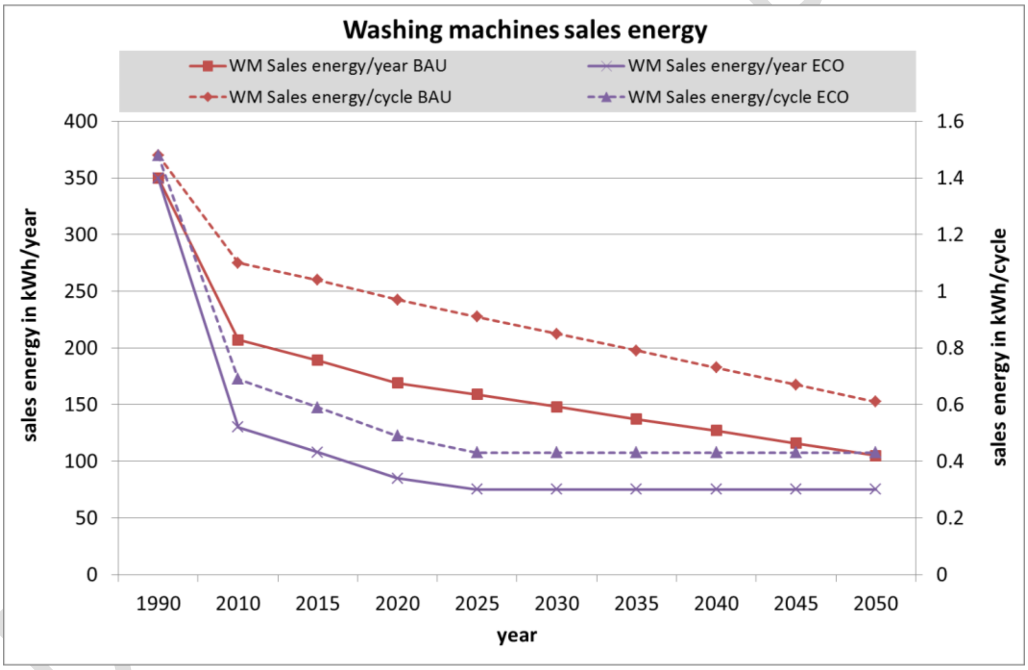


Figure 2-2 **Energy consumption of the washing machines on sale in the European market from 1990 to 2050 – please note that the interval 1990-2010 is not represented proportionally in the horizontal axis (data from (VHK 2014))**

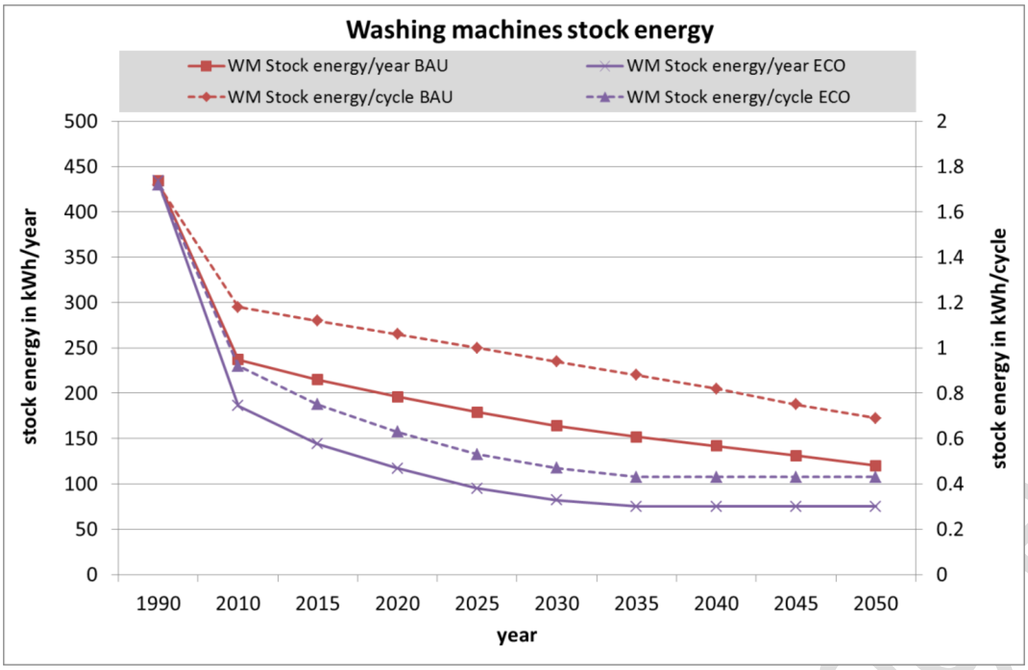


Figure 2-3 **Energy consumption of the stock of washing machines installed in the European market from 1990 to 2050 – please note that the interval 1990-2010 is not represented proportionally in the horizontal axis (data from (VHK 2014))**

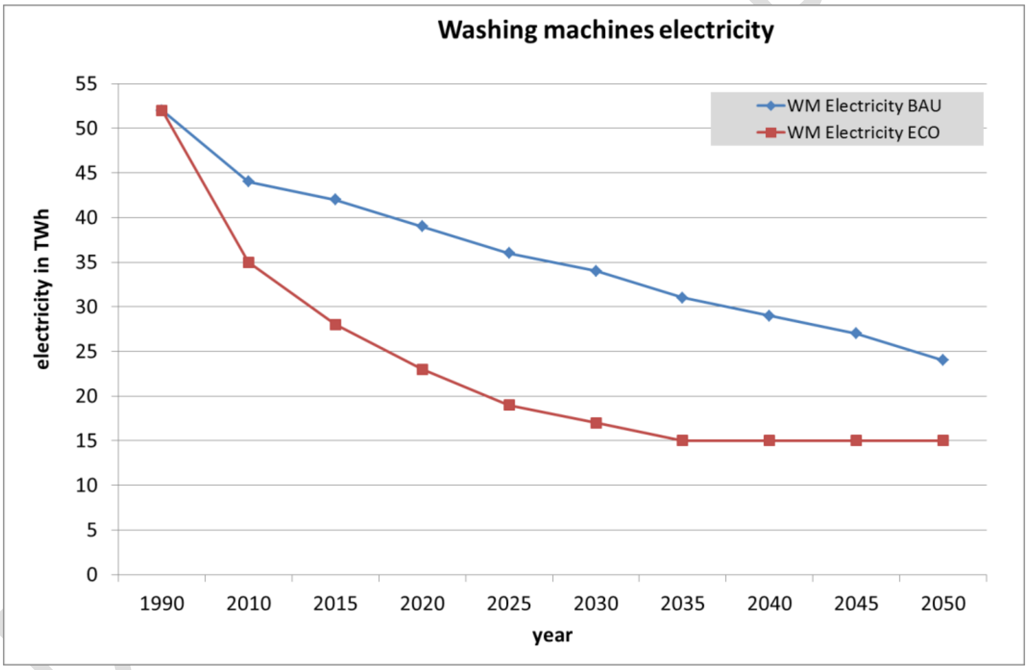


Figure 2-4 **Total electricity consumption of installed washing machines in the European market from 1990 to 2050 – please note that the interval 1990-2010 is not represented proportionally in the horizontal axis (data from (VHK 2014))**

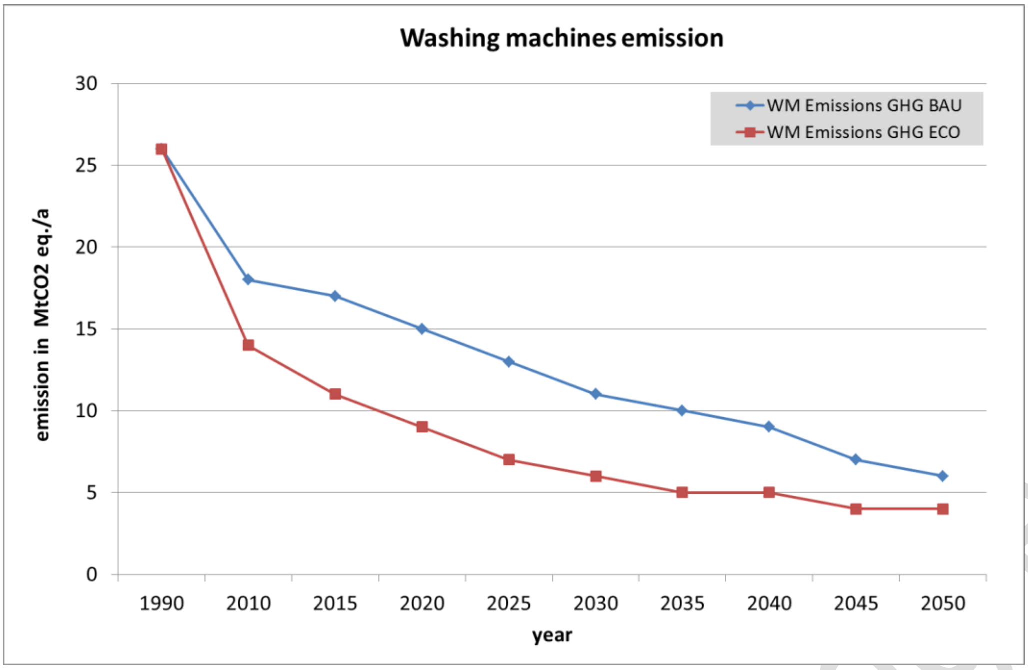


Figure 2-5 **Total greenhouse gas emissions of washing machines installed in the European market from 1990 to 2050 (data from (VHK 2014))**

Table 2.8 Summary of data regarding washing machines from ECODESIGN IMPACT ACCOUNTING (VHK 2014)

Data Washing machines	unit	year									
		1990	2010	2015	2020	2025	2030	2035	2040	2045	2050
Stock	in 000 units	121,000	185,828	196,821	200,805	202,648	204,744	203,893	202,766	202,766	202,766
Sales	in 000 units	9,000	13,099	13,099	14,081	13,518	13,518	13,518	13,518	13,518	13,518
Programme temperature	°C	56	43	39.7	36.4	33.2	29.9	27	23	20	17
Rated capacity	kg/cycle	4.1	6.8	7.1	7.6	7.6	7.6	8	8	8	8
Real (rated) load	kg/cycle	2.9	3.7	3.8	4	4	4	4	4	4	4
Cycles/year per unit (estimated)	cyc/a	237	189	182	174	174	174	174	174	174	174
SAEc (EEI=100)	kWh/a	246	371	387	410	410	410	410	410	410	410
Laundry washed per year	Mt	83	131	138	140	141	142	142	141	141	141
Sales energy/cycle BAU	kWh/cycle	1.48	1.1	1.04	0.97	0.91	0.85	0.79	0.73	0.67	0.61
Sales energy/year BAU	kWh/a	350	207	189	169	159	148	137	127	116	105
Sales energy/cycle ECO	kWh/cycle	1.48	0.69	0.59	0.49	0.43	0.43	0.43	0.43	0.43	0.43
Sales energy/year ECO	kWh/a	350	130	108	85	75	75	75	75	75	75
Stock energy/cycle BAU	kWh/cycle	1.72	1.18	1.12	1.06	1.00	0.94	0.88	0.82	0.75	0.69
Stock energy/year BAU	kWh/a	434	237	215	196	179	164	152	142	131	120
Stock energy/cycle ECO	kWh/cycle	1.72	0.92	0.75	0.63	0.53	0.47	0.43	0.43	0.43	0.43
Stock energy/year ECO	kWh/a	434	186	144	117	95	82	75	75	75	75
Electricity BAU	TWh elec	52	44	42	39	36	34	31	29	27	24
Electricity ECO	TWh elec	52	35	28	23	19	17	15	15	15	15
Emissions GHG BAU	MtCO2 eq./a	26	18	17	15	13	11	10	9	7	6
Emissions GHG ECO	MtCO2 eq./a	26	14	11	9	7	6	5	5	4	4
Unit price BAU	€ (2010)	449	474	466	459	449	449	449	449	449	449
Unit price ECO	€ (2010)	449	541	559	574	565	537	511	486	463	449
Revenue Wholesale BAU	m€ (2010)	121	186	183	194	182	182	182	182	182	182
Revenue Wholesale ECO	m€ (2010)	121	213	220	242	229	218	207	197	188	182
Revenue Industry BAU	m€ (2010)	1628	2503	2461	2606	2445	2445	2445	2445	2445	2445
Revenue Industry ECO	m€ (2010)	1628	2858	2952	3258	3078	2929	2787	2651	2523	2445

2.2.1.2. Washer-dryers

For washer-dryers, the study on Impact Assessment by (VHK 2014) did not provide separate data. It will be further clarified if washer–dryers are included or not in the set of data presented above.

2.2.2. Study "ATLETE II – Appliance Testing for Washing Machines Energy Label and Ecodesign Evaluation"

General compliance check of household washing machines

Atlete II is a EU-funded project (see www.atlete.eu) that had as main objective to check the compliance of washing machines to the provisions of EU Energy Labelling and Ecodesign legislation. Combined washer-dryers were not in the scope of this study.

Selection of products

Specific models were chosen for testing, involving all known manufacturers and conducted by a notary. Appliances were selected on the basis of the companies' market share and the product's availability in specific markets. 50 washing machine models were checked.

Selection of test laboratories

All available laboratories in Europe that were able to test (at least in theory) washing machines were identified. There were 20 in total. All of them were contacted and invited to participate. Thirteen replied positively, and the eight best were shortlisted based on proven capabilities. Based on a visit by two laboratory experts (one nominated by the representation of manufacturers – CECED, and the other by the representation of consumers – ICRT), the six best available laboratories to test washing machines in Europe at that moment were selected.

Selected test parameters

The following parameters were tested: energy consumption, water consumption, washing performance, spinning performance, spin speed, load capacity, power consumption and duration of off mode and left-on mode, ecodesign minimum requirements, product specific requirements and information requirements.

The laboratory tests were conducted on the parameters shown in Table 2.9:

Table 2.9 Parameters tested

Parameter measured	Relevant for		Unit	Tolerance
	Ecodesign	Labelling		
Annual energy consumption	✓	✓	kWh	+10%
Energy consumption	✓	✓	kWh	Step 1: +10% / Step 2: +6%
Programme time	✓	✓	min	+10%
Water consumption	✓	✓	litre	+10%
Remaining moisture content		✓	%	+10%
Spin speed		✓	rpm	-10%
Power consumption in off mode P_0 and left-on mode P_l	✓	✓	W	if > 1W: +10% if ≤ 1W: +0.10 W
Duration of the left-on mode	✓	✓	min	+10 %
Airborne acoustic noise		✓	dB(A) re 1	measured value shall meet

Parameter measured	Relevant for		Unit	Tolerance
			pW	the rated value
Washing efficiency index	✓			-4%

The harmonized standard EN 60456: 2011 has been applied by the laboratories selected.

Additionally, the following generic, respectively documentation requirements were checked:

- Energy Labelling (EU 1061/2010)
  - Presence of Energy Label in the WM unit(s) to be tested
  - Presence of the product fiche in the unit(s) to be tested or delivered by the supplier upon request, the mandatory declarations and in the order requested
- Ecodesign generic requirements according to EU 1015/2010 (different deadlines)
  - Generic requirements about the washing machine
  - Presence and identification of the 20 °C cycle
  - Identification of “standard programmes” on the front of the machine
  - Information in the instruction booklet:
  - Indication of the standard programmes and of their performance
  - Power consumption of the off mode and left-on mode
  - Recommendations on detergent use
  - Indicative information for the main washing programmes (duration, moisture content, energy and water consumption)

The results were communicated to the individual company responsible for each washing machine model, and to market surveillance authorities (MSAs) of countries where the appliances were available, and are finally becoming fully publicly available (http://www.atlete.eu/2/).

Verification of declaration

In the course of the project, the degree of compliance to energy labels affixed to washing machines were tested, checking if these provided accurate information about the technical specificities of the appliance, including their energy efficiency and functional performance. The results of the testing campaign are:

- 100% compliance rate with the energy efficiency class and energy consumption declarations for the Energy Label;
- 100% compliance rate with energy and water consumption ecodesign minimum requirements;
- 92% overall compliance rate for functional performance class and parameters;
- 84% overall compliance of the product fiche, and information availability and proper format requested by ecodesign;
- 64% compliance with the requirement to indicate the standard programme on the machine;
- 38% compliance rate for the information requested by ecodesign to be provided in the instruction booklet; and
- 30% overall compliance rate when including all individual parameters.

Non-compliance cases

Non-compliance cases were essentially due to formal requirements, and not wrong declaration of energy labels. Some specific examples are

- standard cotton programmes not clearly identifiable on the programme selection device or on the display
- missing one or several pieces of information in the instruction booklet , such as indication of the standard cotton programmes, energy consumption of the standard 60 °C cotton programme at full and partial load and of the standard 40 °C programme at partial load, weighted power consumption of the off mode and of the left-on mode, programme time, remaining moisture content, energy and water consumption for the main washing programmes at full or partial load.

A number of manufacturers have subsequently signed the ATLETE II "Voluntary protocol for manufacturer's pro-active participation" limiting the number of non-compliant models to only 8 cases out of 50 models tested (and out of 35 initially assessed as non-compliant).

However, the ATLETE II consortium had neither the responsibility nor the capability to verify that the new and correct documentation has actually been enclosed in all models on the market, or that the model claimed to be discontinued was not sold under a different name/commercial code number in the EU internal market.

The examples of non-compliance described a above highlight the complexity brought up by the way generic Ecodesign and Energy Label documentation requirements are formulated, introducing an area for interpretation due to ambiguities for proper implementation by manufacturers and compliance verification by individual MSAs.

2.2.2.1. Machine technical data overview

The machines tested within ATLETE II also provide a snapshot of the market in the years 2012 and 2013. Due to the semi-random approach of selecting machines from the market, representativeness is not fully ensured, but the selection of 50 models may be seen as a good representation of the models available on the market in 2012 and 2013. Some of the key characteristics of the machines tested are presented below, providing an illustration of the distribution of models in the European market.

Energy consumption values

The energy consumption of a washing machine is measured combining three stages (60 °C full load, 60 °C half load, and 40 °C half load) and three different low power modes (unstable left-on mode, stable left-on mode, and off-mode).

The average of the total energy consumption from the 62 machines measured within ATLETE II was 0.78 kWh, with the distribution presented below:**Error! Reference source not found.**).

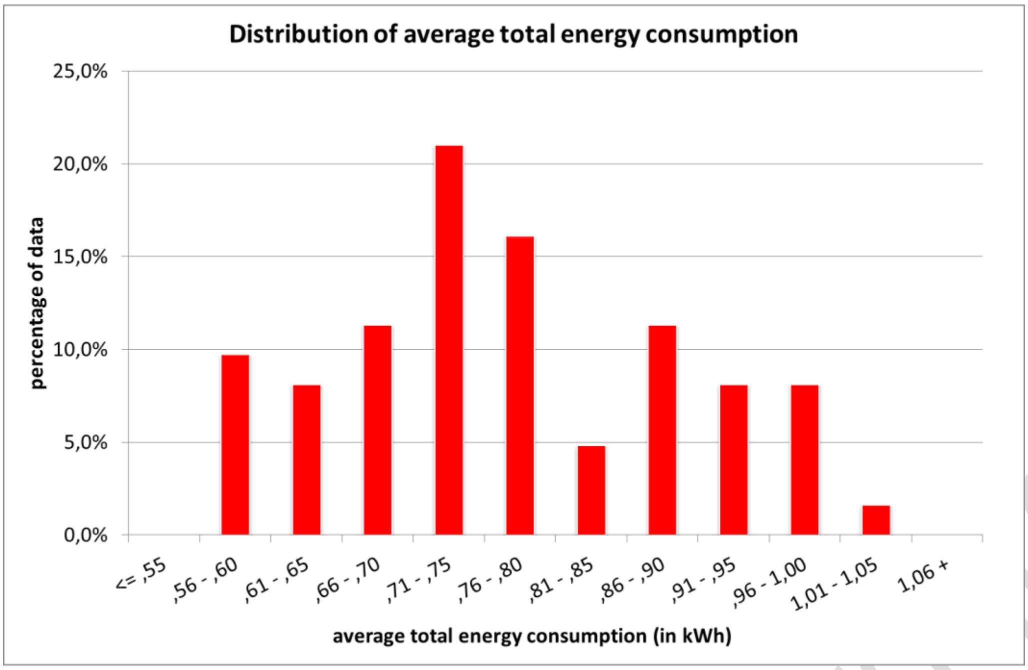


Figure 2-6 **Distribution of the (weighted) average total energy consumption**

A number of additional parameters were also measured, including capacity, low-power energy consumption share, water use, etc. all of which can be checked on the project's website, project authors, and related publications. Key summary figures are presented in Table 2.10 below.

Table 2.10 **Summary of measured data from 62 washing machines measured in ATLETE II (www.atlete.eu)**

	Average	Minimum	Maximum	valid data
Energy efficiency index (in %)	**49,91**	29,90	62,00	62
Standard annual energy consumption (in kWh)/year)	**351,14**	239,70	427,70	62
Weighted annual energy consumption (in kWh)	**173,87**	128,05	233,41	62
Average total energy consumption (in kWh)	**0,78**	0,56	1,04	62
Average power during post programme phase LU (in W)	**0,89**	0,18	2,93	62
Average power during post programme phase LO (in W)	**0,60**	0,02	1,66	62
Average power in off mode (in W)	**0,20**	0,02	0,52	62
Average programme time (in min)	**171,48**	108,00	235,00	62
Average total water consumption (in l)	**41,90**	26,00	63,00	62
Annual water consumption (in l)	**9.218,71**	5.720,00	13.860,00	62
Average value for the total water consumption for the treatment 60 with full load (in l)	**47,52**	33,00	68,00	62
Average value for the max. spin speed (in rpm)	**1.141,27**	909,00	1.595,00	62
Lowest value for the max. spin speed (in rpm)	**1.133,74**	816,00	1.594,00	62
Average remaining moisture content (in %)	**57,40**	45,00	74,00	62
Maximum remaining moisture (in %)	**58,06**	45,00	75,00	62
Nominal total load mass (in kg)	**6,37**	4,00	8,00	62
Washing Efficiency Index for the combined test series	**1,043**	0,994	1,11	62
Specific average total energy consumption (in kWh/kg):	**0,123**	0,073	0,153	62
Specific average programme time (in min / kg):	**27,225**	17,750	35,600	62
Specific average water consumption (in l / kg	**6,651**	4,875	9,800	62
Specific average value for the total water consumption for the treatment 60 with full load (in l / kg):	**7,530**	5,250	10,200	62

2.2.3. Market and sales data for washing machines and washer-dryers

2.2.3.1. Market structure of the European white goods industry

Manufacturers

The European white goods industry in 2012 was dominated by seven major players, as shown in **Error! Reference source not found.**. BSH Hausgeräte is ranked European number one, and global number 3. Electrolux is ranked number 2, both European and globally. Indesit is European number 3. Whirlpool is European number 4, followed by Samsung, LG and Miele. Globally, Whirlpool is number 1 player in 2012. Other important players are Haier, Amica and Fagor. (Capgemini Consulting 2012)

Recently Whirlpool has bought Indesit (Livesey 2014).

Table 2.11 Major players in European white goods industry (Capgemini Consulting 2012)

Company	Main brands (non-exhaustive)	Total turnover* in Europe (2010, bln €)	European ranking	Total turnover* (2010, bln €)	Global ranking
BSH	Bosch, Siemens, Gaggenau, Neff	6.7	1	8.4	3
Electrolux**	Electrolux, AEG, Zanussi	4.8	2	11.5	2
Indesit	Hotpoint, Indesit, Scholtès	2.7	3	2.9	
Whirlpool**	Whirlpool, Bauknecht, Ignis, KitchenAid	2.2****	4	13.0	1
Samsung**	Samsung	1.7***		7.5	
LG**	LG	1.2***		6.1	
Miele	Miele	--		2.8	
* Not all turnover is white goods related. Figures most of the time concern the overall home appliance turnover, including small home appliances.					
** Converted to €, based on June 2010 currency rates.					
*** High level estimate, based on published European Turnover share for all product groups.					
**** EMEA figure, assuming that turnover in Middle East and Africa is small compared to Europe					

Leading manufacturers operate numerous production locations in different European countries, mainly in Italy, Poland, Germany, Spain, Hungary and Turkey. Each production location is specialized in one product group and supplies whole of Europe.

With respect to washing machines and washer-dryers only, stakeholders involved in the elaboration of this preparatory study has indicated which are they key players for the European market, as shown in the table below.

Table 2.12 Major European manufacturers of washing machines and washer-dryers (Own elaboration based on stakeholder feedback)

Washing machines	Washer-dryers

BSH Group Indesit Group Arcelik Group Electrolux Group Whirlpool Group	Indesit Group Candy Group Electrolux Group LG Group BSH Group
Other key players: LG Group, Samsung Group, Candy Group. Some of them have also production in Europe.	

Retail sector

Retail channels for white goods are diverse: there is a large number of smaller retailers specialized in white goods and household appliances, large grocery chains, kitchen manufacturers and resellers, mail-order companies and online shops. (Capgemini Consulting 2012) Data of the importance of e-commerce when purchasing washing machines and washer-dryers have not been found. Generally, the e-commerce of white goods (category "Electronics and Appliances") is supposed to differ widely throughout the European countries, as shown for the example of Germany and Great Britain in 2012 (see figure 2.9). As in Great Britain 42.3% of Electronics and Appliances were bought online, in Germany only 25.5% were sold by this purchase channel.

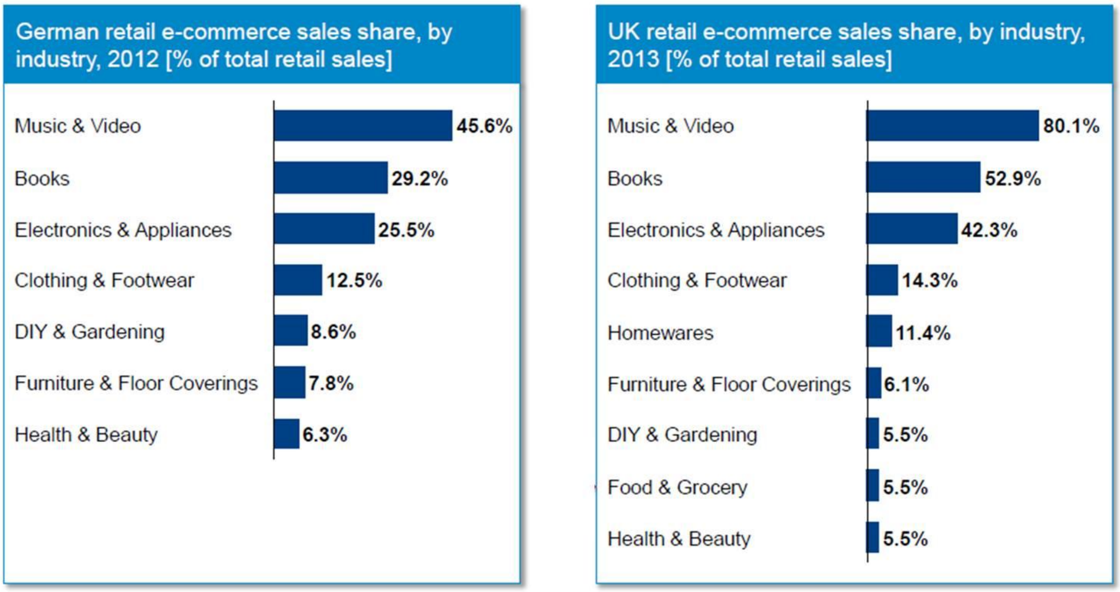


Figure 2-7 E-commerce with household Electronics and Appliances in 2012 (Bachl & Koll 2013)

2.2.3.2. Penetration rates of washing machines and washer-dryers

Based on data from Euromonitor International Passport database (http://www.euromonitor.com/passport), cited by (JRC IPTS 2014a), in 2013 92% of households in Europe had a **washing machine**, in 19 countries the ownership rate was 90% or over. Sweden (79%) and Denmark (81%) have the lowest known washing machine ownership rates due to the way laundry is typically carried out in the Nordic countries. In apartment buildings, student residences, etc. there are typically communal laundry rooms available for use by residents which limits the need for household washing machines. However, many countries are nearing (or may have already reached) saturation in terms of washing machine ownership. In countries such as Spain, Austria and the Czech Republic, ownership of washing machines is 99%.

Penetration of **washer-dryers** in European countries is very different from country to country (Figure 2-8). In many European countries, less than 4% of households possess a washer-dryer. Lowest penetration can be observed in Turkey, Romania, Czech Republic and Germany; the highest share of washer-dryers with around

11% is in United Kingdom, followed by Portugal (around 8%) and Austria (around 7%). Overall, an increase of the penetration of washer-dryers is to be observed.

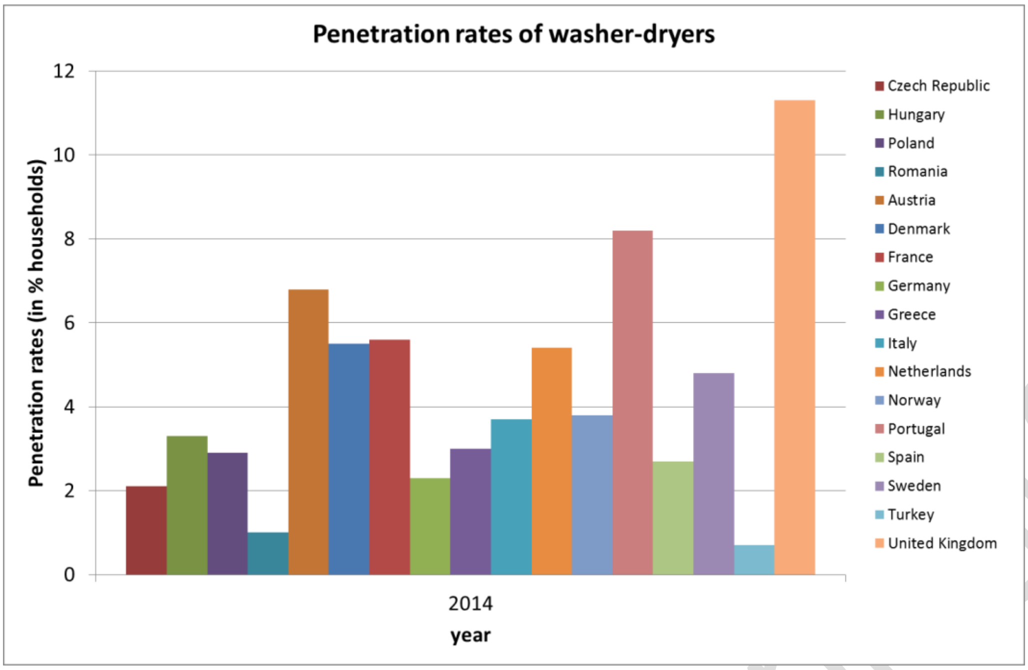


Figure 2-8 **Washer-dryer penetration rate in households of various European countries (Euromonitor International 2014)**

To sum up, it could be assumed that about 90% of families in Europe have a washing machine in their household, while owners of washer-dryers are only about 4%. This would mean that 6-10% of families rely on a different system to wash their laundry.

Stakeholders involved in the elaboration of this study have reported that the penetration for washing machines is constant to slightly growing, and that the 90% saturation seems to be realistic. A penetration of as much as 4% for washer-dryers also seems realistic. The ratio washing machines to washer-dryers would thus be 22.5 : 1 or, in other words, washer-dryers would represent 4% of the total number of washing machines and washer-dryers.

Washer-dryer however has a high deviation among countries and is increasing in almost all countries (GB = 10%). Trends towards the purchase of WD can also be observed in http://www.topten.eu/uploads/File/Topten_recommendations_Washing_machines.pdf

It was also reported that in Switzerland 97% of the households own a washing machine and 2.3% a washer-dryer. The ratio washing machines to washer-dryers would thus be 42.2 : 1 or, in other words, washer-dryers would represent 2% of the total number of washing machines and washer-dryers.

2.2.3.3. Sales data of washing machines and washer-dryers

The following information on sales has been provided by stakeholders(Table 2.13).

Table 2.13: Information on sales data for washing machines and washer-dryers provided by stakeholders

Infor-mation	Washing machines	Washer-dryers
Sales	Europe, 2013: • 25 M units, 5,5 B EUR (220 EUR/unit) Germany (1) :: • About 2.5 million units (front loading) sold (1 each 322 persons) • Scale-up to Europe = 25 million (2.5 x 742.5 / 80.6) Switzerland: • 200 000 (1 each 410 persons) • Ratio Germany to Switzerland = 12.5 : 1 (9.83 by population)	Europe, 2013: • 1,0 M units, 0,4 B EUR (400 EUR/unit) Germany (1) : • About 50 000 units sold (1 each 1610 persons) • Scale-up to Europe = 460 600 (50 000 x 742.5 / 80.6) • Ratio WM to WD = 50 : 1 • Share of WD = 2% Switzerland: • 10 000 (1 each 820 persons) • Ratio Germany to Switzerland = 5 : 1 (9.83 by population)
Trends	Stable in Europe In Switzerland the number of sold units is increasing every year since 2002	Increasing number of sold units in Europe
(1) source: https://www.test.de/thema/waschmaschinen/		

Additionally, Topten publishes each year sales data for Switzerland. The time series for 2004-2013 (see: http://www.topten.eu/uploads/File/FEA-Geraetestatistik-2004-2013-EN.pdf) has been analysed at http://www.topten.eu/uploads/File/Swiss%20appliance%20market%20analysis%202004-2013%20and%20recommendations.pdf. An updated version including 2014 sales data will be published in summer 2015). Moreover, Topten will publish soon EU sales data on washing machines for 2004–2014 (and data for France & Portugal) including information on energy efficiency and energy use, on capacity, water consumption, and purchase price.

According to the "Omnibus study" (VHK et al. 2014), sales of **washer-dryers** in the EU were above 700,000 in 2012. This corresponds to about 4% of the 16 million unit washing machine market. This is an average figure and the sales vary considerably depending on the country. The market for washer-dryers is growing as there is a higher consumer acceptance due to higher rated capacities for washing and/or drying.

Figure 2-9 shows the relative distribution of sales of **washing machines** of a certain energy efficiency class from 2004 to 2012 in 14 European countries (AT, BE, DE, DK, ES, FI, FR, GB, GR, IE, IT, NL, PT, SE) as reported by the German market analysis company Gesellschaft für Konsumforschung (Gesellschaft für Konsum-forschung (GfK), personal communication 2013).

The share of sold washing machines with an energy efficiency class A+ steadily increased up to 44 % in 2010 and decreased afterwards. On the other hand, a gradual decline in sale of the lower energy efficiency classes is seen, particularly for energy efficiency class A.

Since new energy efficiency classes were introduced in December 2011 by Regulation (EU) 1061/2010, the share of sold washing machines with energy efficiency classes A++ and A+++ increased. By having closer look to data related to the sales percentage of the washing machines in 2011 and 2012, it can be seen that the amount of sales for washing machine with A+++, A++ and A+ energy efficiency class has a slight rise while the percentage of sales for washing machine with an A energy efficiency class has a noticeable decrease. The sales of washing machine with B and C energy efficiency class have remained almost constant.

According to these data it is noticeable that since 2006, almost no sales for energy efficiency classes below C have reported and share of washing machine sales with B energy efficiency class has reduced continuously.

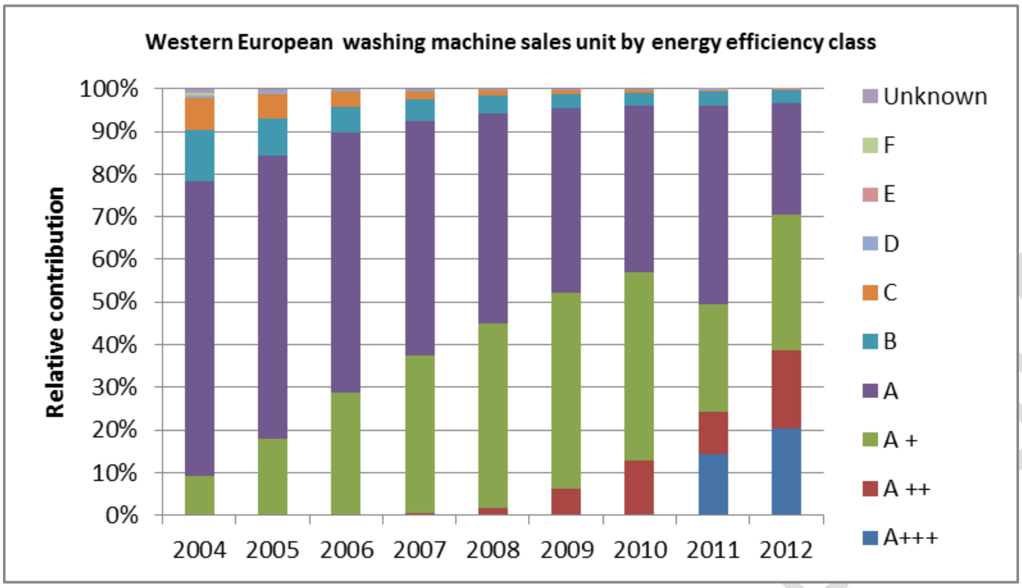


Figure 2-9 **Relative distributions of energy efficiency classes on total washing machine sales from 2004 - 2012 in 14 European countries (AT, BE, DE, DK, ES, FI, FR, GB, GR, IE, IT, NL, PT, SE), (GfK, personal communication 2013)**

Figure 2-10 gives information about the percentages of sales of washing machines in six western European countries based on their energy efficiency classes in 2012. It can be detected that Germany, among the six European countries listed, has the highest sale of washing machines with the energy efficiency class A+++ whereas France has the lowest share of sales of washing machine with the same energy efficiency class which is around 40 per cent and 9 per cent respectively. Belgium by having 5.5 percent difference with Germany has the second rank for the sales of washing machines with the energy efficiency class A+++ and first rank for the sales of washing machines with the energy efficiency class A++ which is around 30 per cent. Great Britain has the highest rank of sales of washing machine with the energy efficiency class B and C among these six analysed European countries.

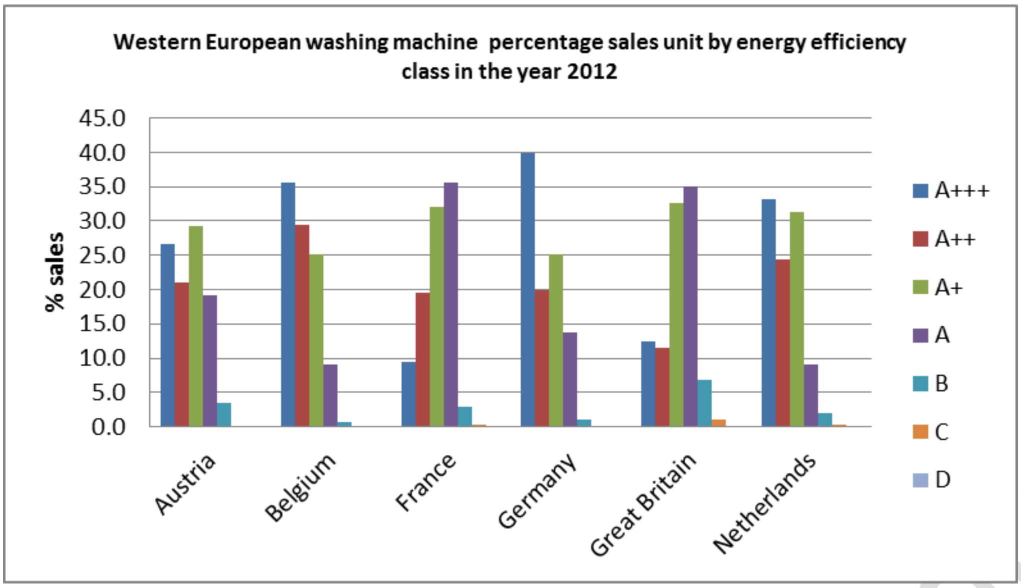


Figure 2-10 **Relative distribution of percentages of sales of different energy efficiency classes on total washing machine sales 2012 (GfK, personal communication 2013)**

The table below show the market segmentation by Energy Efficiency Class in Europe based on information provided by stakeholders.

Table 2.14 **Market segmentation by Energy Efficiency Class in Europe based on information provided by stakeholders**

Product	Current shares in terms of Energy Efficiency class (%)
Washing Machines (A+++; A++; A+)	• Europe, 2014: 35% A+++, 20% A++ 30% A+ (including Washer-dryers). 15% missing are washer-dryers in lower energy label classes and wrong declarations) • Switzerland, 2013: 60% A+++, 15% A++, 17% A+ Switzerland, 2015: 75% A+++, 15% A++, 10% A+ • 44% of the WM sold in the EU in 2013 were already rated in the two highest energy efficiency classes only one year after the introduction of these classes (22% in A+++, 22% in A++). This share is estimated to be clearly higher by today (Source: http://www.topten.eu/uploads/File/Topten_recommendations_Washing_machines.pdf)
Washer-dryers (A; B; C)	• Europe, 2014: 55% A, 40% B, 5% C • Switzerland, 2013: 47% A, 53% B, 0% C

Figure 2-11 illustrates the percentage of washing machines sales units based on their capacities for 14 western European countries from 2004 to 2012. It is evident that the amount of washing machine sales with the capacity of 6 kg or smaller has reduced remarkably from 97.2 per cent to 47.8 percent during this period.

On the contrary, the amount of washing machine sales with capacities larger than 6 has soared noticeably. Moreover, among the washing machines with the capacity larger than 6 kg, the highest sale belongs to the group of washing machines with the capacity between 6.1 to 7 kg. The sales of this group of washing machines have increased from 2.1% in 2004 to 32% in 2012.

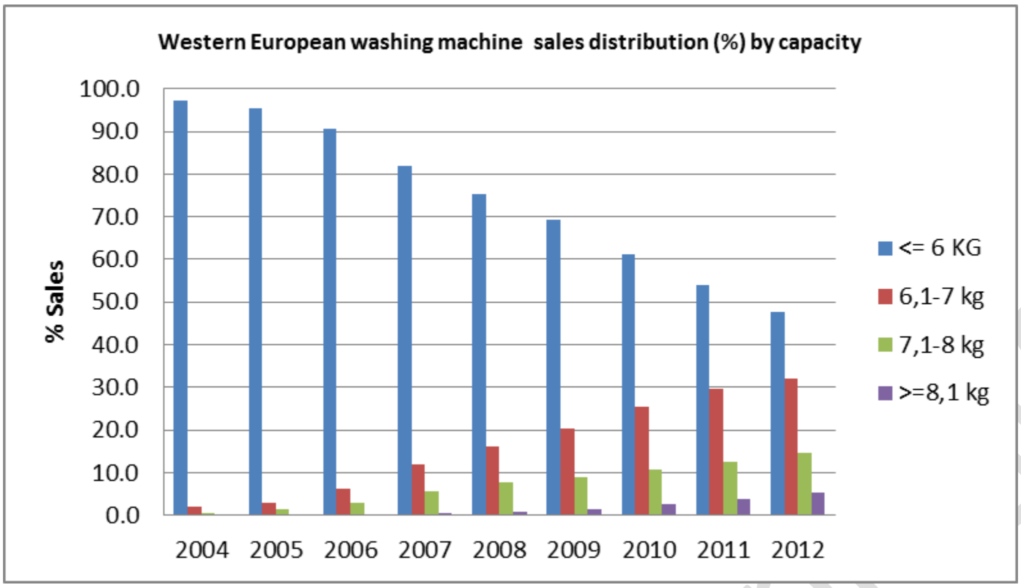


Figure 2-11 **Sales of western European washing machines based on capacity (GfK, personal communication 2013)**

The table below show the market segmentation by capacity in Europe based on information provided by stakeholders.

Table 2.15 **Market segmentation by capacity in Europe based on information provided by stakeholders**

Washing Capacity (kg)	Indicative shares for Europe	
	Washing machines	Washer-dryers
< 5 kg		
5 kg	15%	2%
6 kg	30%	20%
7 kg	30%	30%
8 kg	18%	25%
9 kg	5%	18%
> 9 kg	2%	5%

Additional information on capacities of high efficiency washing machines can be found on:

- < 8 kg: http://www.topten.eu/english/household/washing-machines/8kg.html
- 8 kg: http://www.topten.eu/english/household/washing-machines/8kg-2.html
- > 8 kg: http://www.topten.eu/english/household/washing-machines/8kg-3.html

Information on capacities of high efficiency washer-dryers can be found on http://www.topten.eu/english/household/washer-driers.html

2.2.4. Models offered on the market

The following analysis of washing machines and washer-dryer models available on the European market from 1998 to 2013 is based on the CECED database. It is noticeable that during this period, the European Union has been enlarged from 15 countries to 28 countries and from 380 million inhabitants to over 500 million inhabitants.

2.2.4.1. Washing machines

Total number of washing machine models available on the market

Figure 2-12 shows that number of washing machine models has increased from 4,392 in the year 1997 to 7,745 in the year 2013. This trend can be ascribed to the continuously increasing market with its need to offer a larger variety of models due to different consumer needs and preferences and the invention and implementation of new product features.

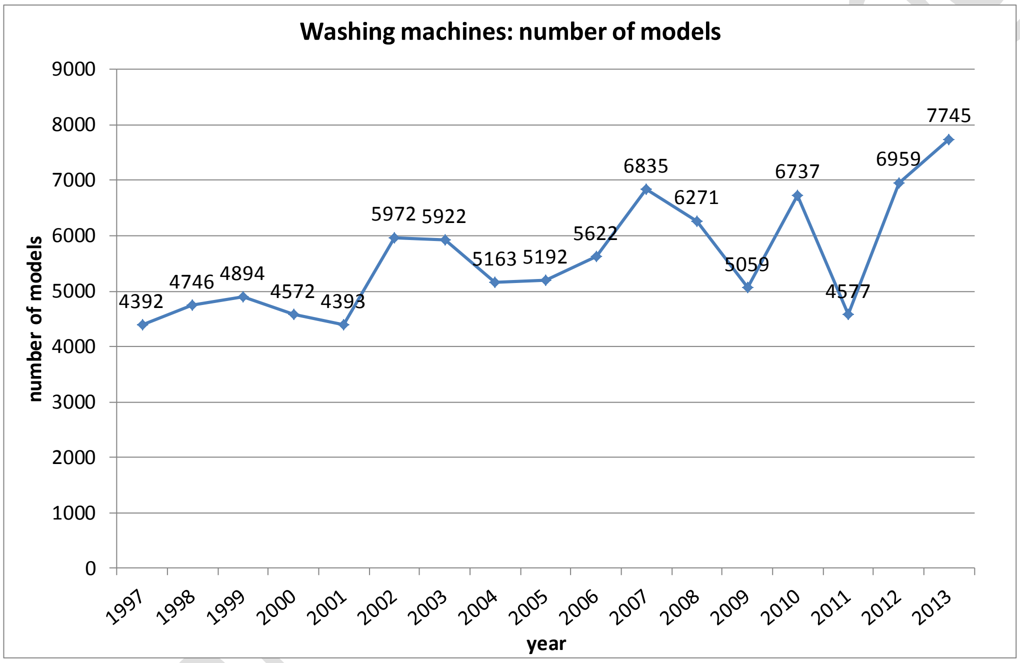


Figure 2-12 **Development of number of models of washing machines on the European market from 1998 to 2013 (CECED 2014)**

Capacities of washing machine models available on the market

The development of washing machine capacities on the European market is shown in Figure 2-13.

The average capacity of the machines (in kg cotton) has increased from about 4.8 kg in 1997 to 7.04 kg in 2013. This tendency seems to have just started in 2002 (Figure 2-13) and is increasing its trend. As average household size is getting smaller, there must be other demographic explanations for this development.

Distribution of rated capacity for the 7,745 washing machine in the year 2013 shows that around 31 percent of washing machines models have 6.5 to 7 kg capacity followed by 24 percent for 7.5 to 8 kg and 23 percent at 5.5 to 6 kg (Figure 2-14). In 2013, the 5 kg models (the former base case of Lot 14) only constitute to a share of around 8%. On the contrary, there are already some models with 9, 10 and 11 kg capacity on the market.

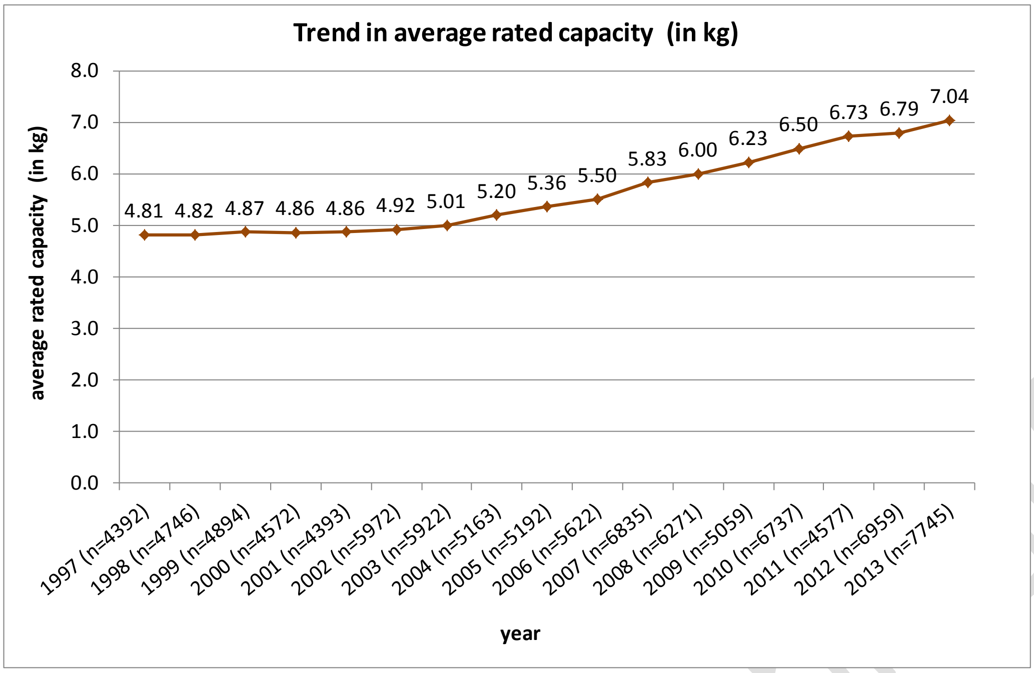


Figure 2-13 **Average rated capacity (kg cotton) of washing machine models (CECED 2014)**

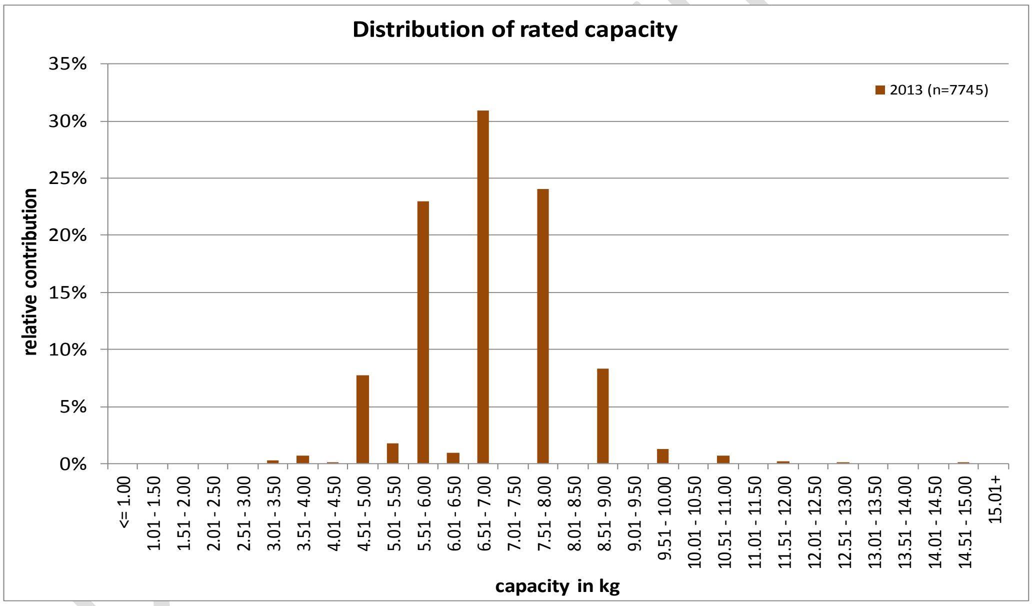


Figure 2-14 **Distribution of rated capacity (kg cotton) of washing machines models in 2013 (CECED 2014)**

Energy consumption of washing machine models available on the market

Concerning the development of the energy efficiency in terms of average energy consumption per kg of capacity a continuous and almost linear improvement can be observed (Figure 2-15).

The average specific energy consumption has been halved from 0.245 kWh/kg in the year 1997 to 0.120 kWh/kg in the year 2013. However, it has to be noted that the reference for the declaration of the energy consumption has changed in 2011. From 2011 onwards energy consumption has been measured in a combination of programmes at 40 and 60 °C with half and full load compared with before where energy was measured only at 60 °C full load. When comparing the distribution of the average specific energy consumption per cycle (Figure 2-15) of year 1997 with 2013, it is evident, that industry has optimised the washing machines models to comply with the energy consumption requirements of the energy efficiency class thresholds.

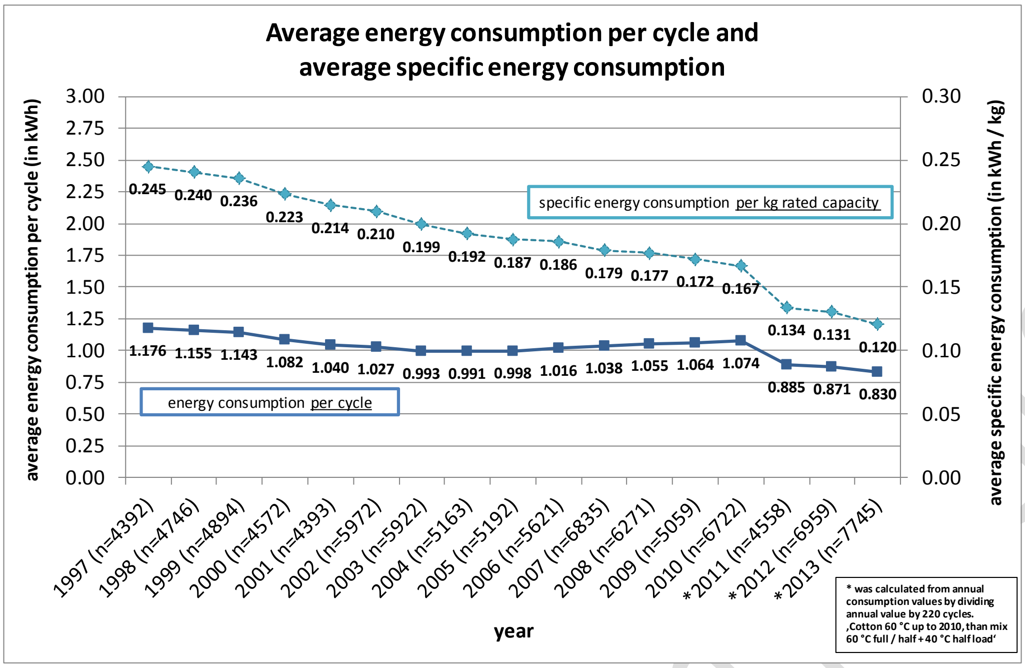


Figure 2-15 **Average energy consumption per cycle and average specific energy consumption per kg (CECED 2014)**

Distribution of energy consumption per cycle in 2013

In Figure 2-16, the distribution of energy consumption per cycle of 7,745 washing machine models in the year 2013 is shown. The energy consumption per cycle has been calculated by dividing annual consumption values by 220 cycles. The range of energy consumption per cycle is broad among the washing machine models available on the market in 2013, starting from less than 0.50 kWh per cycle to 1.46 kWh per cycle and more. The average of this energy consumption per cycle is 0.83 kWh. Most of the washing machine models have energy consumption between 0.86 to 0.90 kWh per cycle, followed by 0.76 to 0.80 kWh per cycle.

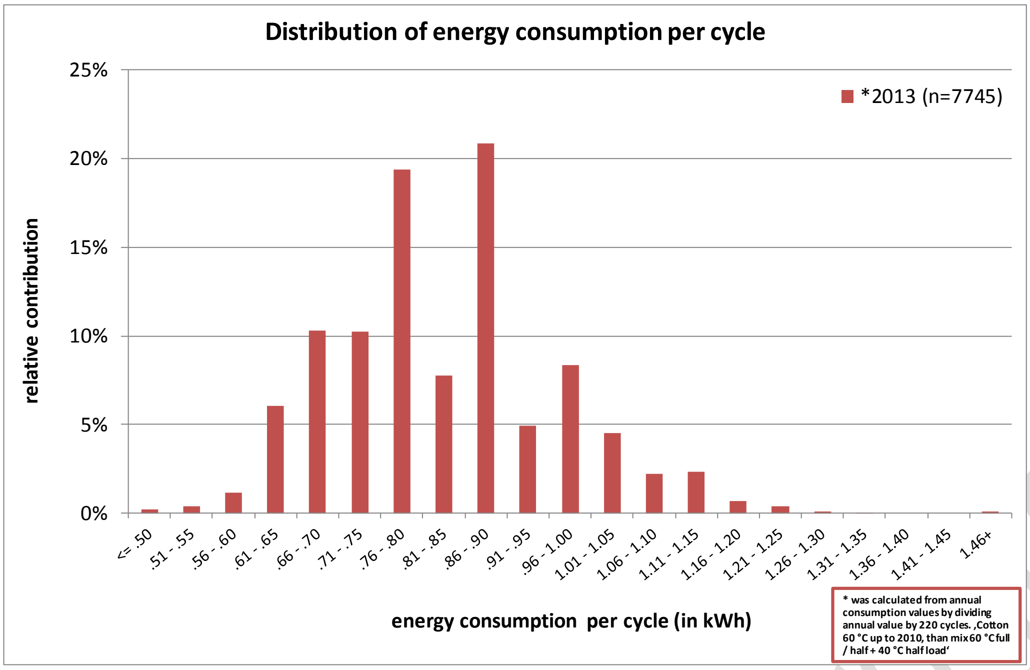


Figure 2-16 **Energy consumption of washing machine models per cycle for the year 2013 (CECED 2014)**

In Figure 2-17, the distribution of the specific energy consumption in kWh per kg load of 7,745 washing machine models in the year 2013 is shown. These values have been calculated by dividing the average total energy consumption per cycle of each machine by its nominal load mass (equals rated capacity). As it can be seen around 72 per cent of the tested washing machines have a specific energy consumption of 0.11 to 0.15 kWh/kg. The average of specific energy consumption is 0.12 kWh/kg.

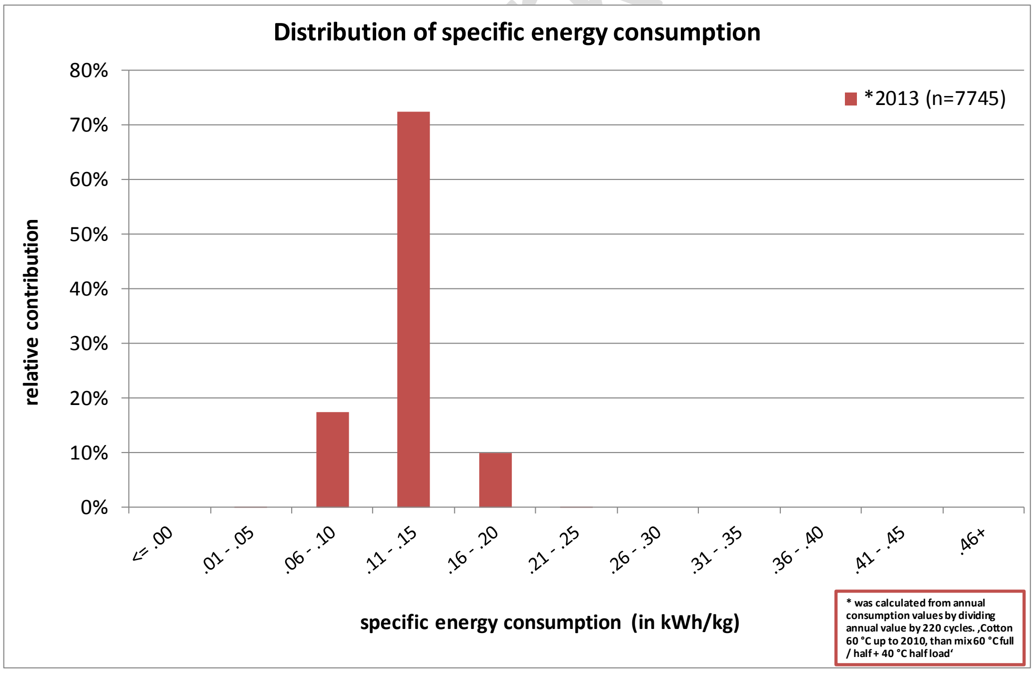


Figure 2-17 **Specific energy consumption of washing machine models in kWh/kg for the year 2013 (CECED 2014)**

Energy efficiency classes of washing machine models available on the market

The current Energy Label for washing machines entered into force by the end of 2010 based on Regulation (EU) 1061/2010 and is mandatory since December 2011. The new energy efficiency classes A+, A++ and A+++ were filled up quickly. Distribution of the energy efficiency classes from year 1997 till 2013 reveals the continuous improvement in energy efficiency classes (Figure 2-18).

As it can be seen the share of energy efficiency classes below the A energy efficiency class has decreased significantly during this period. In 2013 no washing machines worse than class B has registered in the database, showing the Ecodesign Regulation is properly followed. Thus, in 2013 all of the washing machine models registered in the database had energy efficiency class A or better, whereof already 50 per cent of the models had energy efficiency class A+++. This class is somehow driving the development of washing machines towards more efficient models.

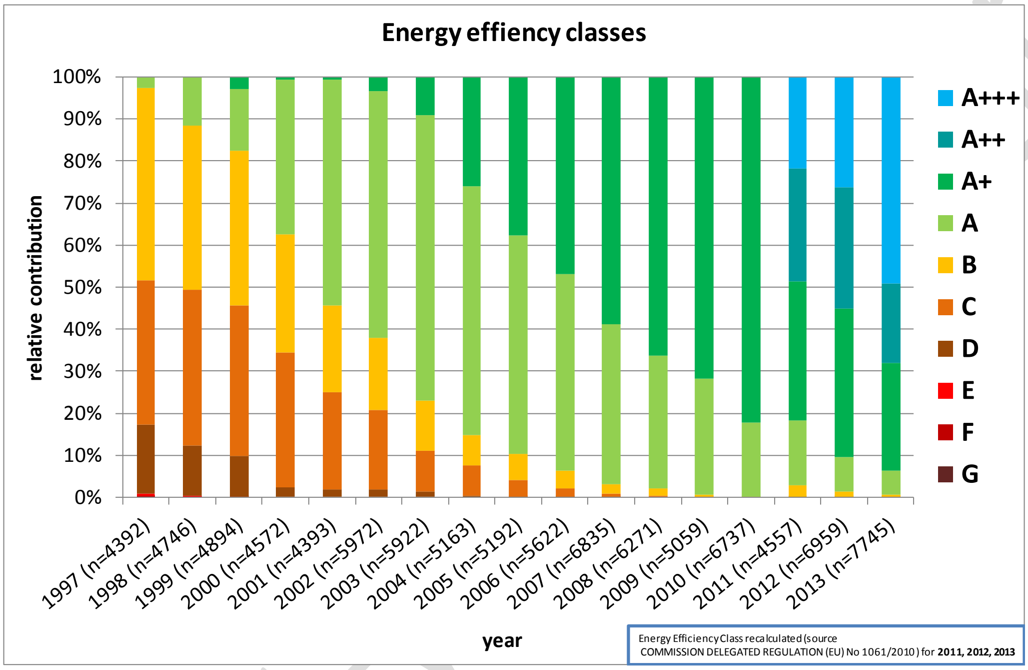


Figure 2-18 **Distribution of energy efficiency classes for washing machines in 1997-2013 (CECED 2014)**

<u>Distribution of energy efficiency classes according to capacity of washing machine models</u>

As it can be seen in Figure 2-19, the most common capacity class of the 7,745 registered washing machine models in the CECED database in 2013 was 7 kg with 31 percent. Within these 7 kg washing machine models, the distribution of energy efficiency classes is 48.7% A+++, 24.7% energy efficiency A++, 23.4% energy efficiency class A+, and 3.2% with energy efficiency B. In general it can be seen that washing machines with larger capacity also have a better energy efficiency class; this is also clearly shown in Figure 2-20.

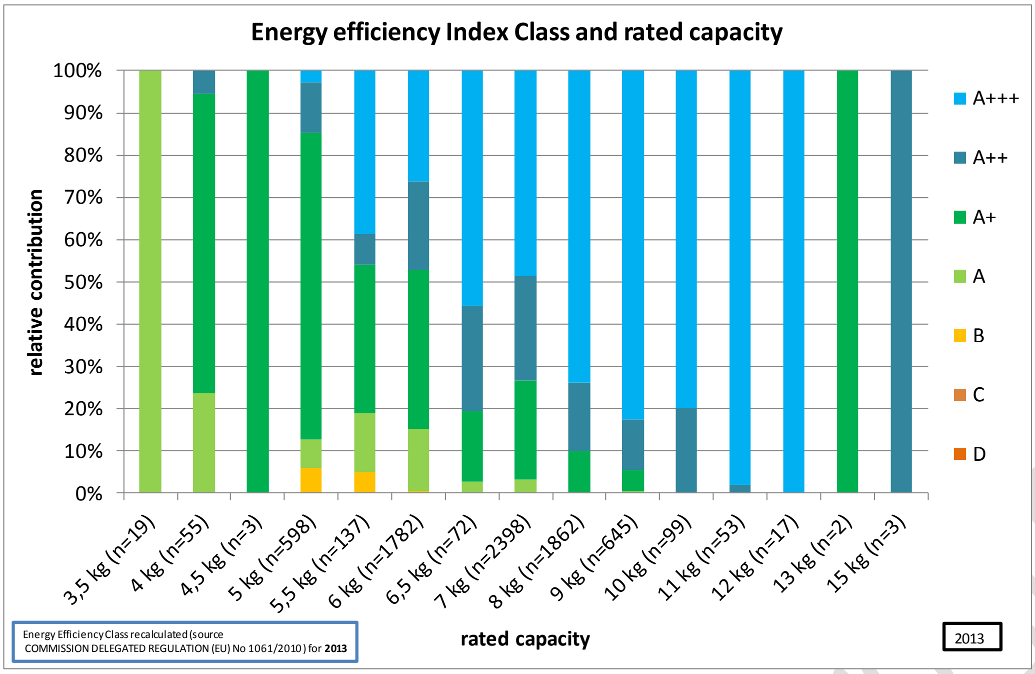


Figure 2-19 **Energy efficiency index class and rated capacity 2013 (CECED 2014)**

Figure 2-20 attempts to model the relationship between two variables including rated capacity and energy efficiency index by fitting a linear equation to observed data. In general one can say that washing machines with a low energy efficiency index (EEI) more often have a higher capacity than machines with a higher EEI.

Further research is needed to assess whether larger machines have higher energy performances and whether larger machines are used less often due to consumers washing more laundry in one cycle.

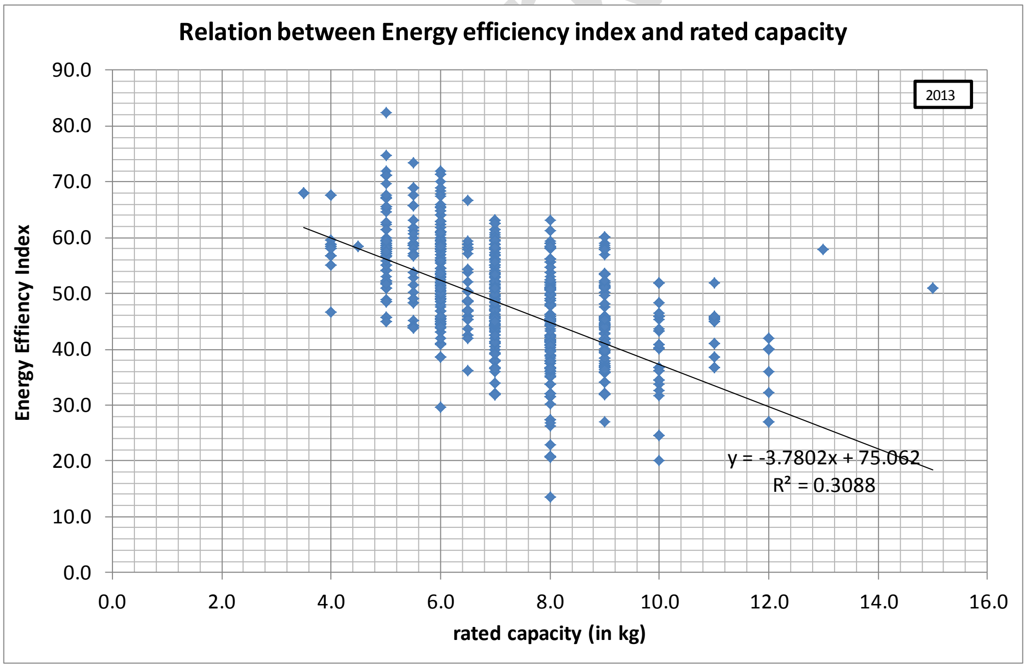


Figure 2-20 **Relation between energy efficiency index and rated capacity (CECED 2014)**

Figure 2-21 illustrates the distribution of washing machine models in terms of their energy efficiency index.

It can be seen that most of the registered washing machine models in the CECED data base in 2013 had an energy efficiency index below 59, including the A+++, A++ and A energy efficiency class. Furthermore, the majority of models had an energy efficiency index that complies with the lower limitation of the corresponding energy efficiency class. For instance about 1,000 washing machine models had an energy efficiency index of 59, which is the lower limit of energy efficiency class A+ (52 ≤ EEI < 59), whereas only around 100 models were in the upper limit of the energy efficiency class.

The distribution of the number of models indicates that manufacturers seem to adjust the energy performance of the label programme to the minimum requirements of a desired energy efficiency class. At the present time, following EU Ecodesign requirements for Energy Efficiency Index (EEI) apply for washing machines sold on the EU market (Commission Regulation (EU) No 1015/2010 and Corrigendum): For all washing machines ≥ 4 kg the EEI has to be < 59, which equals the energy efficiency classes A+, A++ or A+++ on the Energy Label. In other words: only three of the seven classes remain, while the four other classes A, B, C and D are banned from the EU market.

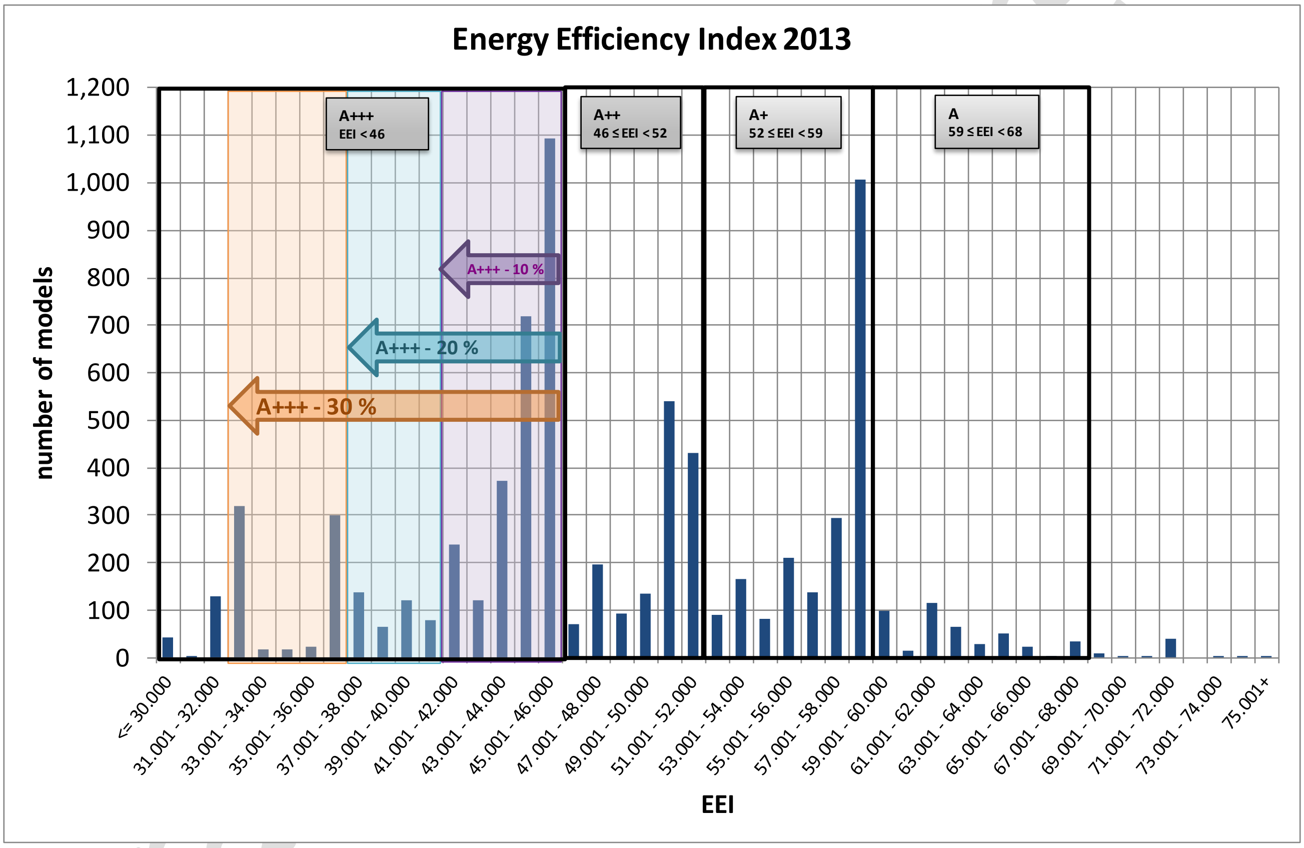


Figure 2-21 **Distribution of washing machine models in terms of energy efficiency index 2013 (CECED 2014)**

Washing performance classes of washing machine models available on the market

Savings in energy and water consumption have been realised without negative implications on the cleaning and drying performance of washing machines. They even could be increased. According to Figure 2-22, the washing performance has improved considerably from year 1997 till 2010. Subsequently the share of washing performance class A has increased whereas the share of other energy classes has declined. In 2010, almost all washing machine models registered in the database had washing performance class A.

From 2011 on, no further declaration of washing performance has been done, as it is mandatory according to the Ecodesign Regulation (EU) No 1015/2010 that all washing machines entering in the European market have to have washing performance class A. Accordingly, washing performance class has no longer been declared on the new Energy Label for washing machines, and database entries end in 2010.

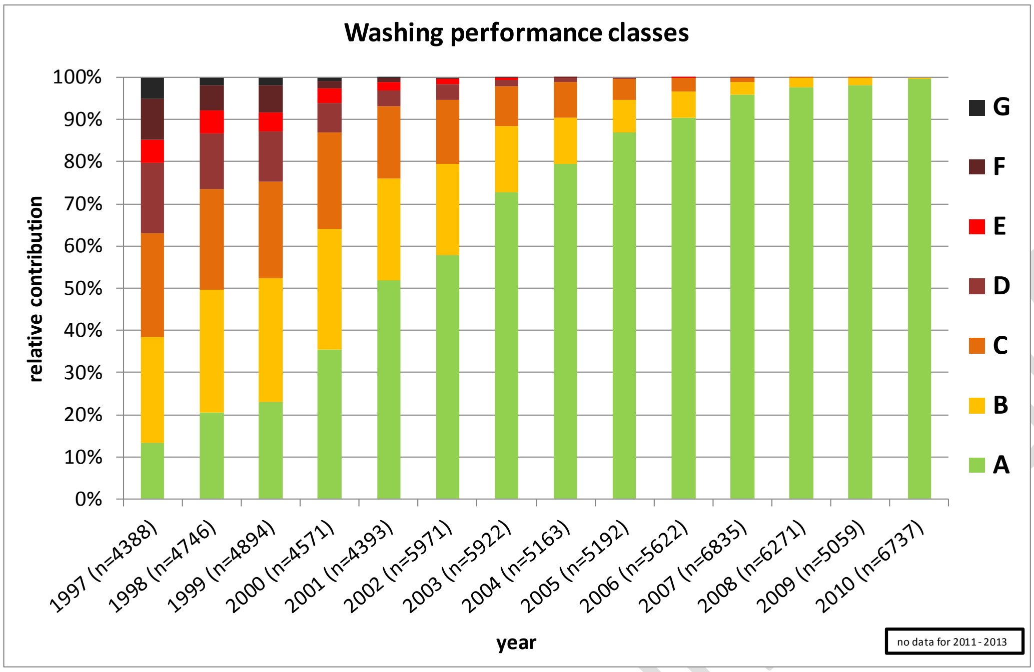


Figure 2-22 **Distribution of washing performance classes for washing machine models in 1997-2010 (CECED 2014)**

Spin drying performance of washing machine models available on the market

Spin drying performance ("efficiency" in the current wording) is part of the label information. The spinning performance is expressed in a class from A to G with A being the best performing class. There are no ecodesign requirements on spinning performance.

Spin drying is an energy consuming function. As spin drying is more efficient than tumble drying in terms of energy consumption, improving the performance of spinning can save energy if consumers use both washing machine and tumble dryer. However, higher spinning speeds have higher wrinkling effects which may increase energy consumption when ironing is applied.

The development of the spin drying efficiency in comparison to washing performance is less obvious over the years (Figure 2-23). In 2013, around 56% of models registered in the CECED database were in class B, 18.5% in class A and 20% in class C. Other drying performance classes have a very low share (around 5 percent) according to the CECED database (CECED 2014).

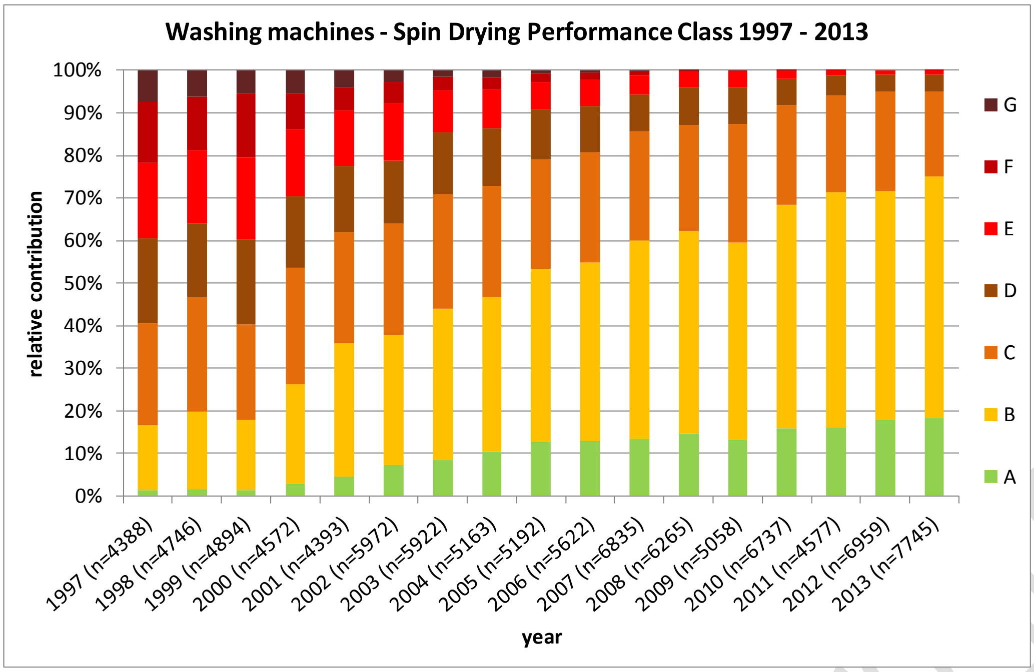


Figure 2-23 **Distribution of spin drying performance classes for washing machines in 1997-2013 (CECED 2014)**

Spin speed is a main driver for the drying efficiency value. The better the laundry is spun, the less energy is needed to dry it. Figure 2-24 shows a clear trend of substituting low spin speed machines (at 900 rpm or lower) by higher spinning machines. These results illustrate a steady increase of the average spinning speed from 828 rpm in 1997 to 1,219 rpm in 2010.

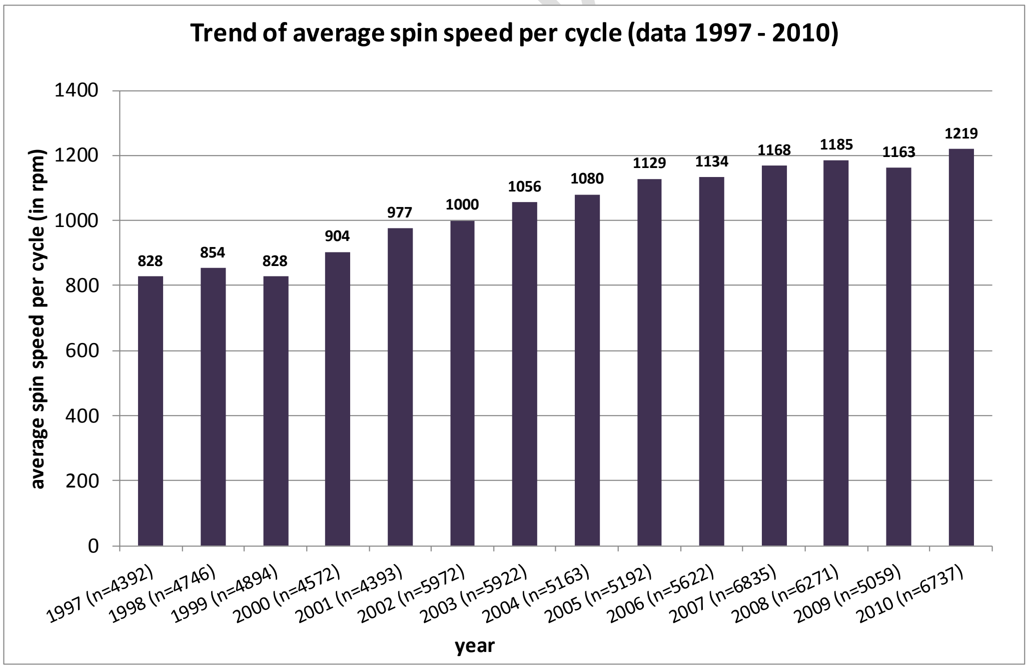


Figure 2-24 **Development of average spin speed per cycle (CECED 2014)**

Figure 2-25 shows correlations between energy efficiency and spin drying performance class among the 7,745 registered washing machine models in the CECED database (CECED 2014).

About 70% of washing machines models with spin drying performance class A have energy efficiency class A+++. Another 15.2% have energy efficiency class A++ and 13.2% have energy efficiency class A+. This shows that there is some correlation between the energy efficiency of the washing process and the spin drying efficiency.

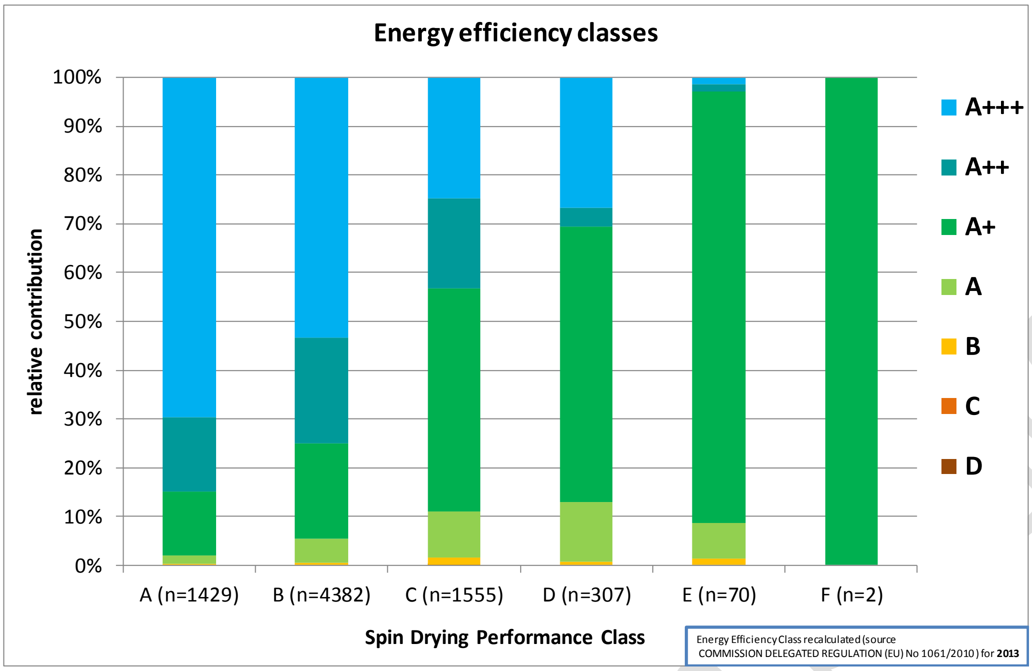


Figure 2-25 Spin drying performance class and energy efficiency 2013 (CECED 2014)

Water consumption of washing machine models available on the market

(Figure 2-26) shows that the average water consumption of washing machine models per cycle significantly declined since 1997, but remained almost constant between 2011 and 2013. While in 1997 water consumption of the majority of machines was 66.8 litres per cycle, in 2013 this value was 45.1 litres per cycle.

When comparing the average specific water consumption (per kg) also ongoing improvement can be observed (Figure 2-26). Average water consumption per kg rated capacity for the years 1997 and 2013 was 13.9 l/kg and 6.5 l/kg respectively.

The difference in the results of the absolute versus specific consumption values is explained by the increase of the average capacity of the washing machines.

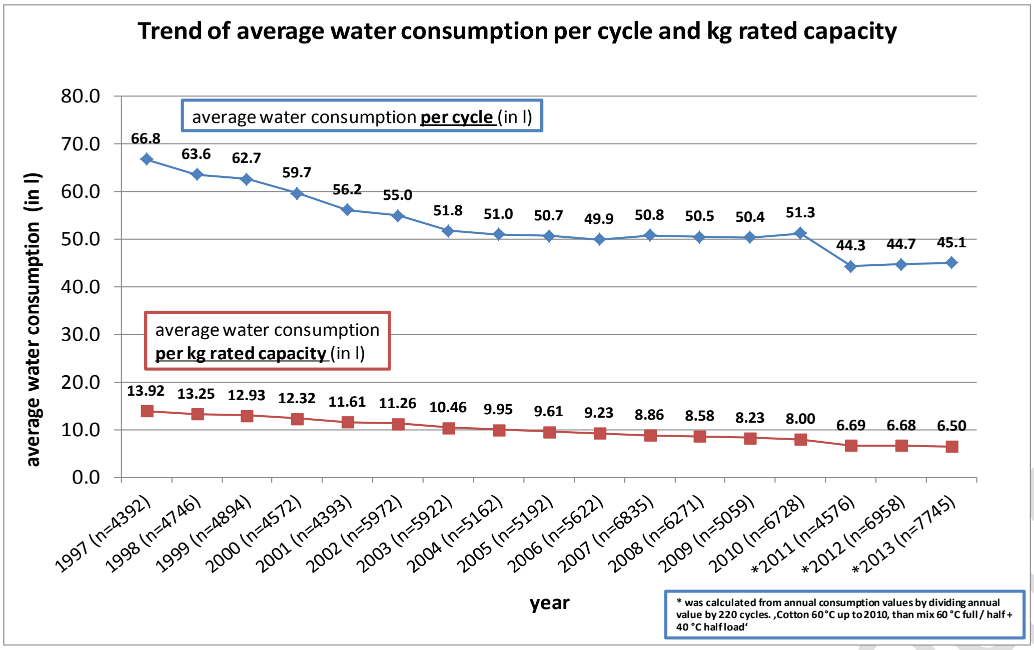


Figure 2-26 **Development of the average water consumption per cycle and per kg (CECED 2014)**

Figure 2-27 shows the average water consumption per cycle for washing machine models with 5 kg and 7 kg capacity. It can be seen that in both groups the average water consumption has declined by passing years. While the absolute water consumption of 7 kg machines is higher compared to a 5 kg machine, the average water consumption per kg capacity is less for the washing machine with 7 kg capacity compared to the washing machine with 5 kg capacity (Figure 2-28).

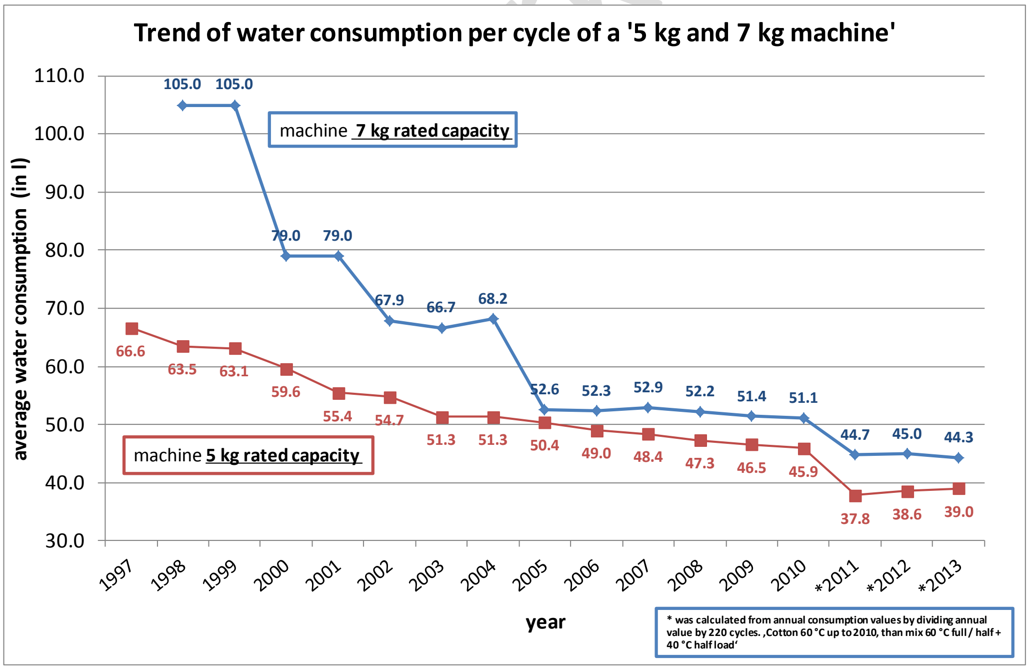


Figure 2-27 **Trend of average water consumption per cycle of a machine with 5 kg and 7 kg rated capacity (CECED 2014)**

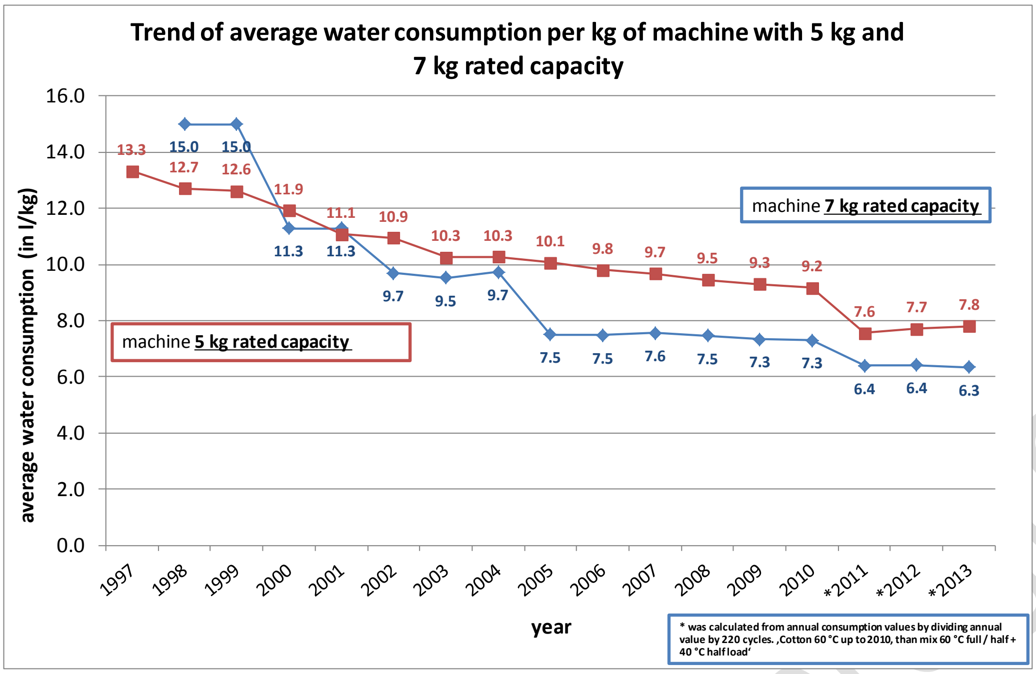


Figure 2-28 **Trend of average water consumption per kg of machine with 5 kg and 7 kg rated capacity (CECED 2014)**

Distribution of water consumption per cycle and per kg of load in 2013

Distribution of water consumption per cycle in 2013 is mainly between 39 and 51 litres. The average is 45 litres (Figure 2-29). The specific water consumption per kg of load is between 5.5 and 8 litres with an average of 6.5 l/kg (Figure 2-30).

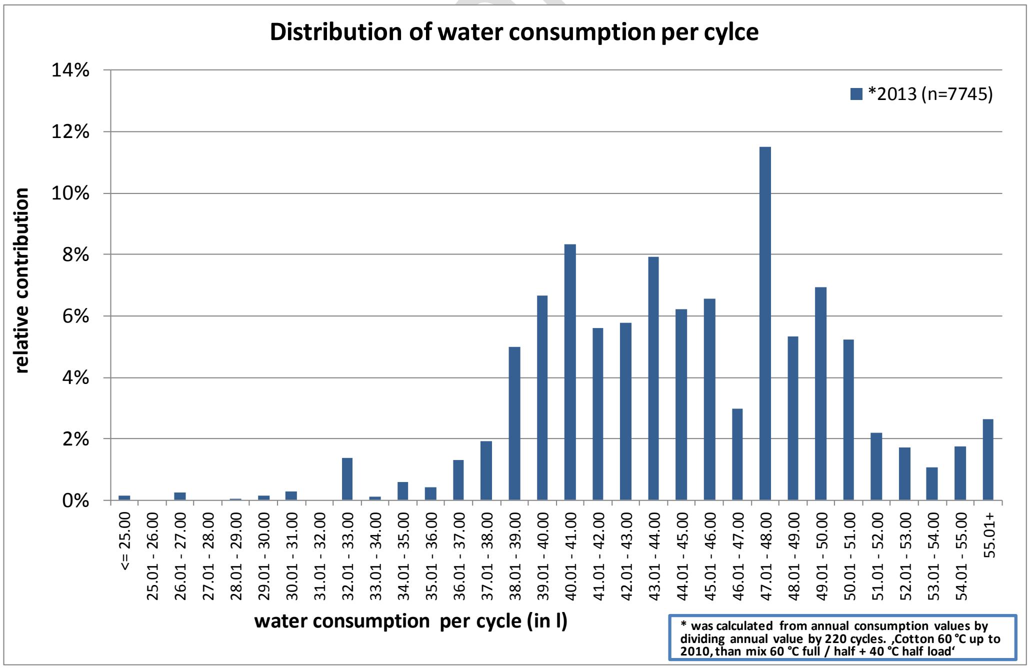


Figure 2-29 **Distribution of water consumption per cycle for washing machines 2013 (CECED 2014)**

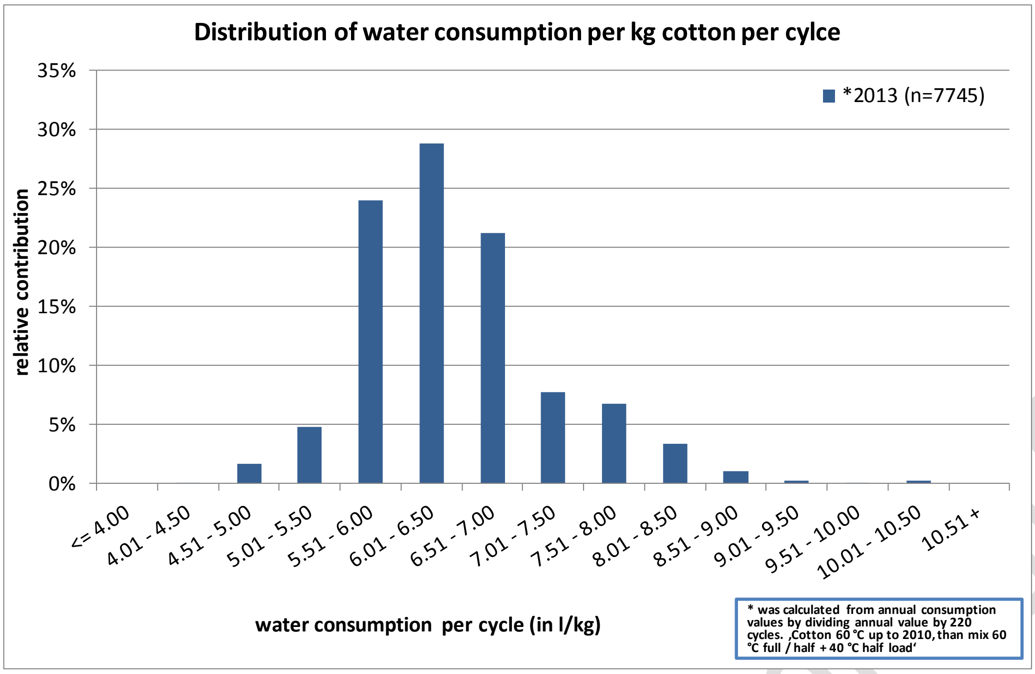


Figure 2-30 **Distribution of water consumption per kg cotton per cycle for washing machines 2013 (CECED 2014)**

Availability of automatic load detection of washing machine models available on the market

As not only the consumption at the rated capacity is of relevance, some information on the ability of the machines to adjust the energy and water consumption to lower loads (e.g. by 'fuzzy'-control) can be found by analysing the presence of the 'automatic load detection' feature, which is included in the reporting. This feature has gained importance and is available in about 98% of the models offered in 2013 (Figure 2-31).

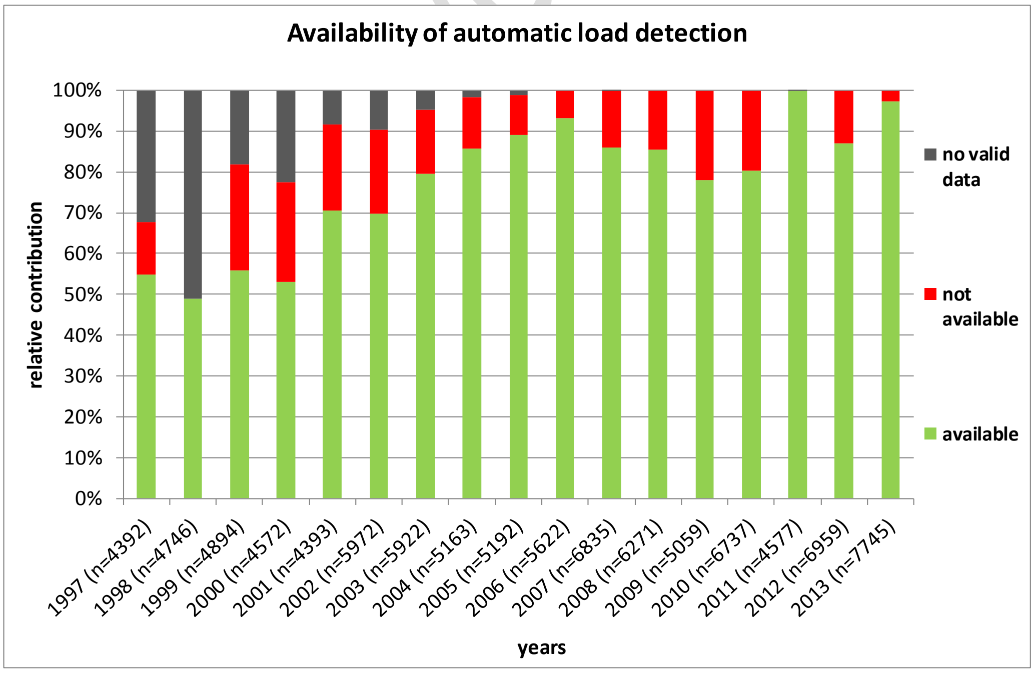


Figure 2-31 **Development of the automatic load detection in washing machines (CECED 2014)**

Noise emissions of washing machine models available on the market

In addition to the energy efficiency ranking and energy efficiency class, information about the machine's capacity, annual energy and water consumption (on the basis of 220 washing cycles), spin drying efficiency, noise in dB(A) in the washing and spinning phases of the washing cycle are included in the Energy Label layout.

Noise is addressed in terms of its declaration for both the washing and the spinning phases. This approach is considered the most appropriate since the loudest noise occurs during the spinning phase, especially at higher spinning speeds. The setting of any noise performance scale would negatively impact on the higher spinning speed machines, which are sold more in Nordic countries to be used in conjunction with dryers.

The washing machines on the today market have an average noise at about 50/75 dB(A) in washing/spinning phases (http://www.eup-network.de/).

Figure 2-32 shows the trend of average noise level of washing and spinning process in washing machine models for the period of 2009 till 2103. As it can be seen the changes on the average values are not significant.

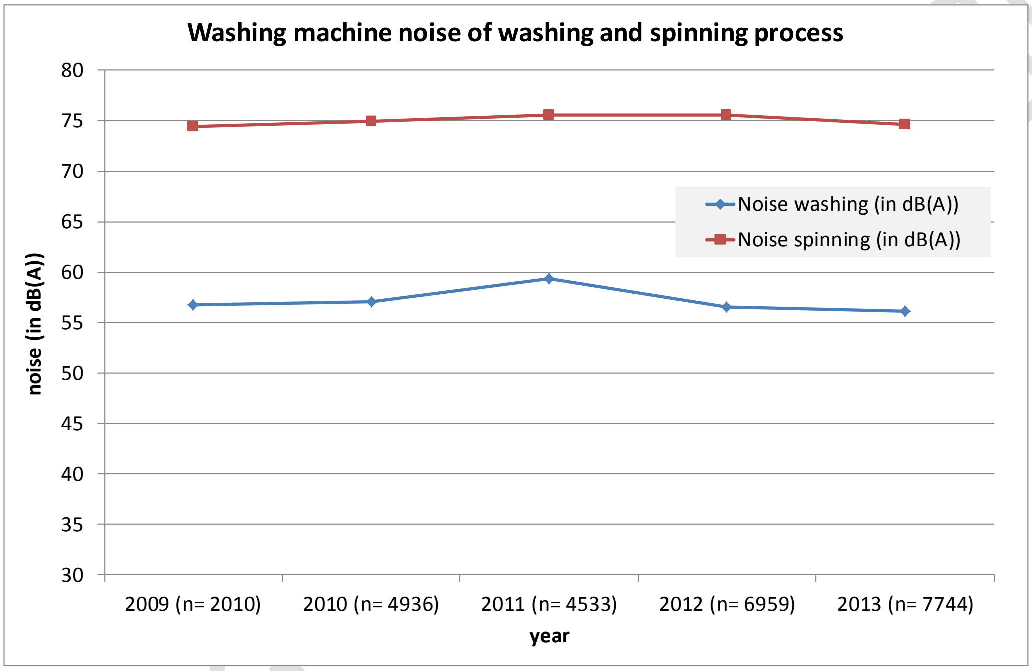


Figure 2-32 **Average levels of noise of washing and spinning process of washing machine (CECED 2014)**

2.2.4.2. Washer-dryers

The following trends are based on the analysis of available and valid CECED data of all models of washer-dryers placed on the European market between the years 1997 and 2013 (CECED 2014).

Total number of washer-dryer models available on the market

During this period the number of models shows a small increase (Figure 2-33) but in comparison with the number of washing machine models, washer-dryers show a very small amount of 5% in relation.

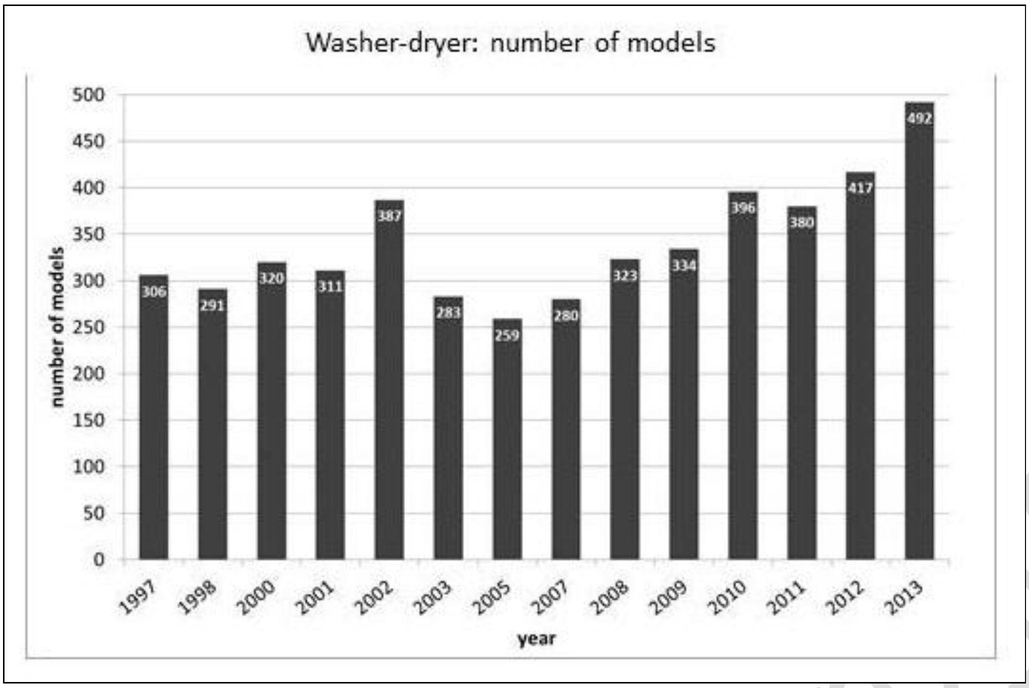


Figure 2-33 **Development of total number of models of washer-dryers 1997-2013 (CECED 2014)**

Capacities of washer-dryer models available on the market

The average washing and drying capacities show an increase of approximately 2.5 kg between 1997 and 2013 (Figure 2-34). A visible growth started in the year 2003. The average washing load capacity reached 7.4 kg (2013) and a maximum load capacity for washing of 11.0 kg (Figure 2-37) was reported.

In the year 1997 only about 50% of the load capacity of a washing cycle was able to dry in one drying cycle. Currently with almost 5kg the average capacity of drying reaches about 66% of the washing capacity (Figure 2-34).

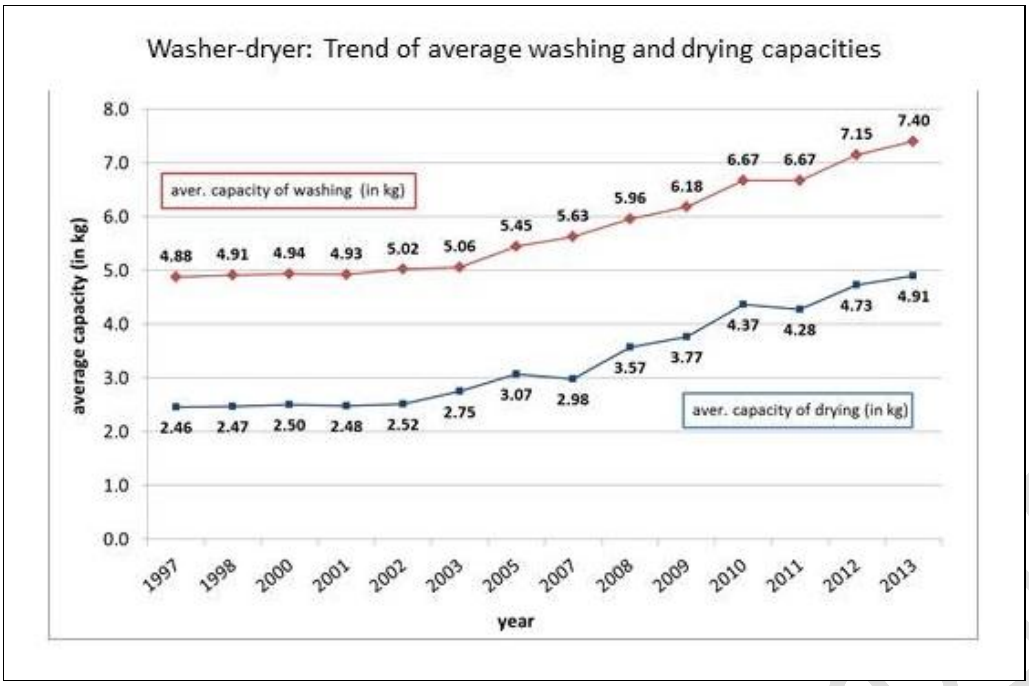


Figure 2-34 **Trend of average washing and drying capacities of washer-dryer models (CECED 2014)**

The trend to larger washer-dryers with higher capacities for washing and drying is also visible in the analysis of the distribution of capacities classes over the years (Figure 2-35) and (Figure 2-36). Until 2003 over 60% of all models had a washing capacity up to 5 kg. In the following years larger machines show higher rates and actually over 50% have a washing capacity of 7 kg and higher.

Comparable is the increase of the drying capacity (Figure 2-38). Before 2003, the majority of all models was characterized by drying loading capacity up to 3.0 kg. Today, over 50% of all models offer a drying capacity between 4 and 7 kg (Figure 2-35).

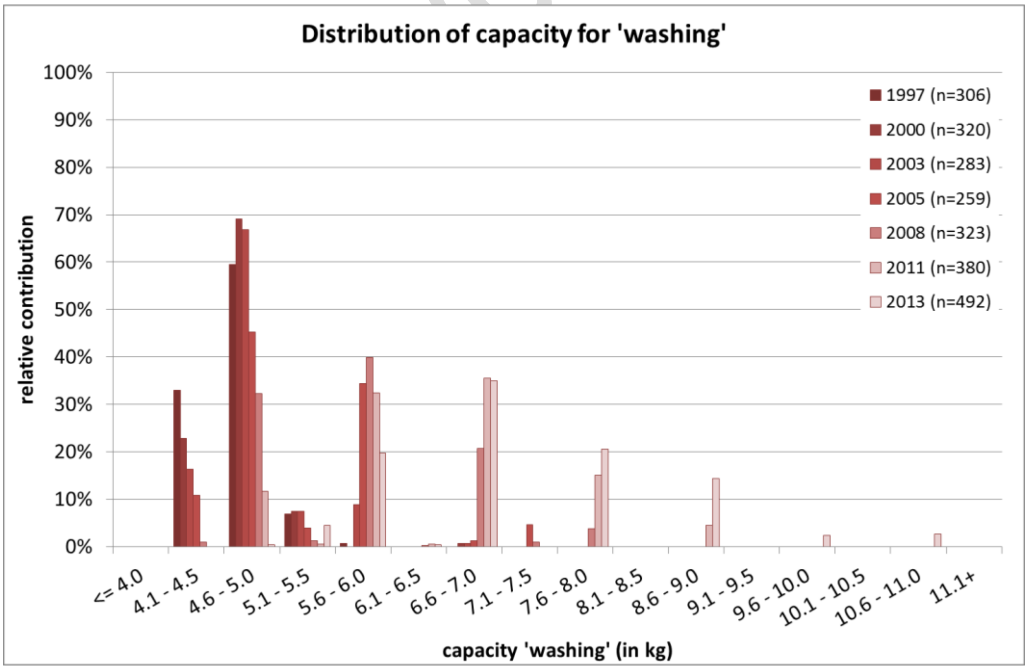


Figure 2-35 **Distribution of rated capacity 'washing' of washer-dryer models (CECED 2014)**

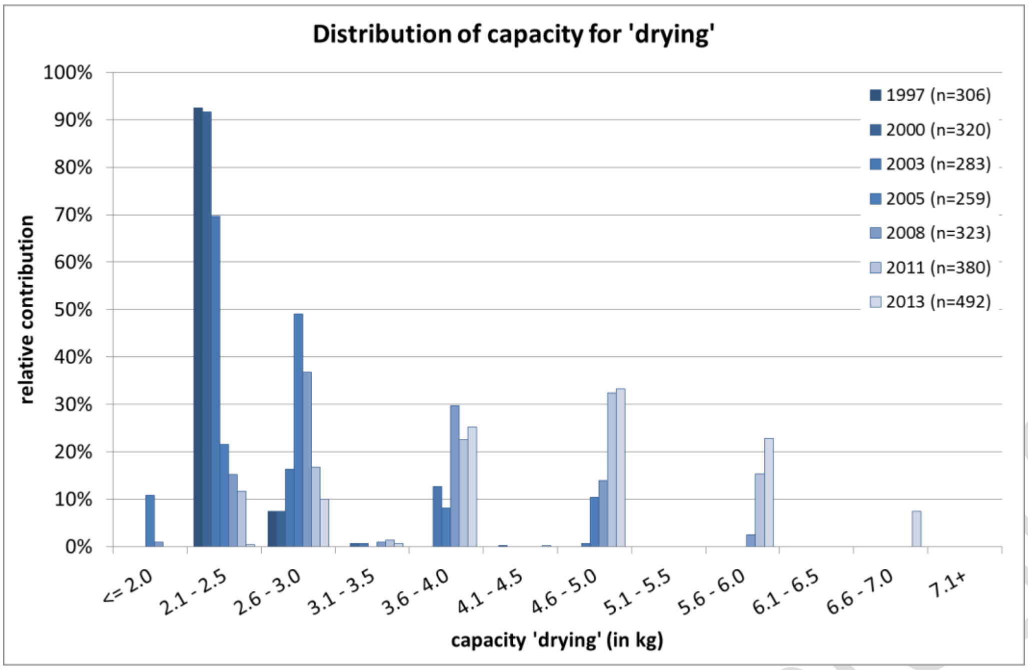


Figure 2-36 **Distribution of rated capacity 'drying' of washer-dryer models (CECED 2014)**

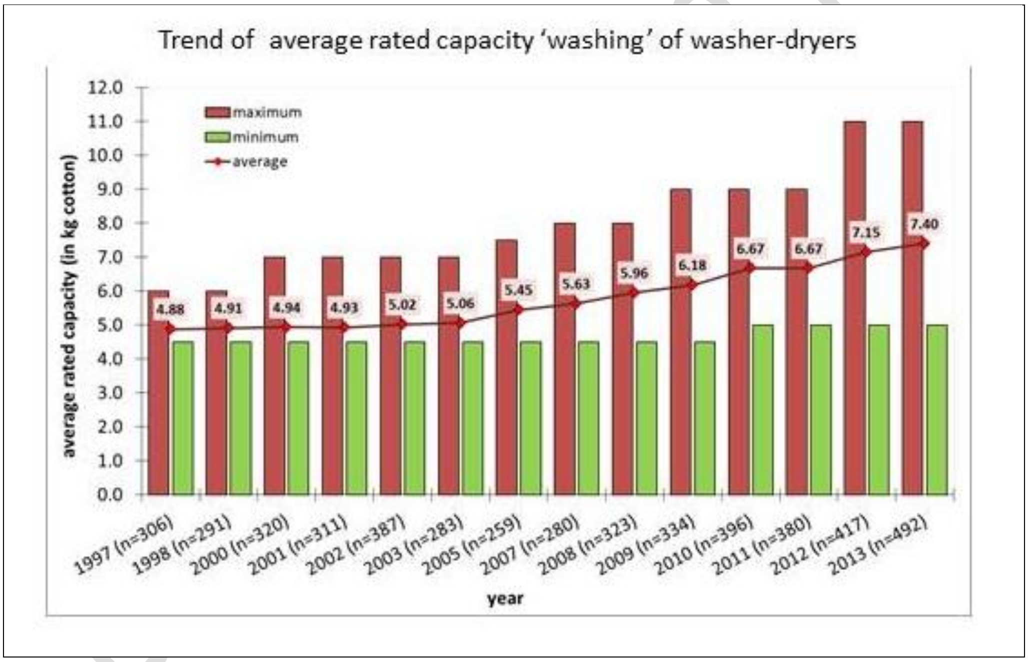


Figure 2-37 **Rated capacity 'washing' of washer-dryer models (statistical results based on (CECED 2014))**

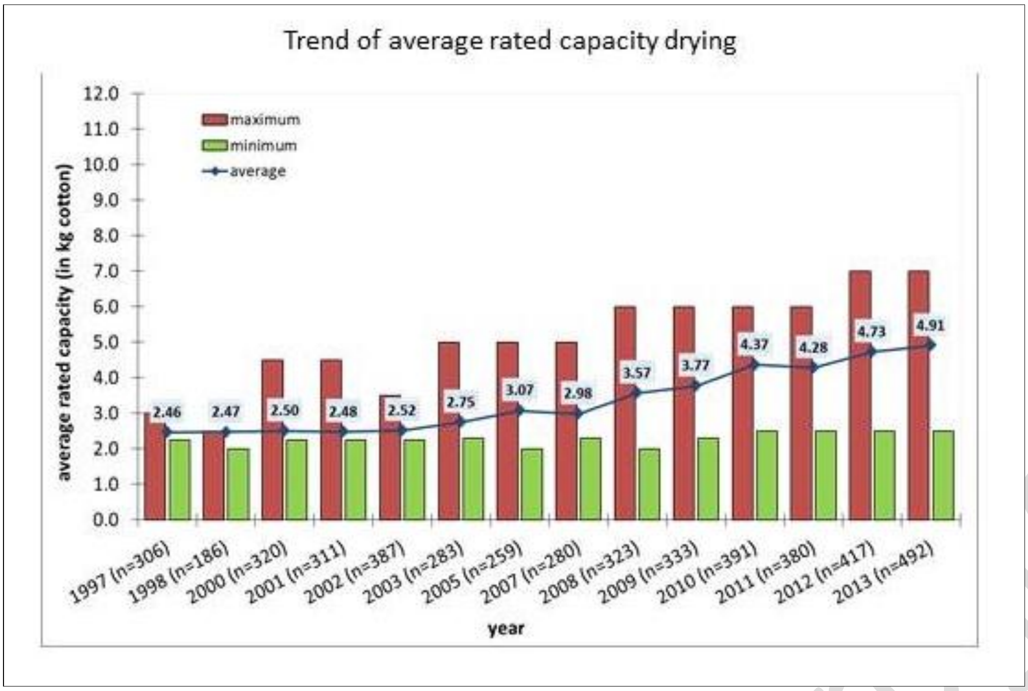


Figure 2-38 **Rated capacity 'drying' of washer-dryer models (statistical results based on (CECED 2014))**

Energy consumption of washer-dryer models available on the market

The development of the average energy consumption for the wash cycle only is comparable with the trend of washing machines. Up to the year 2010 the data of washer-dryers show slightly higher average energy consumption values than washing machines. Over this period the results are nearly constant with an energy consumption of approximately 1.1 kWh resulting in an average of 1.16 kWh per wash cycle in 2013 (Figure 2-39).

The distribution shows that in 2013 nearly 50% of all models have energy consumption up to 1.15 kWh (Figure 2-40).

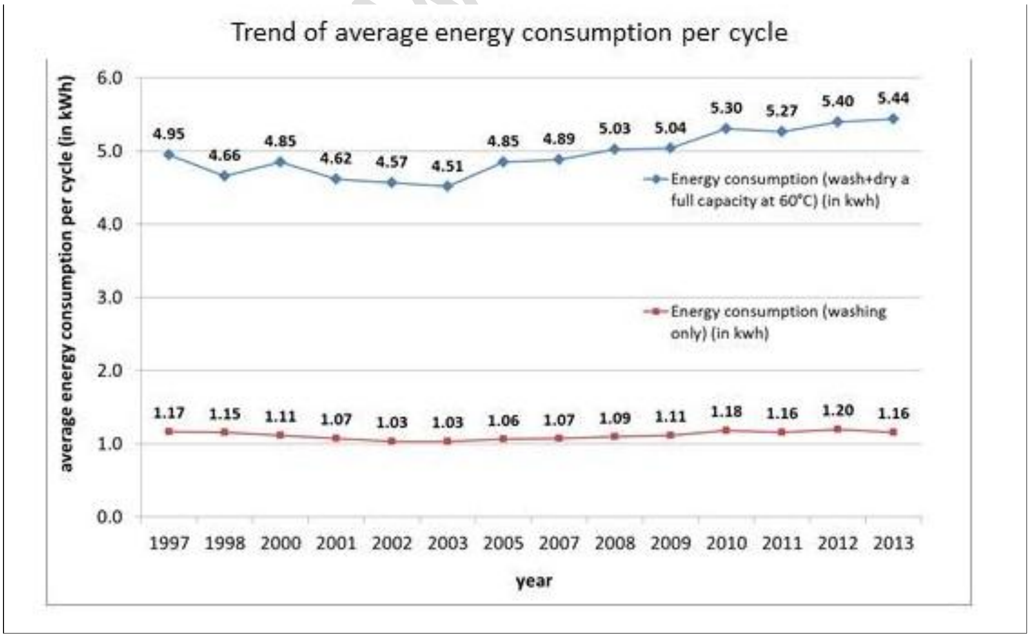


Figure 2-39 **Trend of average energy consumption of washer-dryer models (CECED 2014)**

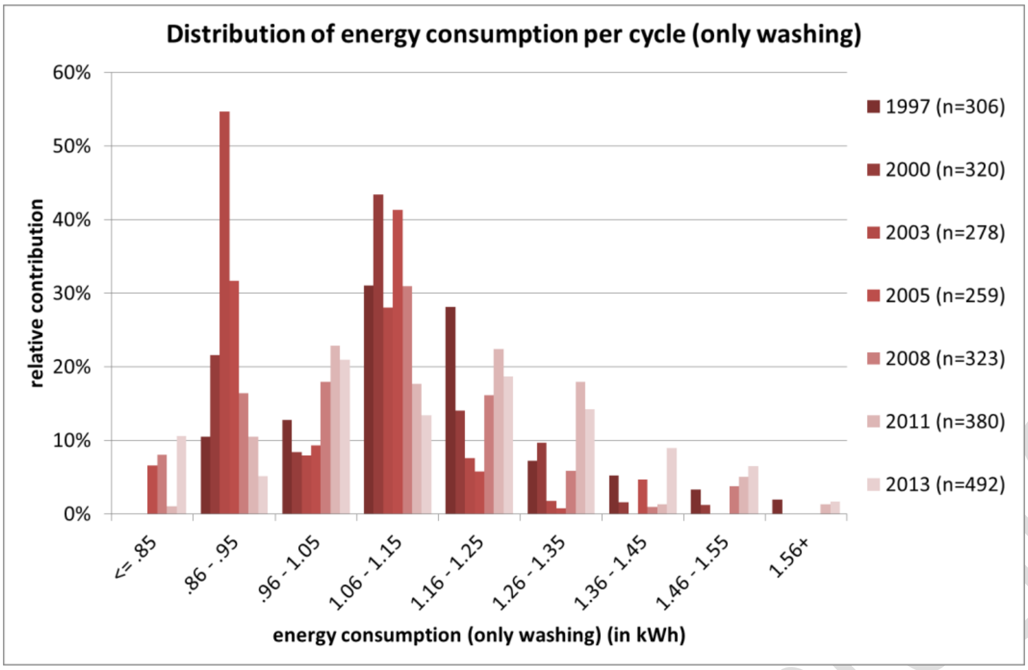


Figure 2-40 **Distribution of specific energy consumption for wash cycle of washer-dryer models (CECED 2014)**

Considering the <u>'wash and dry' cycle</u> (washing and drying of the whole load in one cycle) the absolute energy consumption has increased by 0.5 kWh per cycle between 1997 and 2013 (Figure 2-39). Until 2003 the energy consumption shows a slightly decrease. But then a stronger growth in consumption started and reached actually 5.44 kWh per cycle on average in 2013.

The distribution shows that in 2013 over 60 % of all models reached an energy consumption of 5.50 kWh per ‚wash and dry' cycle (Figure 2-41).

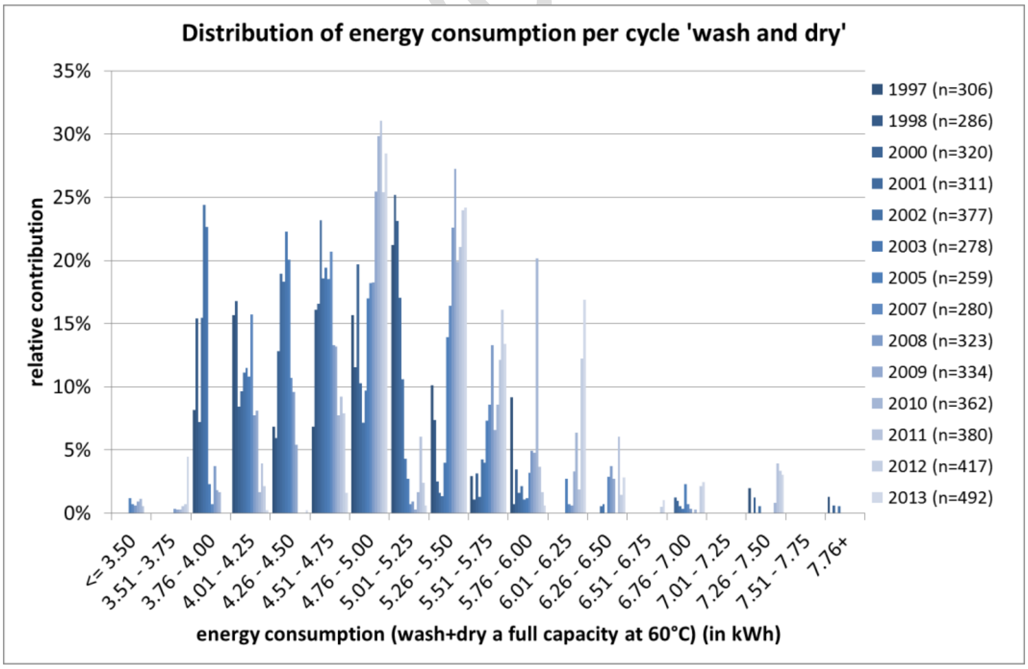


Figure 2-41 **Distribution of energy consumption for 'wash and dry' cycle of washer-dryer models (CECED 2014)**

The growth of the rated capacities of 'washing' and 'drying' over the years gives a possible reason for the observable increase of the energy consumption (Figure 2-42).

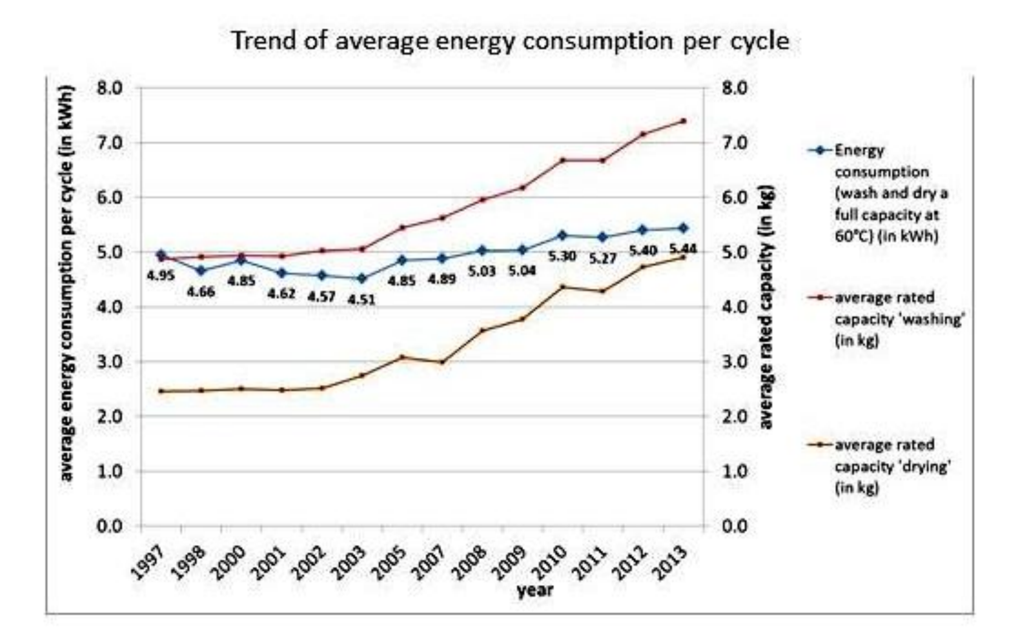


Figure 2-42 **Average energy consumption (wash and dry) and rated capacities of washer-dryer models (CECED 2014)**

However, in comparison with the trend in increasing total energy consumption, the specific energy consumption of 'wash and dry' (the division of total energy consumption by the capacity of 'washing') shows continuously declining values (Figure 2-43). From 1997 to 2013 the specific energy consumption 'wash and dry' decreased from 1.02 kWh/kg to 0.74 kWh/kg in 2013. Also the specific energy consumption of a 'wash cycle' only (calculated by dividing the energy consumption of a wash cycle by the capacity of 'washing) shows a constant declining trend (Figure 2-43) and lies on average at 0.20 kWh per kg load.

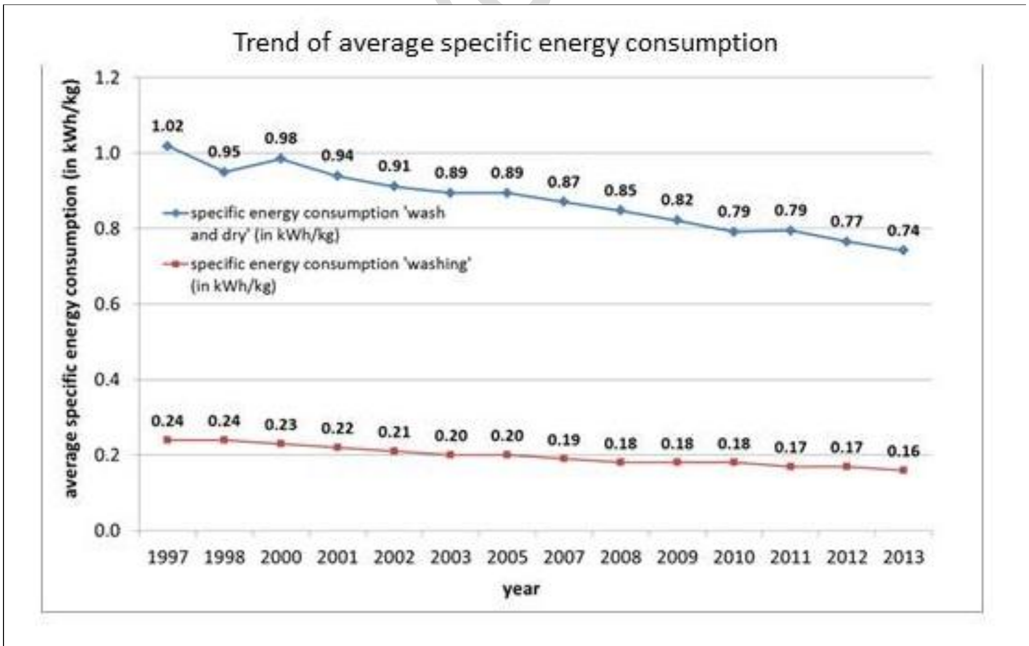


Figure 2-43 **Trend of average specific energy consumption of washer-dryer models (CECED 2014)**

Energy efficiency classes of washer-dryer models available on the market

From 1997 to 2013 the distribution of Energy Efficiency classes has been shifted dramatically towards higher efficiency classes (Figure 2-44). In 2013 about 50% of washer-dryers were labelled with class A and the majority of the rest was labelled as B (Figure 2-45). A minimal share of models, approximately 4 %, lies marginal below the limit of specific energy consumption per cycle of 0.68 kWh/kg.

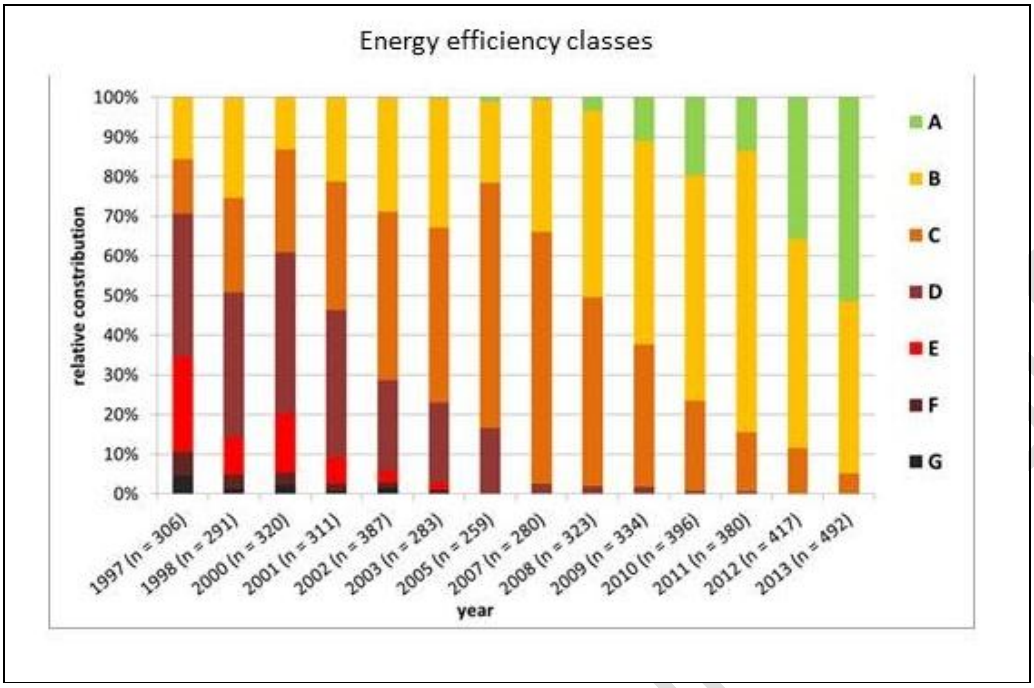


Figure 2-44 **Distribution of Energy Efficiency classes of washer-dryer models (CECED 2014)**

Figure 2-45 illustrates the distribution of washing-dryer models in terms of the limit values for the Energy Label classes.

As for washing machines, it can be seen that the majority of models had an energy consumption that complies with the lower limitation of the corresponding Energy Label class. For instance nearly 30% of washing-dryer models had an energy consumption of 0.81 kWh, which is the lower limit of energy efficiency class B 0.68 < C ≤ 0.81, whereas only very few models were in the upper limit of the Energy Label class B. Manufacturers seem to adjust the energy performance of the label programme to the minimum requirements of a desired Energy Label class.

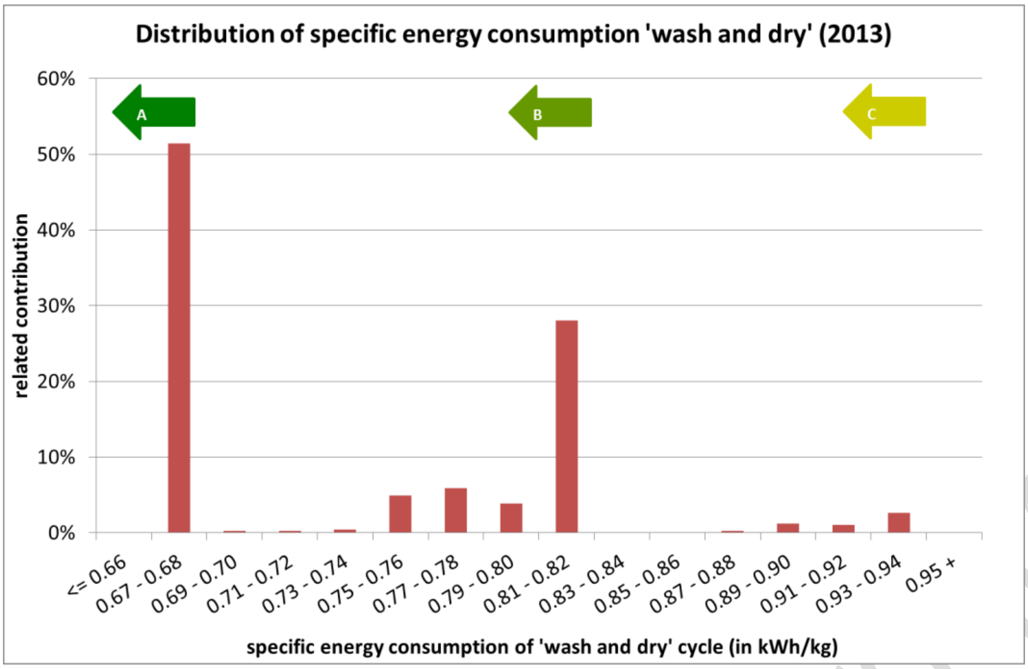


Figure 2-45 **Distribution of specific energy consumption of washer-dryer models 2013 (in-house elaboration based on (CECED 2014))**

Washing performance of washer-dryer models available on the market

Nearly 100 % of all washer-dryer models reached a Washing Performance classes A between the years 2005 to 2011 (Figure 2-46). Later a small number of washer-dryer models are declared 'only' class B in Washing Performance again.

Figure 2-46 **Distribution of Washing Performance classes of washer-dryer models (CECED 2014)**

Spin speed of washer-dryer models available on the market

A more or less continuous increase of the average maximum spin speed can be seen from 1,102 rpm (1997) per wash cycle to 1,396 rpm (2013) (Figure 2-47). While in 1997 most washer-dryers could be found in spin speed class between 901 and 1,000 rpm, in2013 most machines are in spin speed classes between 1,301 – 1,400 rpm (Figure 2-48). In 2013 17% were even declared to be between 1,501 and 1,600 rpm (Figure 2-49).

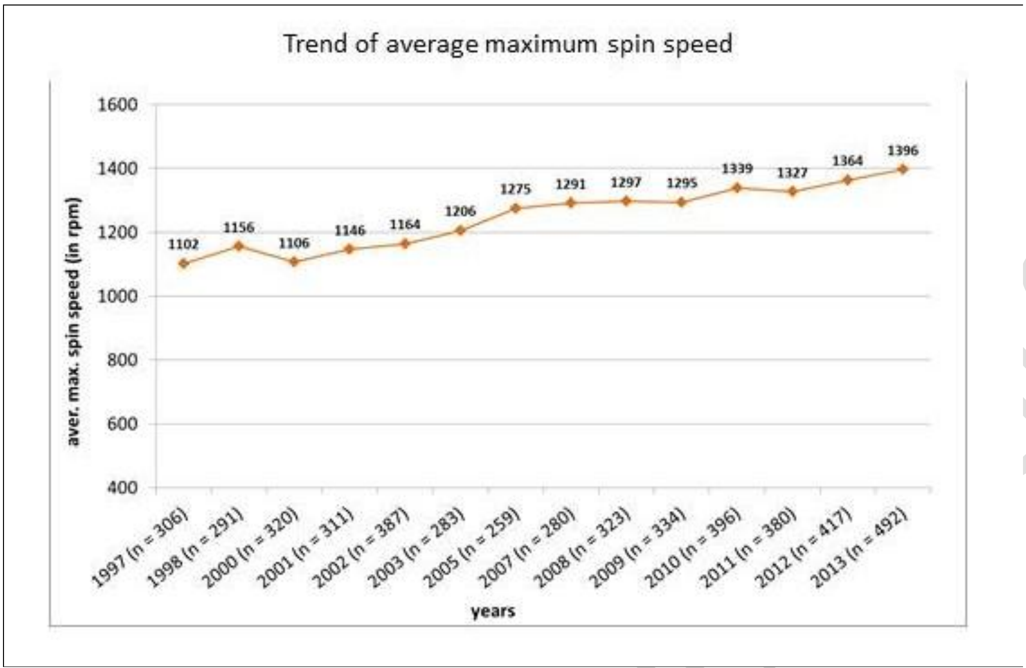


Figure 2-47 **Trend of average maximum spin speed of washer-dryer models (CECED 2014)**

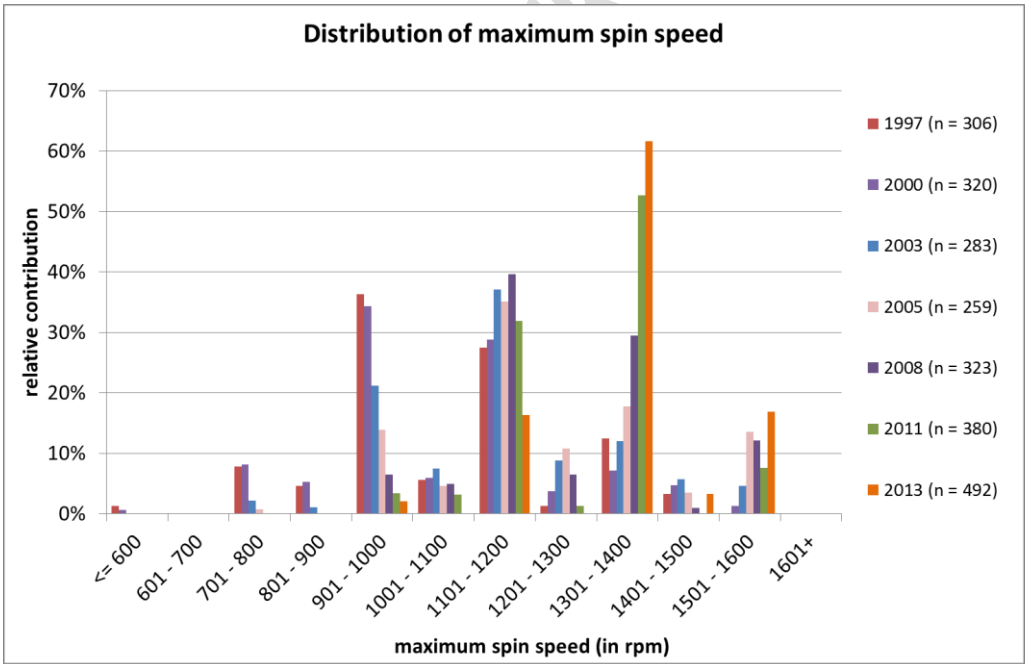


Figure 2-48 **Distribution of average maximum spin speed of washer-dryer models (CECED 2014)**

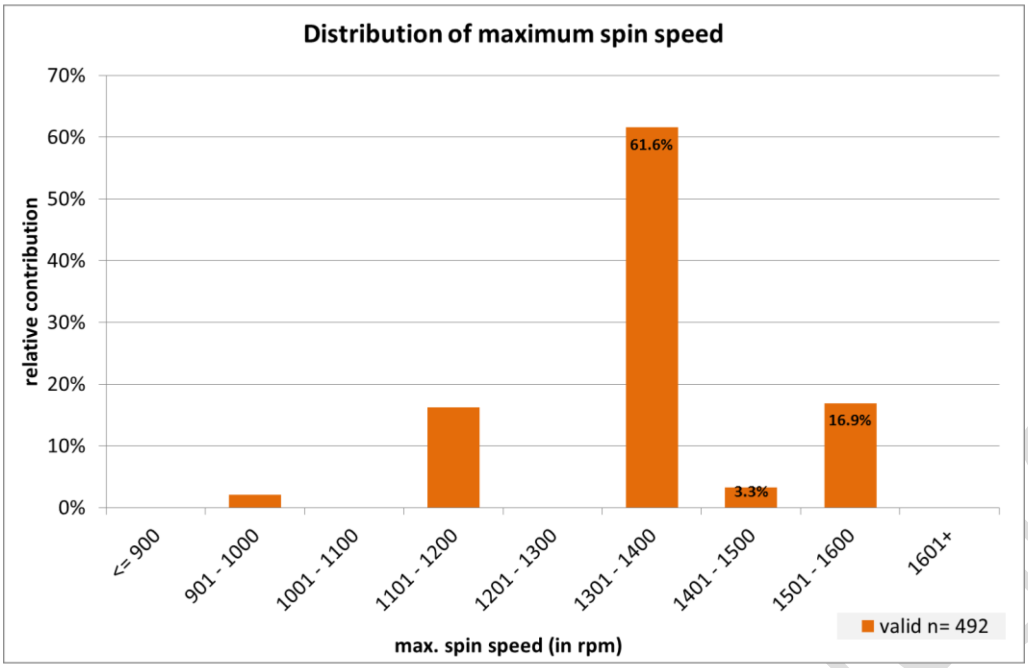


Figure 2-49 **Distribution of average maximum spin speed of washer-dryer models in 2013 (CECED 2014)**

Water consumption of washer-dryer models available on the market

The average total water consumption for washing and drying of washer-dryer models has declined from 129.7 litres down to 98.1 litres (Figure 2-50). This is an improvement of 24% between 1997 and 2013.

The average specific water consumption rated to the capacity of the models has actually halved from 26.8 l/kg down to 13.4 l/kg over this period (Figure 2-51). This again is fostered by the combination of lower absolute values and increasing capacities.

The distribution shows that in 2013 half of all models have consumption values below 100 l per cycle (Figure 2-52).

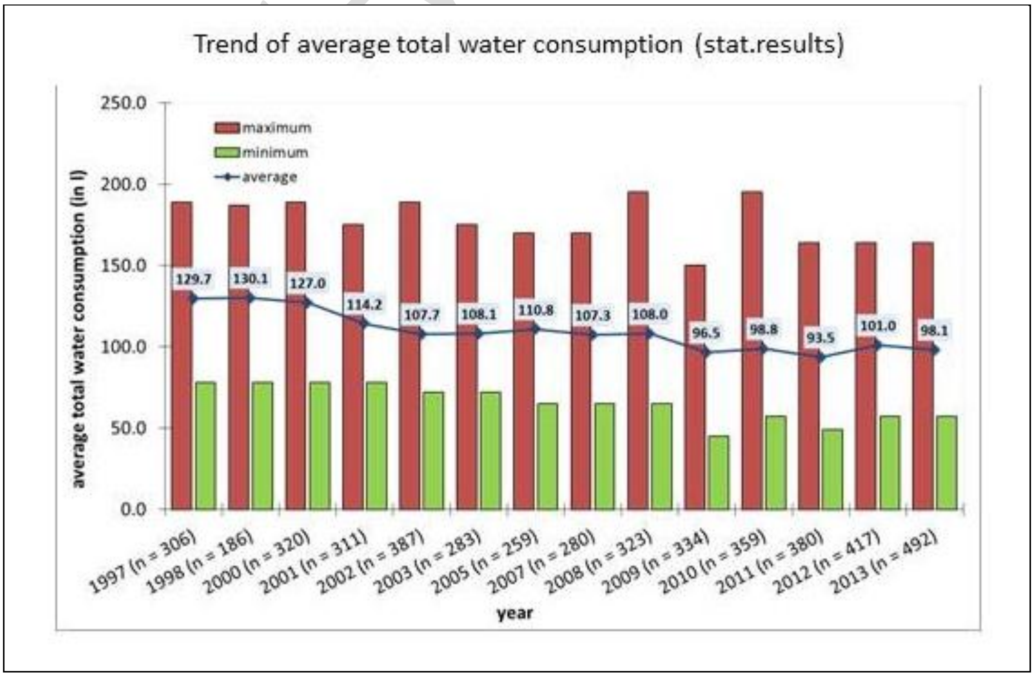


Figure 2-50 **Average total water consumption of washer-dryer models (statistical results based on (CECED 2014))**

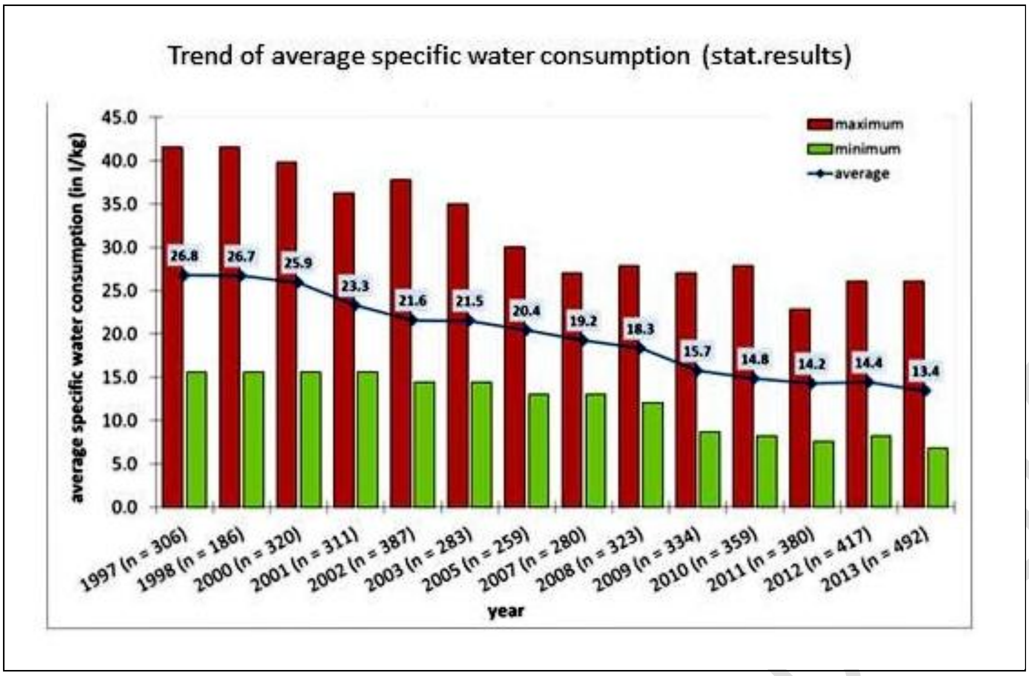


Figure 2-51 **Average specific water consumption of washer-dryer models (statistical results based on (CECED 2014))**

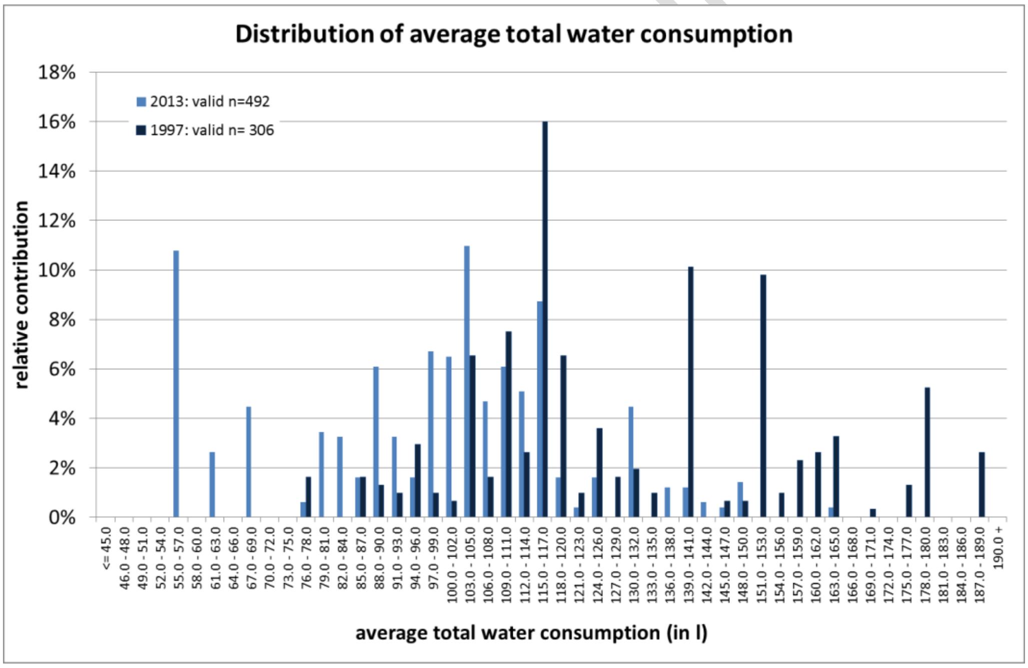


Figure 2-52 **Distribution of average total water consumption of washer-dryer models (CECED 2014)**

Noise emissions of washer-dryer models available on the market

For the analysis of the noise emissions only data between 2009 and 2013 are available.

In comparison to the 'washing' or 'drying' cycle, the noise emission of the spinning cycle of washer-dryers is highest (Figure 2-53). Constantly over this period the noise level of spinning lies by approximately 75 dB(A). The noise emission of 'drying' is on average at 62 dB(A) over the years and also shows no significantly changes during this period. Accordingly the distributions of ,'drying' and ,'spinning' indicate no significant changes over the years (Figure 2-54, Figure 2-55). By comparison, the noise emission of 'washing' decreased by 4 dB(A) to 55 dB(A) in 2013 (Figure 2-53).

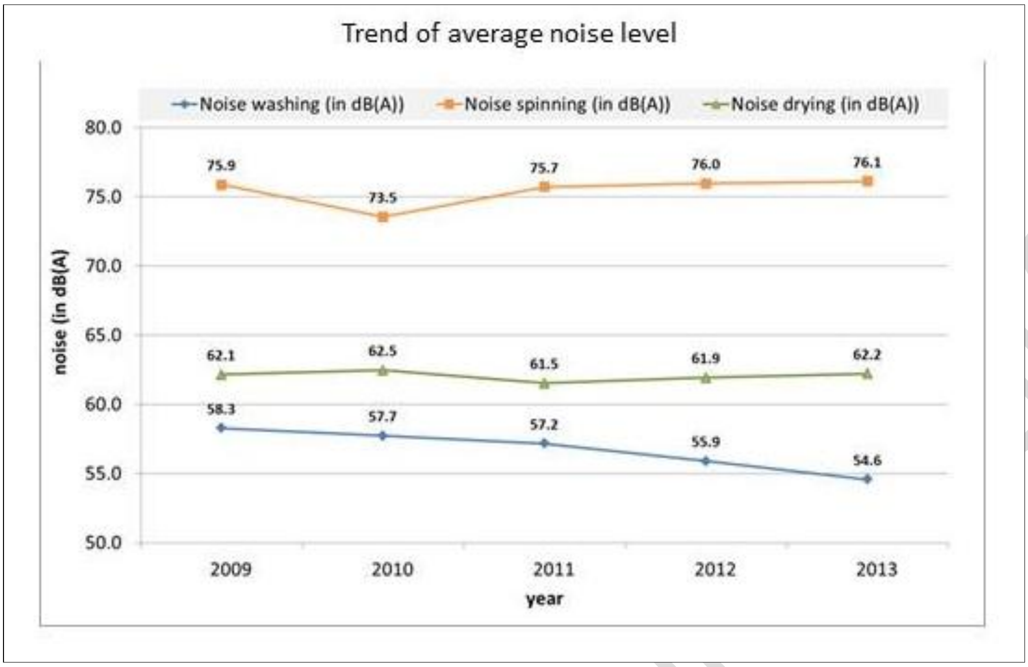


Figure 2-53 **Trend of average noise levels of washer-dryers (CECED 2014)**

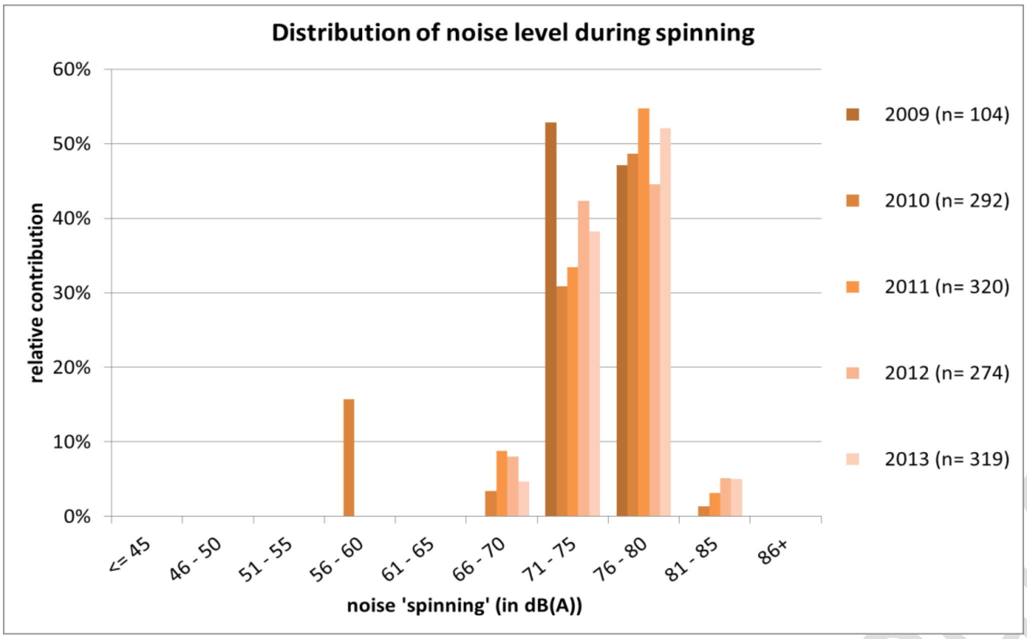


Figure 2-54 **Distribution of average noise level during 'spinning' of washer-dryers (CECED 2014)**

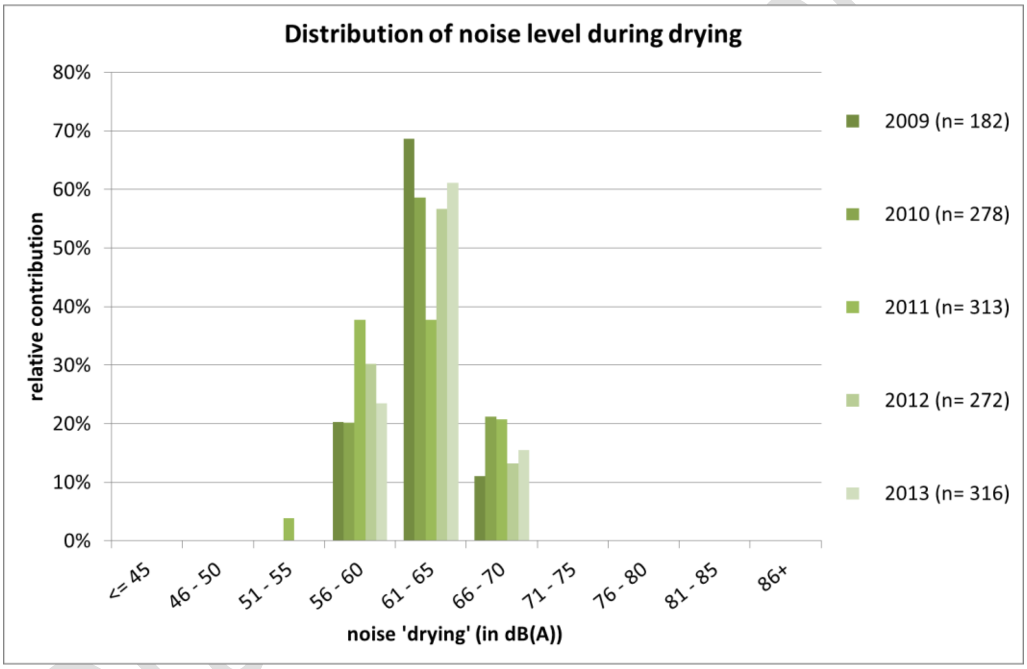


Figure 2-55 **Distribution of average noise level during ''drying' of washer-dryers (CECED 2014)**

Over 50% of all models reach a noise level of 55 dB(A) or lower during 'washing' (Figure 2-56). Especially in the noise range between 46 dB(A) and 50 dB(A) show a noticeable growth up to 18% of all models in 2013.

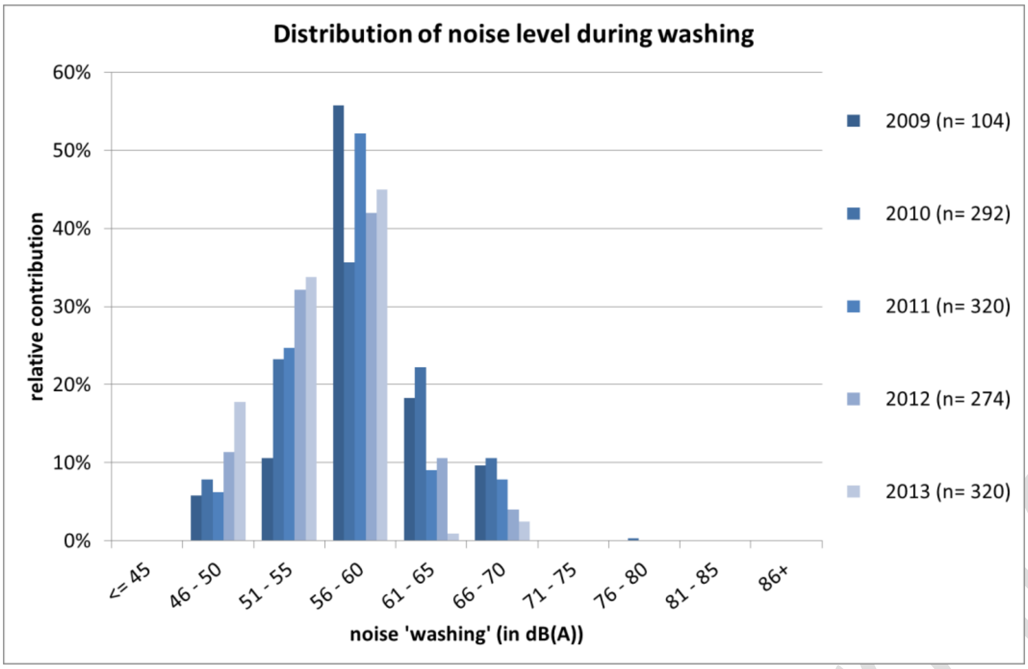


Figure 2-56 **Distribution of average noise level during ''washing' of washer-dryers (CECED 2014)**

2.2.5. General market data and trends

According to stakeholders, the following trends can be expected for the next years:

- A clear trend towards washing machines with a capacity over 8 and up to 13 kg can be observed (5-7 kg machines are becoming less and less). Greater capacity is not in terms of larger drums but larger rated capacity. However, the problem of filling washing machines often only partially is a well-known fact. Even if larger machines would wash more efficiently per kg, the relative savings per kg nominal load are lost in case more and more inefficient part load washing occurs. In other words: large washing machines are only fine as long as they have a low energy and water consumption when they are only little filled. In addition to this, rinsing becomes harder.
- The average washing machine sold has lower capacity than the average of models available, this reflects a general trend which sees higher volumes sold at the medium-lower prices.
- Less water consumption. This can result in worse rinsing efficiency, and can lead to more allergies/hypersensitivity or that people do an extra rinse or load less, which gives less energy efficiency.
- Shorter durability (typical time before the replacement of an appliance used to be about 12 years, but now it is about 6-10 years).
- Greater attention on exterior design.

2.2.6. Market trends

Besides technical improvement options (cf. section4.1.3), savings in resource consumption of a washing cycle can be realised by modifications of the wash programme course, e.g. cutting the amount of water that has to be heated up.

The following trends have been identified:

2.2.6.1. Trends to the design of specific 'standard programmes'

Further, reducing water temperatures in the wash phase of a washing programme and increasing the overall cycle durations are the latest trends in realising energy savings of washing programmes, and in particular for the so called 'standard programmes'. The Ecodesign Regulation 1015/2010 requires a 'standard programme' to wash cotton at 40 and 60 degrees. Since the implementation of the regulation, all washing machine models provide a 'standard' 60 °C and a 'standard' 40 °C washing programme that are used for the performance testing according to EN 60456:2011 and are also basis for the data declared on the Energy Label.

The Energy Label gives valuable information at the point of sale. Before purchasing white goods, many consumers inform themselves about latest state of the art in technologies, consumptions and relevant product factors that have to be considered. To do so, they read for example users advice online and or recommendations of independent consumer organisations, e.g. German "Stiftung Warentest" (STIWA), British "Choice" or French "Que Choisir". Those consumer associations periodically perform washing machine tests and publish the results in their magazines and on their webpages, together with useful information about best practices, new technologies and features.

For instance, referring to differences between 'standard programmes' and 'normal programmes' with regard to energy consumption, water consumption, approximate duration and remaining moisture as well as cost of electricity and water some studies have been carried out by "Which?" and "Stiftung Warentest". In the following some results of these surveys are described.

Most modern washing machines have more than one programme for washing cotton at each 40 °C and 60 °C. The more efficient one is often declared as eco programme or energy saving programme. In the regulation this programme is referred to as the 'standard programme'. This programme usually uses less electricity and less water than other cotton washing programmes at 60 and 40 degrees. For example, Figure 2-57 compares the electricity and water cost in one wash cycle for both the energy saving 'standard programme' and the 'normal programme' at 60 degree. The analysis shows that the consumption of energy and water (expressed as costs) in the normal 60 °C programme is considerably higher compared to the 'standard 60 °C programme'.

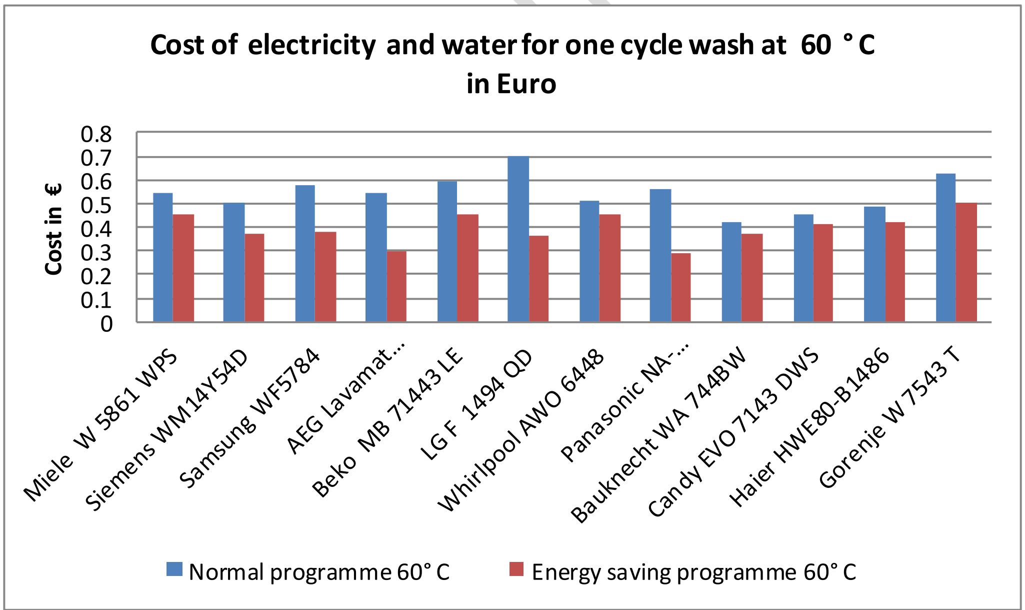


Figure 2-57 **Cost of electricity and water for one washing load at 60 °C in Euro (according to (Stiftung Warentest 2013))**

The 'standard' programmes are often designed to use as little energy at the minimum requested washing performance as possible, in order to maintain high energy efficiency classes on the Energy Label. Especially since the implementation of the new energy efficiency classes in 2010, manufacturers seem to apply a washing strategy with lower temperatures combined with longer programme durations to realise energy savings needed to meet the requirements of the highest energy efficiency class possible.

A comparison of the 25 most sold washing machine models in Europe 2014 (models data provided by GfK, personal communication 2013) shows that the normal programme for a cotton 60 °C load uses in average 38% more energy and 34% more water than the 'standard cotton programme' for the same load. Depending on the machine this may go up 80% or more. This is done at a programme duration which is reduced by just 17%.

Table 2.16 **Ratio of normal cotton wash 60 °C to 'standard cotton 60 °C programme' at full load regarding for 25 most selling washing machines (based on (GfK, personal communication 2013))**

	average	max	min
Energy	138%	185%	92%
Water	134%	176%	105%
Time	83%	103%	58%

2.2.6.2. Trends to lower maximum washing temperatures than indicated on the programmes

This is a trend observed by different organisations. For example, "Which?" tested 12 washing machines and found out that 8 of them did not reach 60°C on the 60°C cotton programme. The washing machines that reached 60°C only maintained that temperature for either a few minutes or a few seconds. Of the nine machines that reached 55°C or more, the water spent less than 10% of its time at or above this temperature, on average.

Almost all of the washing machines tested follow a similar pattern: the water is heated until it reaches the hottest temperature (sometimes for just seconds) and then the temperature falls quickly before setting into a long cooling process, as Figure 2-58 shows.

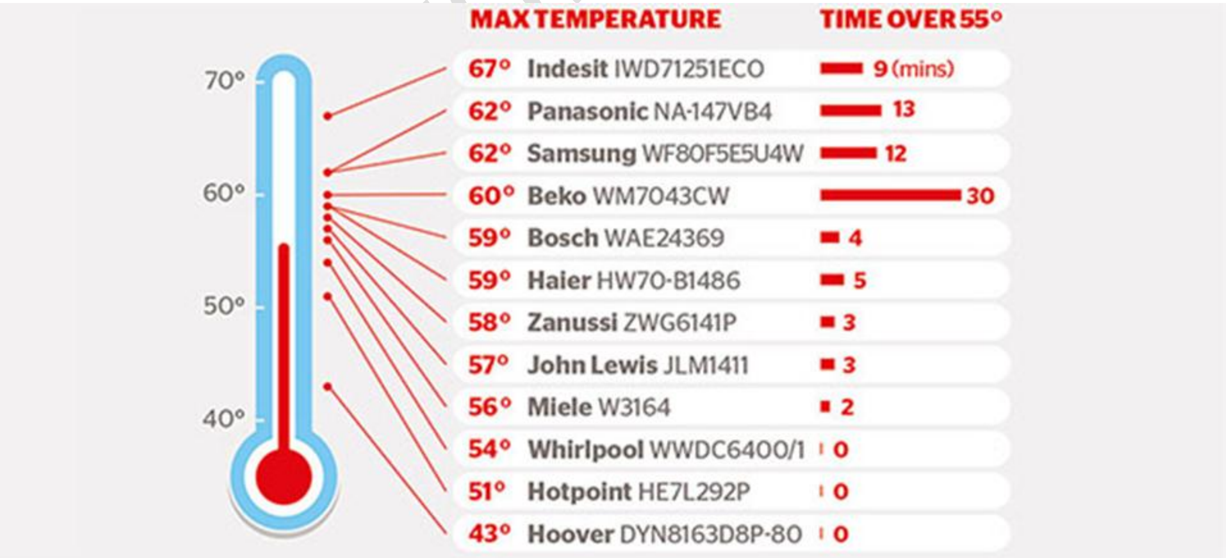


Figure 2-58 **The highest temperatures reached and duration each machine spent above 55°C (Which? 2013)**

Even though the test results demonstrate machines often do not hit 60°C, manufacturers are not actually cheating the EU Energy Label because there's no minimum requirement for the washing machine to reach the temperatures stated on the control panel. However, the programmes used to calculate the rating stated on the Energy Label – the 40˚C and 60˚C cottons programmes – must reach a certain level of washing performance (the weighted average of the washing performance of the standard programmes at 40 and 60 °C has to be >1.03 which represents class A in washing performance according to EU regulation 95/12/EC). Instruction manuals must also contain wording stating that the temperature specified might not be reached, which many manufacturers have quoted as the reason for not needing to reach 60˚C.

For example, the "Whirlpool WWDC6400/1" reached just 54°C in tests carried out by "Which?" (Which? 2013). A "Whirlpool" spokesperson said: 'On this machine the 60°C cottons programme is operating within the Energy Labelling criteria, which is optimised for energy consumption and cleaning efficiency.' This also means that the "Hoover" washing machine that only reaches 43 °C and gets an A+++ energy rating is acceptable under the current requirements of the EU label.

2.2.6.3. Trends to longer cycle duration

This approach saves considerable energy. The reduced temperatures are compensated through longer cycle durations.

Where the 'normal 60 °C cotton programme' needs between 2 and 3 hours the 'standard cotton 60 °C programme' runs for 3 to 5 hours. For instance, Siemens introduced washing machine to the market which consumes 50 percent less energy than the washing machine in the energy efficiency class A+++. In this regard, the washing duration has increased to 6 hours 30 minutes to compensate reducing the temperature and having a good washing result.

Longer cycle time opens the possibility to wash with lower temperatures with the same washing result and can therefore increase the energy efficiency. Figure 2-59 shows the amount of energy consumption, water consumption, approximate duration and remaining moisture in 'Cottons 60 °C', 'Cottons 40 °C' versus 'Standard 60 °C cotton' and 'Standard 40 °C cotton' in the "AEG L89495FL" washing machine. (AEG 2014b)

As it can be seen in Figure 2-59, the amount of energy consumption for the 'Cottons 60 °C' is 1.55 kWh and for 'Standard 60 °C cotton' is 0.64 kWh. At the same time, the approximate duration in 'Cottons 60 °C' and 'Standard 60 °C cotton' is 170 and 226 minutes respectively, i.e. the duration of the 'standard cotton programme' is considerably longer than the duration of normal cotton programme.

Programmes	Load (Kg)	Energy consumption (kWh)	Water consumption (litre)	Approximate programme duration (minutes)	Remaining moisture (%)[1)]
Cottons 60 °C	9	1.55	79	170	52
Cottons 40 °C	9	0.97	79	164	52
Synthetics 40 °C	4	0.55	54	120	35
Delicates 40 °C	4	0.60	59	89	35
Wool/Hand wash 30 °C	2	0.35	58	60	30
Standard cotton programmes					
Standard 60 °C cotton	9	0.64	57	226	52
Standard 60 °C cotton	4.5	0.34	41	185	52
Standard 40 °C cotton	4.5	0.34	40	199	52

1) At the end of spin phase.

Figure 2-59 **Energy consumption, water consumption, approximate duration and remaining moisture in different programmes (AEG 2014b)**

The increase of energy efficiency often goes along with longer programme times. However, high energy efficiency and relatively short programme times do not have to exclude each other. This is demonstrated by washing machines listed at Topten machines with short times of the 'standard programmes', as for instance:

- 2 h 20 min (60°C full), 1 h 35 min (60°C half) and 1 h 30 min (40°C half) respectively (Schulthess 'Spirit eMotion 7040i' and Merker 'Bianca 735', both with a capacity of 7 kg and an EEI of 43, which equals A+++ -6.5%).
- New Miele-models presented at IFA 2014 reach A+++ - 40% by introducing a new washing system called Power Wash 2.0. They achieve the required performance with a washing programme just below 3 hours and are consuming just 130 kWh per year for a 9 kg rated capacity.

.Further indications provided by Topten are provided in Table 2.17 below.

Table 2.17 **Programme duration of best performing washing machines according to Topten.eu**

Rated capacity (kg cotton)	Programme		
	60 °C full	**40 °C full**	**40 °C partial**
< 8 kg	140 – 240 min	95 – 210 min	90 – 210 min
8 kg	179 – 240 min	120 – 220 min	130 – 215 min
> 8 kg	179 – 240 min	120 – 210 min	130 – 180 min

2.2.6.4. Impacts on real-life energy and water consumption

The real energy and water consumption of a washing machine depends on how consumer uses the machine. This can rather differ from the rated annual consumption as shown on the product information. The rated energy and water consumption is based on test results of the 'standard programmes'. By providing different programmes (normal and standard) for the same washing 40 °C and 60 °C cotton, with considerably different energy and water consumptions as well as programme durations, it might be that

- Consumers do not detect the energy efficient standard programmes at all on the panels;
- Consumers do not understand the differences between standard and normal cotton programmes and thus accidentally chose the more consuming normal programmes;
- Consumers intentionally chose the more consuming normal programmes
  - Due to too long cycle times not being convenient for consumers (some stakeholders comment that to their knowledge, consumers' maximum acceptable duration is around 3hrs);
  - Due to the lower washing temperatures as indicated as consumers might be concerned about hygienic issues.
- Consumers may not even find the data about the difference of consumptions for the normal and standard programmes as this is not requested by the regulation.
- Energy (and water) consumption at the consumers' home may be significantly higher as what is declaration on the Energy Label and what was the basis for the purchasing decision.

These possible influences on consumer behaviour are further analysed in Chapter 3..

2.2.7. Market data and trends with regard to detergents

The market analysis done within the EU Ecolabel revision for laundry detergents revealed that laundry detergents are available in a range of formats. In general, market trends show that sustainability is of growing importance to consumers of laundry detergents, with an increase in concentrated/compacted products, use of plant-based ingredients and minimisation of packaging. (JRC IPTS 2015b)

According to the detailed market analysis of 2012 provided by (JRC IPTS 2014a), of the laundry detergents, powder detergents are the most popular (34% of the market by volume), followed by liquid detergents (19%). Detergent tablets make up a relatively small proportion of the market in comparison (4% by volume) with other detergents accounting for 4% of the total market for laundry care products. Other laundry care products include fabric conditioner (31% of the market by volume), stain removers and other additives (6%) and fabric fresheners (2%).

(JRC IPTS 2014a) summarise the product trends in the laundry detergent market as follows:

- A significant overall increase in liquid detergents (+47% 2007-2012, compound annual growth rate (CAGR) 6.61%).
- An overall decrease in the use of powder detergents (-17% 2007-2012, CAGR -8.46%).
- An increase in the use of concentrated products, most significantly concentrated liquid detergent (228% increase in sales of concentrated liquid detergents 2007-2012, CAGR 21.94%).
- An increase in liquid tablet detergents (193% increase 2007-2012, CAGR 20.09%) which is mirrored by a decrease in sales of compacted powder tablets.

Thus, in Europe the long term trend in the laundry detergent market is a move towards concentrated liquid (including gel) detergents both in liquid and tablet form. However, according to (JRC IPTS 2014a) this trend is highly sensitive to price – in 2011 there was an increase in powder detergent use in Europe as consumers went for lower priced options.

Many of the recent developments and innovations in the detergent market have centred on the production of laundry tablets (also marketed as 'pods') and unit dose products. The convenience factor is a significant driver for the sales of laundry tablets, which provide an easy way to dose detergents. Sales of liquid capsules in particular have seen significant growth since 2007 (with a compound annual growth rate CAGR of 20.09%) but still make up a very minor part of the market. This trend appears to be driven by a select few European countries – primarily Italy and the UK – where take-up of these laundry tablets has grown significantly since 2007. (JRC IPTS 2014a)

Many manufacturers are offering double concentrated formats instead of standard concentrated products. Besides at least 2x, but often 3x concentrated products, further innovation in compaction technology has even led to the development of 8x concentrated laundry detergents. The increase in these 'super-concentrated' products can be seen across Europe. However, the move towards more concentrated products needs to be accompanied by a greater amount of information on packaging aimed at consumers. Without proper information, consumers continue to dose as with non-concentrated products and therefore overdose these concentrated detergents. For example, a 2 litre bottle of concentrated detergent may provide the same number of 'washes' as a 3 litre bottle, but consumers are measuring out the same amount regardless of bottle size. (JRC IPTS 2014a)

According to (JRC IPTS 2014a), unit dose products are a relatively new innovation in the laundry care market and act as a direct replacement for the more traditional liquid and powder laundry detergents. These products consist of 'pods' or packets which contain a pre-measured unit dose of laundry detergent. Liquid 'pod' detergents in particular are advertised as a sustainable innovation in the laundry market. These consist of a liquid detergent in a water-soluble and (typically) biodegradable film capsule. This prevents the user from overdosing the laundry detergent, a common problem with liquid or powder detergents.

Finally, in recent years detergent manufacturers have invested significant efforts to improve washing performance at low temperatures. Household laundry detergents are now available on the market which claim wash efficacy at temperatures as low as 15 °C. This has largely been achieved through the choice of surfactants and polymers and the use of sophisticated enzyme systems.

2.3. Consumer expenditure data

2.3.1. Average unit value of household washing machines produced in EU28

According to the Ecodesign Impact Accounting study by (VHK 2014), the price of a household washing machine is assumed to be relative constant at about 450 € including VAT (in 2010 prices) for the assumed Business-as-Usual (BAU) scenario, while for the ECO scenario the cost increase estimated by the introduction of the Energy Labelling requirements according to EU 1061/2010 and Ecodesign requirement according to EU 1015/2010 is predicted to be 100 € in maximum but is reduced continuously after 2015 and will end up with the same price as in the BAU scenario (see Figure 2-60). For further details regarding the scenarios, please refer to section 2.2.1.

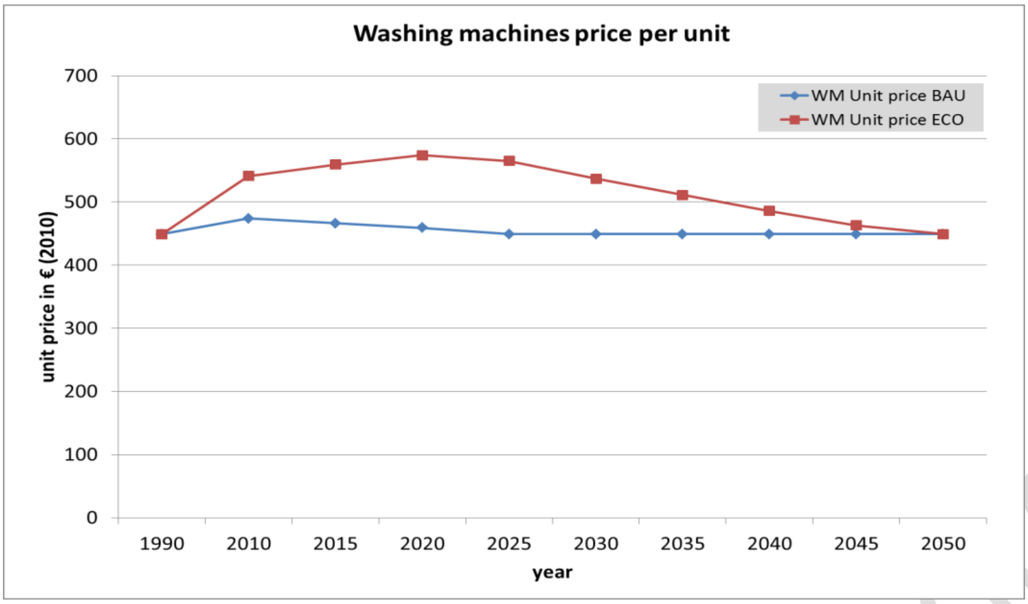


Figure 2-60 **Average price in € (basis 2010) for a washing machine in the European market from 1990 to 2050 (data from (VHK 2014))**

Additional to these data, the following table shows the calculated average unit values of 'Clothes washing and drying machines, of the household type' produced in EU28 and certain Member States as reported by (Eurostat 2015a) for those Member States where information was available (cf. section 0). It can be seen that the unit value of clothes washing and drying machines produced in Germany achieve higher unit values compared to the other producing Member States as well as the EU28 average. In total, the values have been rather stable or partly increasing between 2007 and 2013. However, it has to be noted that Prodcom values data relate to the manufacturer selling price, not to the end consumer price, and data cover not only washing machines, but also clothes dryers and combined washer-dryers.

Table 2.18: **Calculated average unit value (in Euro) of 'Clothes washing and drying machines, of the household type' produced in the EU28 between 2007 and 2013 (own calculation based on (Eurostat 2015a))**

Declarant	2007	2008	2009	2010	2011	2012	2013
France	0	220	213	203	204	213	230
Germany	476	:	481	476	455	:	:
Italy	193	193	203	210	207	210	208
Poland	213	220	201	200	181	192	186
Spain	193	197	195	209	:	219	222
Sweden	341	:	:	:	:	:	:
United Kingdom	140	171	174	:	:	:	:
EU28TOTALS	230	230	234	232	226	228	221

":" means data not being available

Figure 2-61 illustrates the trend of changes in prices of the washing machines in 14 western European countries (AT,BE,DE,DK,ES,FI,FR,GB,GR,IE,IT,NL,PT,SE) from 2004 to 2012 based on the provided data by German Gesellschaft für Konsumforschung (GfK, personal communication 2013). As it can be observed the washing machines price per unit has declined gradually from 462 Euro in 2004 to 434 Euro in 2012.

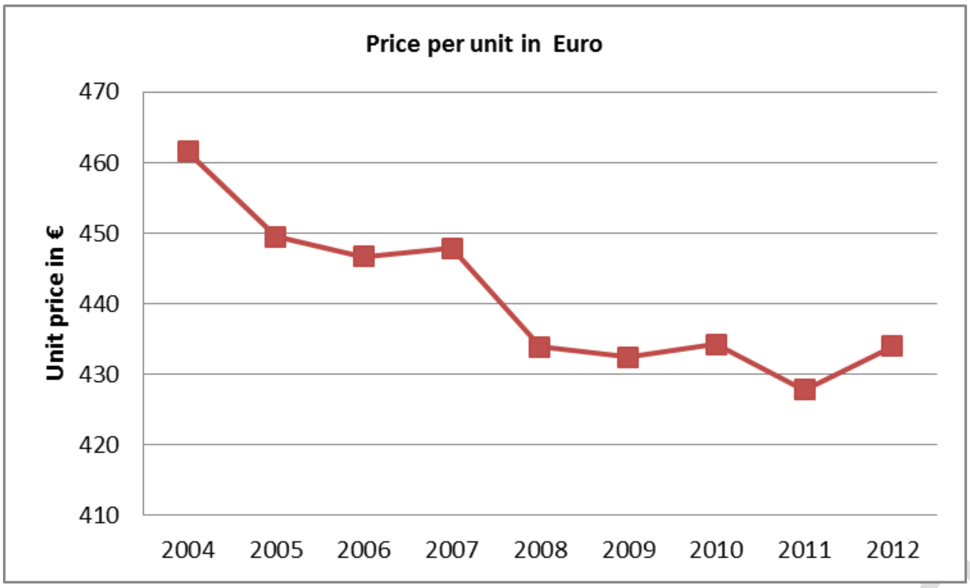


Figure 2-61 **Average price per unit of washing machine in Euro for 14 Western European countries from 2004-2010 (GfK, personal communication 2013)**

2.3.2. Consumer prices of consumables

The German consumer journal Stiftung Warentest conducts performance tests with washing machine detergents on a regular basis. In 2012 extensive test has been performed to compare different kind of detergents. In this regard, 21 washing detergents (2 powder detergents and 19 liquid detergents) were investigated.

Results of survey shows that even though powder detergents have a higher price than several tested liquid detergents but they have better cleaning effects than liquid detergents. Another recently published article compared the best washing powder for white clothes; washing powder from the big package versus compact powder. The data indicates that in general the compact powder is better than powder from big packages, while there is no remarkable difference between prices of these detergents (Stiftung Warentest 2012a); (Stiftung Warentest 2014)

Table 2.19 **Price of detergent per cycle in Germany 2012 and 2014 (According to (Stiftung Warentest 2012a) and (Stiftung Warentest 2014)**

		Powder		**Liquid**	
	Product tested	Min.	Max.	Min.	Max.
2012	21	0.21 €	0.25 €	0.13 €	
2014 (Compact)	13	0.11 €	0.32 €	-	
2014 (Big pack.)	8	0.10 €	0.32 €	-	

2.3.3. Further prices

The Methodology for the Ecodesign of Energy related Products (COWI and VHK 2011) suggests to use EU average values for all preparatory studies, partly adjusted with an overall escalation rate (e.g. for energy prices) which results in the monetary outcomes of all studies being comparable. The EU-27 average data provided in this study are the following for electricity, gas, water, interest, inflation and discount rates.

Table 2.20: Energy, water and financial rates as proposed by (COWI and VHK 2011) for the year 2011

	Domestic (incl. VAT)	Long-term growth per year
Electricity	0.18 €/kWh	5%
Gas (net calorific value NCV)	14.54 €/GJ	3-5%
Water	3.70 €/m³	2.5%
Interest	7.7%	-
Inflation rate	2.1%	-
Discount rate (EU default)	4.0%	-
Energy escalation rate, i.e. real (inflation-corrected) increase per year*	4.0%	-
VAT	20.0%	-

* To be applied to the electricity rate in order to adjust the actual rate for 2015 for the case that the real inflation-corrected energy prices growth rates do not deviate more than 1%-point from the given 4%. If that happens, the differentiated LCC calculation with actual prices should be followed.

In (COWI and VHK 2011) the electricity prices for households in EU-27 are indicated as a sum of production and distribution costs, indirect taxes and value added taxes. The total price per kWh lies between 0.09 €/kWh in Bulgaria and 0.28 €/ kWh in Denmark, while the average of all 27 EU countries is 0.18 €/ kWh. Tax rates are fluctuating and contribute a high percentage of the total electricity price in several countries, e.g. Denmark and the Netherlands.

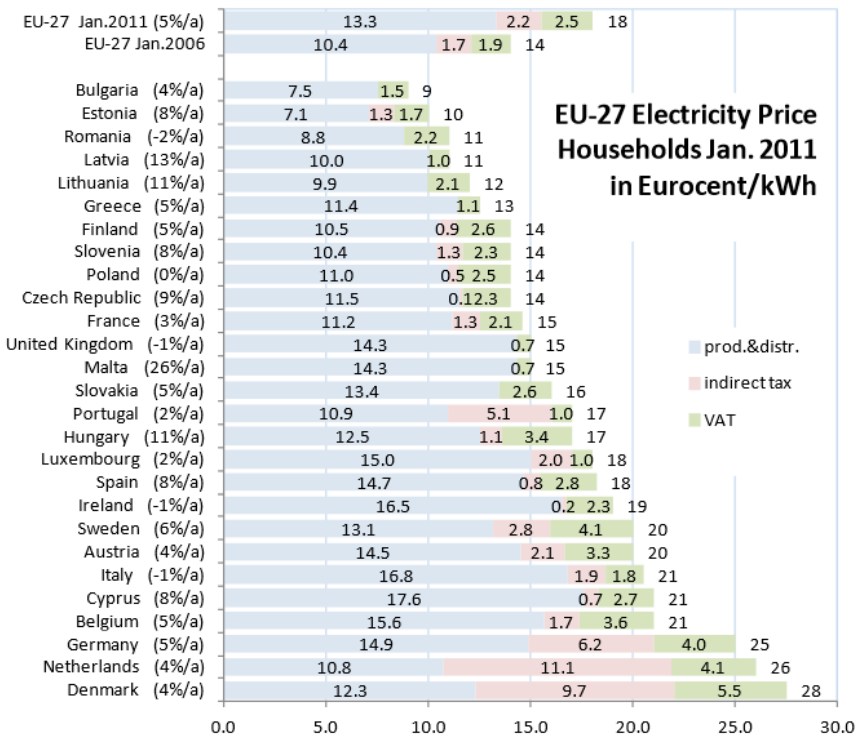


Figure 2-62 **Electricity prices households Jan. 2011 (recent annual growth rates in brackets, in %/a) (COWI and VHK 2011))**

Consumer information material published by (VZ RLP & Öko-Institut 2012) provide a comparison of total costs for energy and water, for washing machines with different energy efficiency classes (see Table 2.21).

Table 2.21 **Comparison of costs for washing machines of different energy efficiency classes (VZ RLP & Öko-Institut 2012)**

Efficiency class	A+++	A +	old appliance*
Power consumption	150 kWh	220 kWh	250 kWh
Power cost**	36 €	53 €	60 €
Water consumption	9270 l	11660 l	13135 l
Water cost***	36 €	46 €	52 €
Total costs	72 €	99 €	112 €

* 6 kg capacity, 12 years old, ** 0.24 €/kWh, *** 3.9 €/m³

2.3.4. Overview of life cycle costs

On the basis of the analysis of the feedback received from stakeholders in response to the technical questionnaire that was released in March 2015, a preliminary table has been compiled to start compiling and summarising life cycle costs to use in the development of next tasks.

Table 2.22 **Summary of information on life cycle costs for washing machines and washer-dryers on the basis of the feedback received from stakeholders**

Cost category	**Average costs**	
	Washing machines	**Washer-dryers**

Consumer purchase prices of the machine (€/product)	220 - 380 EUR (but they can often cost also about 1000 EUR)	400 - 630 EUR (but they can often cost also about 1000 EUR)
Factory prices (production costs) (€/product)	Not available	Not available
Consumer purchase price for detergents (€/kg, please specify type of detergent)	About 0,50 EUR per cycle	
Installation costs (€/product)	From 0 EUR to about 50 EUR	
Type, average number of maintenance actions and related costs (e.g. deep cleaning) along the product life time (€/product – please specify the considered lifetime)	From 0 EUR to about 2 times per lifetime at a cost of 150 Euro/a time	
Type, average number of repairs and related costs along the product life time (€/product – please specify the considered lifetime)	About 2 times per lifetime at a cost of 150 Euro/time	
Disposal costs (€/product) It is assumed that under WEEE, the financing of the costs of collection, treatment, recovery and environmentally sound disposal of WEEE from private households is producer's responsibility. Normally, this cost is passed over to the consumer in the final purchase price.	In accordance to the WEEE directive provisions, producers fulfil their responsibility of financing the costs of collection, treatment, recovery and environmentally sound disposal of domestic WEEE deposited at collection facilities. To some extent these costs are passed over to the consumer in the final purchase price. WEEE financing is a part of selling price, with relevant differences across the EU. In UK the fee is not visible, in Italy the fee is visible to trade partners, but not to consumers, in France the fee is visible also to final consumer. Costs also vary from country to country, logistic costs are a main source of variability. Manufacturers can leverage on economies of scale to ensure that collection and treatment costs are optimised.	
Note: 1. it is assumed that VAT is included 2. It is assumed that all costs are given with reference to 2015		

Information on purchase price of high efficient washing machines and washer-dryers is provided on most of the 18 Topten-websites in Europe. The total costs of the average of the most energy efficient models listed at TopTen amount to 2,459 to 3,015 Euro (Table 2.23). The last two lines in the table show that there is a difference of 600 to 1000 Euro between the total costs for the least and the most expensive Topten model. Compared to that, the total costs of inefficient models amount to 1,919 to 2,532 Euro (Quack 2010)

Table 2.23 Overview of life cycle cost structure for washing machines. Assumed life time: 15 years (Quack 2010)

	CEE (Poland)		North (Norway)		West (Germany)		South (Spain)	
	Topten models	inefficient models	Topten models	inefficient models	Topten models	inefficient models	Topten models	inefficient models
Average purchase price	911 €	261 €	1.198 €	554 €	771 €	399 €	1.392 €	582 €
Average total energy costs	398 €	410 €	548 €	581 €	666 €	752 €	451 €	646 €
Average total water costs	490 €	588 €	609 €	577 €	506 €	544 €	496 €	644 €
Average total detergent costs	660 €	660 €	660 €	660 €	660 €	660 €	660 €	660 €
Average total costs	**2.459 €**	**1.919 €**	**3.015 €**	**2.372 €**	**2.604 €**	**2.355 €**	**2.998 €**	**2.532 €**
Min total costs Topten models	1.945 €		2.723 €		2.335 €		2.554 €	
Max total costs, Topten models	3.699 €		3.677 €		3.054 €		3.223 €	

The results of the life cycle cost analyses of washing machines show that the average total costs of the Topten models are always higher than the total cost for the inefficient model, (Table 2.23). The total energy costs are always lower for the Topten models' average then for the inefficient model. Norway is an exception due to the rated capacity of the models in Norway being 7-8 kg instead of 5-6 kg as for the other countries. A single washing cycle of a 7 or 8 kg machine needs more electricity than one of a 5 or 6 kg machine. On the other hand more clothes can be washed at the same time in bigger machines therefore a lower number of washing cycles per year might be expected. Unfortunately studies (e.g. ISIS 2007b) show that people do not use the full capacity but put fewer clothes in. In average the loading is about 3.5 kg/washing cycle (Quack 2010).

Besides the purchase costs that contribute with 30 to 46% (average of most efficient Topten models) respectively 14 to 23% (inefficient models) to the total life cycle costs of washing machines the share of the costs during the use phase is also significant (Figure 2-63): the electricity costs, the water costs and the detergents costs. Their share is between 15 and 32% each. Together they amount to 54 to 86% of the total life cycle costs, being highest for the inefficient models (77 to 86 per cent).

In most of the cases the detergent costs have the highest absolute value and share of total costs. As for all countries the same costs were assumed for the detergents (0.22 Euro/washing cycle, ISIS 2007), there will be some variance in reality. Concerning the water costs, for some countries they are higher than the electricity costs (Poland; Germany; Norway, Topten models), only for Spain and Norway (inefficient model) they are lower resp. equal. For the water costs it must be stated that the same water price was assumed throughout Europe (3.70 Euro/m^3, ISIS 2007). As the water price mostly is organised on the level of the municipalities (see e.g. EUREAU 2009) it may vary and therefore the results for one specific city may deviate significantly from the above calculations (Quack 2010).

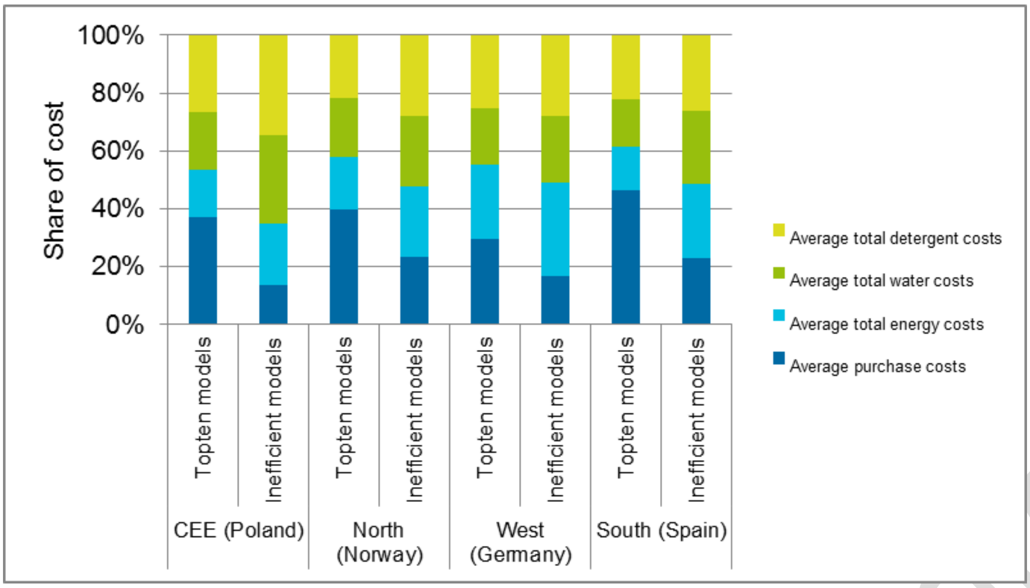


Figure 2-63 **Share of the different cost elements of the Topten washing machines and the inefficient models in the different countries (according to (Quack 2010))**

2.4. Summary and discussion: markets

2.4.1. Summary of findings

The following preliminary findings have resulted from the market data collection exercise undertaken:

- At European level, the penetration of washing machines in households is constant to slightly growing, and lies at about 90% on average. The market penetration of washer-dryers is around 4%.
- The volume of produced household washing machines in the EU28 has declined from 27.7 million units in 2007 to 20.5 million units in 2013. The total value of produced household washing machines in the EU28 has declined from 6.4 billion Euros in 2007 to 4.5 billion Euros in 2013. Thus, the production value has decreased slightly more than the production volume.
- Germany, UK and France are the largest importing countries of household clothes washing and drying machines, followed by Italy, Netherlands, Sweden, Spain and Belgium. Slovakia, Poland and France have the largest number of exports from their country to other EU Member States. The trade data suggest that for nearly all Member States, the Intra-EU trade is greater than the Extra-EU trade. Sales of top-loading washing machines ≤ 6 kg is rather small compared to the front-loading machines. Exports to extra-EU countries are small.
- The average specific energy consumption of washing machine has been halved from 0.245 kWh/kg in 1997 to 0.120 kWh/kg in 2013. The average energy consumption per cycle (standard cotton cycles at 40 and 60 °C with full and half loads) of washing machine is 0.83 kWh. Most of the washing machine models have energy consumption comprised between 0.86 to 0.90 kWh per cycle.
- Washer-dryers show slightly higher average energy consumption values than washing machines resulting in an average of 1.16 kWh per wash cycle in 2013 (based on a 60 °C cotton cycle full load).Considering the 'wash and dry' cycle (washing and drying of the whole load) the absolute energy consumption has increased by 0.5 kWh per cycle between 1997 and 2013 due to an increase of the capacity of the machines offered. However, the specific energy consumption of 'wash and dry' (the division of total energy consumption by the capacity of 'washing') shows continuously declining values. From 1997 to 2013 the specific energy consumption 'wash and dry' decreased from 1.02 kWh/kg to 0.74 kWh/kg in 2013. Also the specific energy consumption of a 'wash cycle' only shows a constant declining trend and lies on average at 0.20 kWh per kg load.
- The most common capacity class of the 7745 registered washing machine models in the CECED database in 2013 was 7 kg (31%). Within these 7 kg washing machine models, the distribution of energy efficiency classes is 48.7% A+++, 24.7% energy efficiency A++, 23.4% energy efficiency class A+, and 3.2% with energy efficiency B. Various stakeholders are concerned about the trend of larger capacity machines that are more efficient only at nominal full load conditions. Even if these larger machines wash more efficiently per kg, they fear that more partially load washing cycles will occur and no saving would be actually achieved under these conditions.
- The average washing and drying capacities of washer-dryer show an increase of approximately 2.5 kg between 1997 and 2013. A visible growth started in the year 2003. The average washing load capacity reached 7.4 kg (2013) and the average of drying load capacity reached 4.91 kg. The energy efficiency classes of washer-dryer models available on the market from 1997 to 2013 shows the distribution of Energy Efficiency Classes has been shifted dramatically towards higher efficiency classes. In 2013 about 50% of washer-dryers were labelled with class A and the majority of the rest was labelled as B., according to the Commission Directive 96/60/EC (and not the Commission Delegated Regulation (EU) No 1061/2010). Nearly 100 % of all washer-dryer models reach a washing performance classes A.

• The development of the spin drying efficiency of washing machines in comparison to washing performance is less obvious over the years. In 2013, around 56% of models registered in the CECED database were in class B, 18.5% in class A and 20% in class C. Other drying performance classes have a very low share (around 5 percent). These results illustrate a steady increase of the average spinning speed from 828 rpm in 1997 to 1219 rpm in 2010. For washer-dryers, a more or less continuous increase of the average maximum spin speed can be seen from 1102 rpm (1997) per wash cycle to 1396 rpm (2013)

- The average water consumption of washing machine models per cycle significantly declined since 1997, but remained almost constant between 2011 and 2013. While in 1997 water consumption of the majority of machines was 66.8 litres per cycle, in 2013 this value was 45.1 litres per cycle. The average water consumption per kg rated capacity for the years 1997 and 2013 was 13.9 l/kg and 6.5 l/kg respectively.
- The distribution of water consumption per cycle for washer-dryers in 2013 is mainly between 39 and 51 litres. The average is 45 litres. The specific water consumption per kg of load is between 5.5 and 8 litres with an average of 6.5 l/kg. The average total water consumption for washing and drying of washer-dryer models has declined from 129.7 litres down to 98.1 litres. This is an improvement of 24% between 1997 and 2013. The average specific water consumption rated to the capacity of the models has actually halved from 26.8 l/kg down to 13.4 l/kg over this period. This is fostered by the combination of lower absolute values and increasing capacities.
- Reducing water temperatures in the wash phase of a washing programme and increasing the overall cycle durations are the dominant trends for achieving energy savings of washing programmes, and in particular for the so called 'standard programmes'. The 'standard' programmes are often designed to use as little energy at the minimum requested washing performance as possible, in order to be able to declare a high energy efficiency class on the Energy Label. The real-life energy and water consumption of a washing machine depends on how much consumers use the 'standard cotton programmes' of their machines. If they don't use them the water and energy consumption can be higher.
- Powder detergents are the most used (34% of the market by volume), followed by liquid detergents (19%). Detergent tablets make up a relatively small proportion of the market in comparison (4% by volume) with other detergents accounting for 4% of the total market for laundry care products. Other laundry care products include fabric conditioner (31% of the market by volume), stain removers and other additives (6%) and fabric fresheners (2%). The trend in the laundry detergent market in Europe is a shift towards concentrated liquid (including gel) detergents both in liquid and tablet form. However, this trend is highly sensitive to price.
- The purchase price of a household washing machine in the EU is relatively constant, and lies at about 450 € (in 2010 prices, including VAT). Based on the provided data by German Gesellschaft für Konsumforschung (GFK), the washing machines price per unit has declined gradually but only slightly from 462 Euro in 2004 to 434 Euro in 2012. The cost increase estimated by the introduction of the Energy labelling requirements in 2010 was estimated to be 100 € at most, but it was also assumed that this would be reduced gradually and level out after 4-5 years.

Discussion point 2.1

a) Is the market information presented accurate? Which of the sources provided is considered to be more representative and which less?

b) Do you agree with the indication that, on average, 90% of families in the EU own a washing machines and that 4% own a washer-dryer? What is the percentage of families that own both appliances? Which are the trends for the next years?

c) The Prodcom code 27511300 includes "Clothes washing and drying machines, of the household type".

- Based on your experience, are washer-dryers included in such statistics?

- Could you provide any practical approaches for estimating roughly the quota of market allocated to washing machines, washer-dryers and drying machines?

d) Official trade statistics of Eurostat are based on CN codes (e.g. CN 84501110), that include fully-automatic household or laundry-type machines and differentiate based on the top/front loading mode and on the capacity of the machines.

- Based on your experience, are washer-dryers included in such statistics?

- Could you provide any practical approaches for estimating roughly the quota of import/export allocated to washing machines, and washer-dryers?

e) Do you have detailed information to provide about the distribution of products on the market in terms of noise emission levels? Is there any significant variance among products on the market? Are there any significant differences between washing machines and washer-dryers?

f) There is an apparent trend towards the increase of the spin speed. Which is the maximum level that could be reached and what is the variance in terms of spin drying efficiency among products on the market? Are there any significant differences between washing machines and washer-dryers?

h) In the course of the written stakeholder consultation, it was pointed out that some wrong declarations occur for washer-dryers (washer-dryers would be labelled as washing machines). Would you agree with this statement or could you describe how washer-dryers are labelled in practice, and where/how wrong declarations may take place?

2.4.2. Use of market data for the definition of base cases: washing machines

Following the MEErP methodology, the definition and further environmental-economic assessment of base cases and design options are needed for the definition of ecodesign/labelling requirements.

Base cases must be representative in terms of market share and implemented technology. The selection of bases cases is discussed in Chapter **Error! Reference source not found.**, also based on the market data resented in the chapter above.

The base cases will be discussed with stakeholders trying to reflect, as far as possible, recent market and socio-demographic changes, user behaviour, technology development and standardisation issues (e.g. observed evolution of the average size of households in the EU countries; supply of appliances with higher average capacity also as market response to the method for the EEI calculation for the energy labelling).

In the former preparatory study Lot 14 of 2007, two Bases Cases (none is available for washer-dryers) were chosen for household washing machines:

- 5 kg front-loading machine, energy efficiency class A
- 6 kg front-loading machine, energy efficiency class A+/A

The newer market data indicates that the average appliance capacity has increased since 2007, and over 30% of the machines are of 7 kg or more, representing the highest share of models, followed by 8 and 6 kg machines (each approximately 23-24%). Large (9 kg) and small (5 kg) machines each have a share of 7-8% of all models available in the market in 2013 (cf. Figure 2-14). Please, note that the market shares provided are calculated based on the number of models on the market and not on the relative sales volumes.

Also, the majority of appliances are front-loading machines whereas top-loaders have rather low market volume. The spread of energy efficiency classes with regard to the according capacities is shown in Figure 2-19.

Regarding the formulation of new base Cases, two different strategies might be possible for washing machines:

- Taking the most common capacity as most representative base case for the spread of capacities, i.e. only one washing machine base case:

  - 7 kg front-loading machine, energy efficiency class A++/A+++
- Representing the market spread also within the Base Cases to analyse differences and impacts of smaller and larger appliances, i.e. two washing machine base cases:
  - 5 kg front-loading machine, energy efficiency class A+
  - 7 or 8 kg front-loading machine, energy efficiency class A+++

The definition of base cases is further discussed in Chapter 4, which provides further details on improvement design options.

Discussion point 2.2

a) Is the market data for washing machines presented accurate? This information will be used for the selection of base case(s).

2.4.3. Use of market data for the definition of base cases: washer-dryers

This revision study will assess the feasibility of including washer-dryers into the scope of the regulations.

Market data shows that also for washer-dryers, the market shifts towards larger washing capacities (7 kg models had the highest market share in terms of number of models - NOT market share by sales volume - in 2013, with around 35%), followed by 6 and 8 kg models (each around 20%), and 9 kg models (15%). In 2013, nearly no 5 kg washer-dryer models were provided any more (cf. Figure 2-35). The share of energy efficiency classes is shown in Figure 2-44.

For washer-dryers, it would thus make sense to propose a washer-dryer base case of a washing capacity of 7 or 8 kg, and a drying capacity of 4 to 5 kg, and energy efficiency class A.

As for washing machines, the definition of base cases is further discussed in sections 4.1.2 and 4.1.3, which provides further details on improvement design options.

Discussion point 2.3

a) Is the market data for washing machines presented accurate? This information will be used for the selection of base case(s).

2.4.4. Niche markets

In the current ecodesign and energy label Regulations, 'household washing machines that can also be powered by batteries' are included in the scope. The market data collected, however, reveals that these kinds of appliances do not have any market relevance. No battery-operated household washing machines or washer-dryers could be detected.

Further, the current test standards do not explicitly describe a test procedure for battery powered appliances. Thus, if being included, specifications and test procedures would have to be developed and included in the performance standard for household washing machines and washer-dryers.

Also for the coming years it is expected that battery powered household washing machines or washer-dryers will not enter into the market. Theoretically, battery powered household appliances might work as capacity storage in a smart-grid network; however, it is assumed that such a power storage would rather be realised as a central storage system for the whole household with the single appliances still being electric-mains operated.

Subject to further discussion with stakeholders, these market data support the proposal made in the scope section (Chapter 1) to exclude battery-powered household washing machines and washer-dryers.

Additionally, stakeholders have proposed to exclude the following niche products or special purpose equipment from the scope (see Section 1.1.2):

- Micro-washing machines, i.e. washing machines with a capacity of 1 kg or less, as the test standard is suitable only for 1 kg and above.
- Water heated washing machines and washer-dryers, i.e. appliances with no own heating element that use external sources of water for heating and cooling the process water (not to be confused with appliances with hot/cold fill), cf. also section 4,, as no test method independent from the water heating/cooling system is available (according to stakeholder information, this product was available on the market before 2010, and then was phased out from the current Ecodesign regulation because it could not reach A class washing performance).
- Waterless washing machines (which are excluded by the current definition) as they have a different technology and not foreseen for laymen usage.

On the other hand, stakeholders have proposed to include explicitly (in principle they are not excluded) the following niche products or special purpose equipment in the scope:

- Alternative heated appliances (e.g. if heat sources are available in the household)
- Smart-grid ready appliances as upcoming technology where only the time of the energy consumption will be adjusted, i.e. which have no direct energy savings (see section 4). As reason for inclusion into the scope, one stakeholder argues that they will shortly stop being a niche market and any washing machine might/will have this function. Further, he proposes that the energy efficiency of the wireless LAN modules of these appliances should be evaluated / rated separately for instance in relation to networked standby.

Discussion point 2.4

a) Would you agree to exclude battery-powered appliances from the scope because of low market presence? A standard to measure the performance of these appliances is at the moment not available.

b) Should micro-washing machines (washing machines with a capacity of 1 kg or less) be explicitly excluded from the scope (the test standard is suitable only for 1 kg and above)? What is their market relevance?

c) Should water heated washing machines and washer-dryers (appliances with no own heating element that use external sources of water for heating and cooling the process water) be excluded from the scope? What is their market relevance?

d) Should waterless washing machines continue to be excluded by the current definition (they have a different technology and not foreseen for laymen usage)? What is their market relevance?

e) Should alternative heated appliances included/excluded as potential new technologies? What is their market relevance?

f) Should smart-grid ready appliances be explicitly included (as upcoming technology)? What is their market relevance?

g) Should the same approach be followed for both washing machines and washer-dryers or would any differences apply?

3. Task 3: Users

The Ecodesign and Energy Label Regulations as well as their underlying test and measurement standards are based on certain assumptions on user behaviour. This includes among others elements related to the choice of programmes and temperatures, appliance capacity, annual number of cycles, detergents.

There are some indications suggesting that the finally achieved savings based on real-life user behaviour deviate from an estimation of savings based on the assumed used of energy-saving programmes.

The objective of this chapter is to report and analyse information on the consumption of resources and on any other relevant environmental impacts. In particular, to gain more reliable and up-to-date information, two online user surveys have been designed in the context of this study, one for washing machines and another one for washer-dryers. The surveys will be undertaken in the course of the project and the results analysed and presented in this report. The two main resources consumed during the use of these products are water and energy. Water and energy consumption is influenced by several factors, including: product technology used, user behaviour patterns, and technical systems in which the product is used.

Products must indeed be seen as part of a system. The consideration of system aspects is important for determining "indirect" burdens associated to the use of products. In the present context, the product system is considered to include:

- Textiles and their production and usage
- Detergent and its usage
- Laundry sorting, washing, drying and ironing.

This section in particular focuses on user behaviour and system aspects while product technologies are described and analysed more deeply in Chapter 4.

3.1. System aspects use phase

3.1.1. Consumer behaviour with regard to use phase

This section, still under development, aims to address user behaviour aspects as:

- Frequency of operations and loading practices
- Selection of washing and drying programmes, in particular with respect to the choice of energy saving programmes and washing temperatures and the duration of the washing cycle,
- Selection of detergents and hygiene issues
- Availability and understanding of information reported on appliances and user manuals.

In this respect, results of consumer behaviour studies which have been carried out by Bonn University, the International Association for Soaps, Detergents and Maintenance Products (AISE) and other sources are presented in the following sections. The aim of section is to understand user behaviour as well as guide standardisation and revision of Ecodesign and Energy Label requirements for household washing machines and washer-dryers.

Please note:

Washing habits in Europe have been studied extensively by different organisations through the use of questionnaires asking thousands of consumers about their washing behaviour and attitude. Nevertheless, all these *surveys are based on the information the interviewee was willing and able to provide and on the seriousness the answers were given. Also the formulation of questions and answers can influence the results. Therefore interpretation of the results of any analysis on consumer behaviour should be handled with care.*

3.1.1.1. Washing machines

Consumer surveys carried out by the University of Bonn

In 2011 over 2000 European households of 10 European countries (Czech Republic, Finland, France, Germany, Hungary, Italy, Poland, Spain, Sweden, the UK) were interviewed by the University of Bonn about their washing and drying behaviour and their opinion about energy issues in general. Questions handled in the user survey cover initially

- Type and sources of information supporting purchase decisions;
- Purchase criteria.

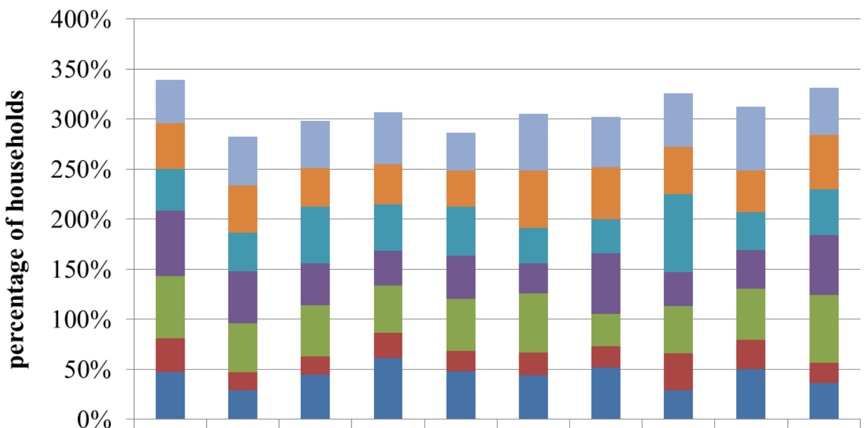
As washing machines are appliances which are operated on consumer demand only, the consumption of resources in the use phase is determined by the following factors:

- Frequency of operations;
- Load size used;
- Amount and type of detergent used;
- Availability and selection of programme and options/features, including the programme temperature, under real conditions of use.

A selection of the most significant results in relation to these factors is presented in the following.

<u>Type and sources of information supporting purchase decisions</u>

When the consumers were asked about the sources of information they would consult before buying a new appliance (multiple answers were allowed), the main source of information mentioned by them was visiting internet websites of manufacturers (52 %) (Figure 3-1). The second main source of information is own experience (50%). Information on the Energy Label is important for influencing the buying decision for about 50 % of the participants to the survey. Information on the Energy Label, advice and experience of friends and test reports from consumer organizations are of approximately similar importance. Interestingly, consumers seemed to pay less attention to product brochures, Energy Labels and sales representatives.



	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
Own experience	43%	49%	47%	52%	38%	57%	50%	54%	63%	47%
Advice and experience of friends	46%	47%	38%	40%	37%	57%	52%	47%	42%	54%
Information on the energy label	42%	39%	57%	47%	49%	36%	33%	78%	38%	46%
Test reports from consumer organisations	66%	52%	42%	34%	43%	30%	61%	34%	39%	60%
Manufacturers' internet sites	62%	49%	51%	47%	52%	59%	32%	47%	51%	68%
Manufacturers' brochures	34%	18%	18%	25%	21%	23%	21%	37%	29%	20%
Recommendation and advice from a sales representative in a shop	47%	29%	44%	61%	48%	44%	52%	29%	51%	36%

country

Figure 3-1 **Source of information consulted to support a purchase decision for a new household appliance (according to (Schmitz & Stamminger 2014))**

The consumers were also asked to indicate which information they would expect to see on the Energy Label (up to four multiple answers were allowed from the list provided).

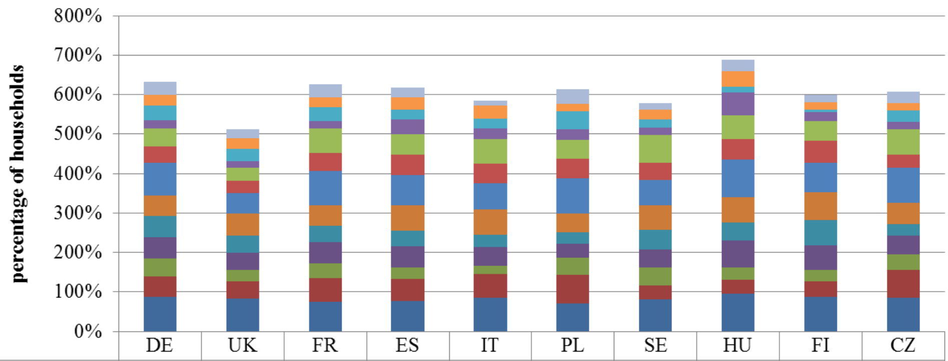
Information on the energy efficiency class (83%) and on the water consumption (78%) were considered very important (Figure 3-2). In addition, more than half of the respondents chose options which are already listed on the Energy Label, such as capacity (59%), noise emission (54%) or cleaning/washing performance (51%). Spin/drying performance (43%) and information on the programme duration (46%) were slightly less frequently answered in 2011.

With respect to the energy consumption, consumers seemed to prefer receiving information on the consumption per cycle (52%) rather than on the annual consumption levels (35%).

Other information resulted to be less interesting, as for example:

- Information about all programmes and features of the appliance or indication about the programme and temperature used for the assessment (selected by approximately 26% of the consumers).
- Financial aspects, such as yearly running costs or running cost per cycle (selected by about 26% of the respondents.

Significant differences between countries can be moreover observed (Figure 3-2).



	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
Yearly running costs	34%	23%	34%	25%	11%	37%	16%	30%	19%	29%
Programme and temperature used for the assessment	27%	28%	24%	31%	33%	18%	26%	40%	18%	18%
Running costs per cycle	37%	32%	34%	25%	26%	45%	19%	13%	7%	29%
Detailed information on all the programmes	22%	17%	20%	36%	27%	27%	20%	59%	22%	19%
Noise emission	45%	31%	62%	52%	61%	50%	69%	60%	49%	64%
Programme duration	42%	32%	46%	52%	50%	50%	43%	52%	57%	34%
Water consumption	84%	51%	86%	78%	67%	88%	64%	95%	75%	88%
Capacity	52%	57%	52%	64%	63%	49%	64%	64%	70%	54%
Spin/drying performance	53%	44%	42%	39%	31%	28%	48%	46%	64%	29%
Cleaning/washing performance	55%	43%	53%	55%	47%	36%	47%	68%	63%	48%
Energy consumption per year	45%	29%	37%	29%	21%	43%	45%	31%	28%	38%
Energy consumption per cycle/day	52%	44%	59%	56%	60%	73%	33%	36%	40%	71%
Energy efficiency class	88%	82%	76%	77%	86%	70%	82%	95%	87%	86%

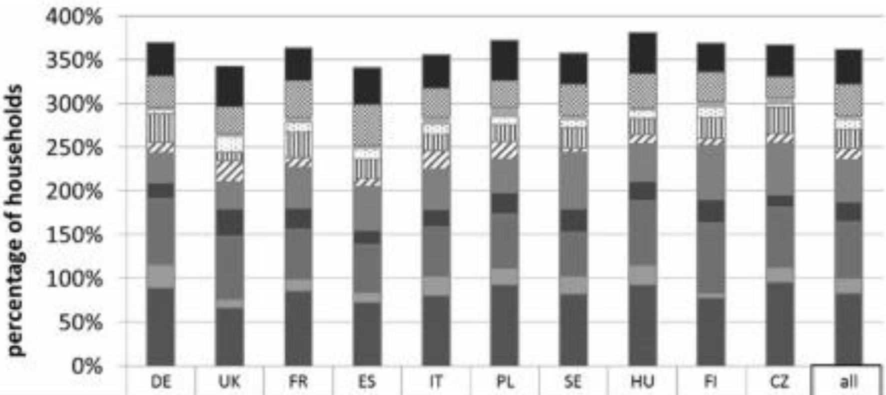
country

Figure 3-2 **Information expected on the Energy Label (multiple answers allowed) (according to (Schmitz & Stamminger 2014))**

Purchase criteria

A very low water and energy consumption is the most important aspect for the consumers when they plan to buy a new appliance (84%) (Figure 3-3). A very good washing performance also has a high priority for over 60 % of those respondents. Nearly half of all participants to the survey indicated that they pay attention to a low operating noise emission of the appliance. Accordingly, a lot of consumers not only look at the low purchase price of the machine (40%) but also at the good assessment results on the Energy Label (35%). Almost one quarter of the consumers indicated that they pay attention to a good textile protection and short programme duration as well.

The other criteria analysed though the survey, such as low detergent consumption or a large number of different (washing) programmes and (appliance) options, were only mentioned by 13 and 16% of the consumers, respectively. The attributes with the least importance were a higher capacity of the appliance (11%) and an innovative aesthetic design (5%). The answers of consumers from different countries are also considerably different.



	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ	all
Low purchase price	38%	47%	38%	43%	39%	47%	36%	47%	33%	37%	40%
Good assessment results on the energy label	35%	29%	41%	46%	33%	30%	36%	39%	33%	24%	35%
Innovative aesthetic design	1%	4%	6%	3%	7%	10%	4%	3%	5%	6%	5%
Higher capacity of the appliance	7%	18%	11%	13%	13%	10%	9%	9%	14%	5%	11%
Good dishes-/ textile protection	32%	10%	30%	22%	18%	19%	23%	18%	23%	29%	23%
A large number of different (washing) programmes and (appliance) options	13%	24%	11%	9%	21%	20%	6%	11%	8%	12%	13%
Low operating noise emission	34%	31%	46%	50%	47%	38%	64%	43%	62%	59%	48%
Short programme duration	18%	32%	25%	16%	20%	24%	27%	23%	27%	15%	23%
Very good cleaning /washing performance	75%	72%	56%	55%	56%	62%	50%	74%	80%	69%	65%
Low detergent consumption	26%	10%	13%	12%	22%	18%	20%	22%	5%	17%	16%
Low water and/ or energy consumption	89%	67%	86%	72%	81%	93%	83%	93%	78%	95%	84%

Figure 3-3 **Attributes with high importance for the consumer when buying a new household appliance (Schmitz & Stamminger 2014)**

Frequency of operation

According to the results of the studies being carried out by University of Bonn in 2006 and in 2011, the average number of washing cycles in Europe has decreased from 4.0 to 3.8 cycles per week, which corresponds to an annual average of 198 wash cycles per household (n= 2,290 households). This means that an assumption of 220 cycles per year (being the basis for the Energy Efficiency Index calculations for Ecodesign and Energy Label Regulations) could overestimate the annual energy consumption. Therefore, 200 cycles per year could be a better estimation.

Trends towards lower frequency of use of washing machines are supported also by other studies, despite of the methodological differences in terms of data gathering:

- An historic analysis by Kemna and Stamminger (Kemna & Stamminger 2003) reports that until the early 1980s, there were around 277 wash cycles per machine per year and this frequency decreased to around 234 in 2005 (4.5 cycles per week).
- The International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) survey (A.I.S.E. 2011c), (see next section) indicates that the average weekly wash frequency in 2011 could be around 3.5 cycles per household per week, which corresponds to an annual average of 182 wash cycles per household.
- '…Data from the Water Energy Calculator reports that households use the washing machine on average 4.7 times each week, lower than previously used data (5.5 times per week)…' (Energy Saving Trust 2013).

The reason for a continuous reduction of wash cycles per year per machine is most likely related to a combination of demographic factors (the average household size has decreased during that period) and machine characteristics (the average capacity of a new washing machine has increased, from about 4.8 kg in 1997 to

7.04 kg in 2013). This trend has started around 2002 and is continuing, and is expected to lead to further reduction in the wash frequency.

In the following the average number of washes per household for each country is shown (Figure 3-4). As it can be seen, in 2011 the average number of wash cycle per week ranged from 3.5 (France, Czech Republic and Sweden) to 4.1 (Italy, Poland and the UK).

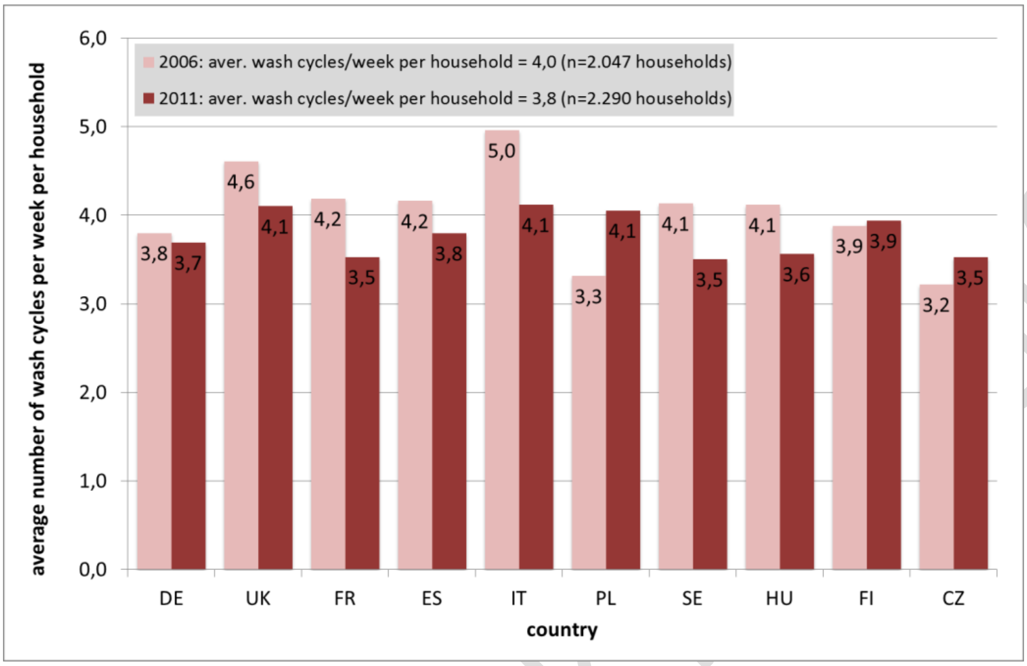


Figure 3-4 **Average number of wash cycles per week per household per country in 2011 compared with a similar study done in 2006 (according to (Schmitz & Stamminger 2014))**

As the household size may be different from country to country, it may be more relevant to compare the number of wash cycles per week per person living in a household. This calculation shows that this number lies between 1.2 (Czech Republic, Hungary and Spain) and 1.5 (Finland, Sweden and the UK) (Figure 3-5). The average of wash cycles per person per week is 1.3 for the year 2011 (n=2,290 households). An average decrease of 0.2 wash cycles per person per week is registered if these results are compared with those of a similar study which was carried out within Lot 14 in 2006 (ENEA/ISIS 2007a).

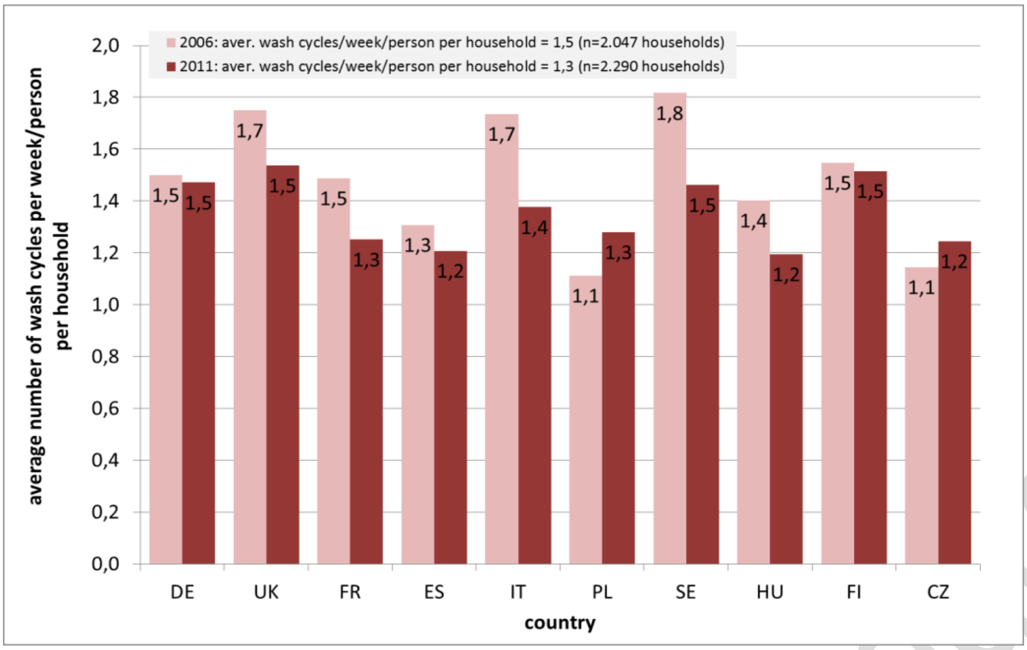


Figure 3-5 **Average number of wash cycles per person per household (according to (Schmitz & Stamminger 2014))**

<u>Selected programme temperature and cold washes</u>

Figure 3-6 shows a clear preference, for almost 2,290 consumers from 10 countries, of washing at 40 °C.

On average, around 40% of washes are done at 40°C (Figure 3-6). However, the washing temperatures are quite variable in different countries. For instance, in Spain almost 40% of the washes are done at cold temperatures . In other countries more than 50% of the washes are done at 40 °C (especially in Sweden and Finland) (Figure 3-6). Also, in the United Kingdom and France the share of wash temperatures of 30 °C reached nearly 35% of all wash cycles (Figure 3-6). For the United Kingdom there was an increase of 19% for the 30 °C programme in comparison with the results of Lot 14 in 2006 (ENEA/ISIS 2007a).

The second most used temperature is 60 °C. On average, around 19% of washes are done at 60 °C. 5% of the washes are instead done at 90 °C programme.

The average of these nominal washing temperatures is 43.3 °C (Figure 3-7). In comparison to the results for the year 2006 (ENEA/ISIS 2007a) the average washing temperature decreased about 1.6 °C. The reason of this reduction is related to more frequent use of colder temperatures (like 30 °C). and the decrease (2-3%) of the use of 60 °C and 90 °C programmes.

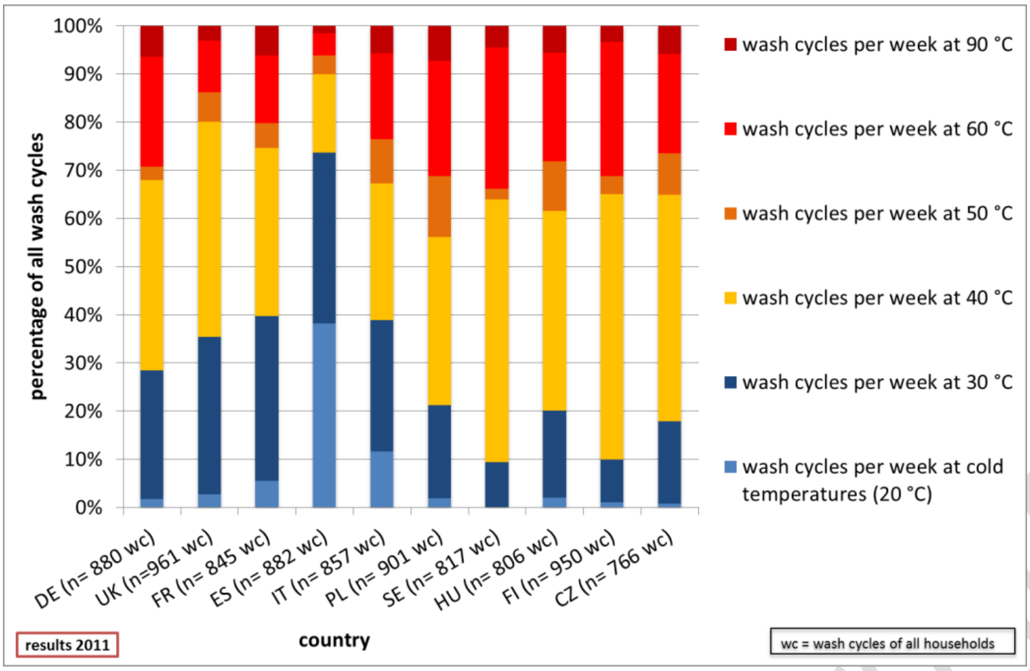


Figure 3-6 **Relative frequency of wash temperatures used 2011 (according to (Schmitz & Stamminger 2014))**

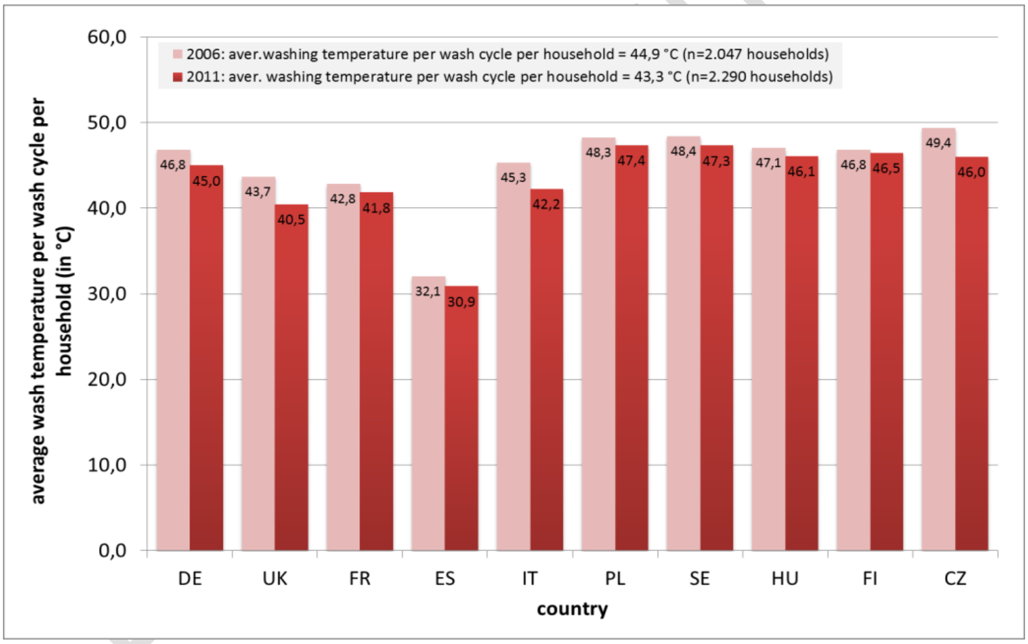


Figure 3-7 **Average wash temperature per country for year 2006 and 2011 using the nominal temperature values of 20 °C, 30 °C, 40 °C, 50 °C, 60 °C and 90°C for calculating the average (according to (Schmitz & Stamminger 2014))**

Low temperature washing

Already in 2011 several machines offered a 20 °C cycle (Josephy et al. 2011). In the meantime, some manufacturers have even gone a step further and for their latest generation of appliances created a 15°C cycle. Thus, even less heating energy is needed. No matter if 20°C or 15°C, these cycles are specifically designed for 'cold wash' and may include correspondingly optimized mechanics and extended washing time to achieve good washing results.

The high energy saving potentials of 'cold wash' has been recognised also by the EU through the EU Ecodesign Regulation, which states that from December 2013 a 20 °C wash cycle is mandatory for all washing machines put on the EU market (European Commission 2010).

Stakeholders informed that in July 2013 the Energy Savings Trust in the UK published the report "At home with water", which contains an analysis of information on water use reported by more than 86,000 households in UK (Energy Saving Trust 2013). The responses showed that '…households are using their washing machines at lower temperatures. The vast majority (95%) say that they wash clothes at 30°C or 40°C, showing that a shift to cooler temperatures is happening. But there is potential for further savings: only 24% opt for programmes that wash at 30°C or below'

In 2010, Defra, DECC and the Energy Saving Trust launched a study on the electricity use of English households. The Household Electricity Use Study analysed 251 households across England from 2010 to 2011. 26 of these homes were monitored for a whole year. The rest of the homes (225) were monitored for one month on a rolling basis throughout the trial. The outcome was consolidated in the report "Powering the Nation-Household electricity-using habits revealed" (Owen 2012). According to the report:

'…From the householders' diary entries it was found that around half of all washes were performed at 40 ˚C; just over a quarter (26%) was washed at 30˚C; another 15% were done at 50/60 ˚C and only two per cent at 90 ˚C. Nearly two thirds of washes (64 per cent) were claimed to have been 'full washes', with 16 per cent at half load. There were instances of single garments being washed, but these were relatively rare occurrences. The big surprise in this area is the difference in the various households' washing habits and frequency of cycles. The single-person household (non-pensioner) had a higher number of cycles and average annual energy consumption than the 'household with children' category (300 versus 284 respectively). The household type 'multiple with no dependents' is by far the highest group for laundry activities. This could be because households made up of house-sharers may not combine washing in the same way a family unit would.'

Programme options

Referring to the question 'Which of the following options would you use if doing this would enable you to save energy and/or money?' which was asked in the user survey carried out by Bonn University in 2011, 80% of respondents answered that they would select economy programmes (Table 3.1).

The results for the options accepting longer programme cycles and delaying the starting time of the programme were approximately equal; over 40% of respondents indicated they would choose both options.

Using an external hot water supply was the least popular option: only 26% of the respondents would consider this option whilst almost 30% of them were against this option.

Table 3.1 Usage of possible options to save energy and/or money (according to (Schmitz & Stamminger 2014))

		DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
		% of all hh	*% of all hh*	*% of all hh*	*% of all hh*	*% of all hh*	*% of all hh*	*% of all hh*	*% of all hh*	*% of all hh*	*% of all hh*
Using an external hot water supply	y	23	35	19	22	35	31	23	33	27	14
	p	44	43	44	41	38	45	47	34	48	38
	n	34	22	37	36	27	25	30	34	26	48
Accepting longer programme cycles	y	49	44	46	34	45	28	58	34	51	52
	p	36	41	33	48	38	39	30	45	38	38
	n	15	15	21	19	17	32	13	22	12	11
Delaying the starting time of the programme	y	42	49	59	37	55	22	46	51	35	45
	p	38	37	29	45	26	44	38	38	46	39
	n	20	14	11	18	19	34	16	11	18	17
Using economy programmes	y	84	79	86	82	58	85	82	91	71	81
	p	14	21	12	16	28	14	17	8	27	19
	n	2	0	2	2	14	1	2	1	2	0

Some of the previous findings are supported by the results of the washing programmes and options/features chosen. The research by Bonn University (Figure 3-8) shows the average use of washing programmes by respondents. The washing programme chosen showed a clear dominance of the "cotton-type" programmes (cotton/linen and mixed, i.e. a mixture between cotton other types of textiles): more than 50 % of the consumers mentioned these programmes to be used always or often.

Programmes for easy-care, delicate or synthetic laundry appeared to be used more rarely, and programmes for washing silk and wool articles even more seldom.

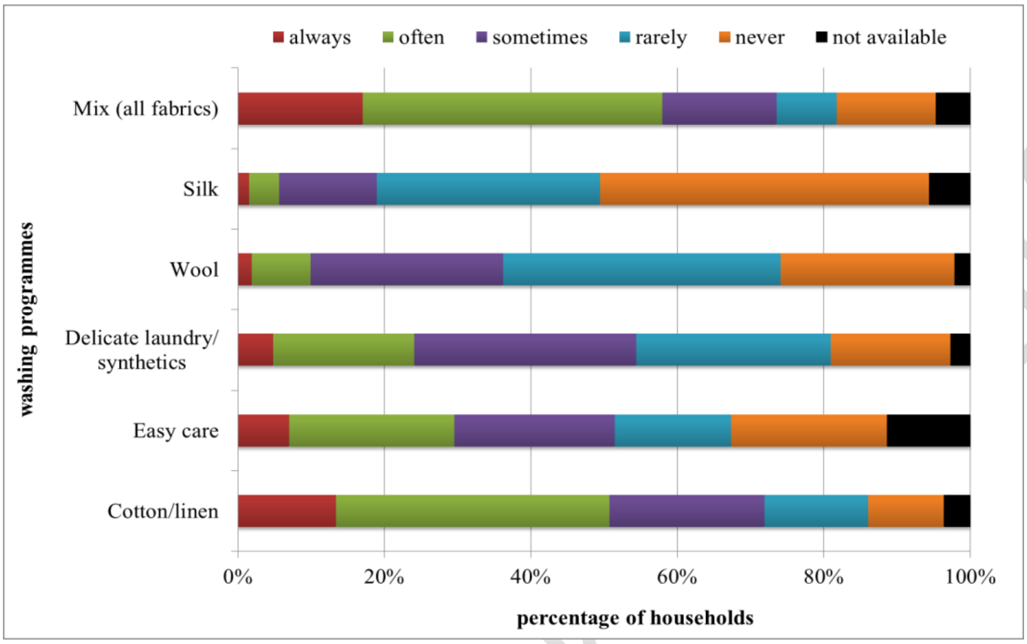


Figure 3-8 Average use of washing programmes (according to (Schmitz & Stamminger 2014))

As there are other programme options available on washing machines, actual water and/or energy consumption levels may be affected by the selection of these options. The results of the question about possible ways for saving energy and money are given below. Energy saving/eco wash was found to be the most frequently used option or programme, followed by quick wash/time-saving wash and soft wash (Figure 3-9). In particular, it should be noted that the quick wash/time-saving programme is often demanding for more energy, although this depends on the specific appliance. Programme options which consume more energy (stain wash/intensive wash) or water (extra rinse, additional water) is used "always" or "often" only by approximately 11-12% of the respondents.

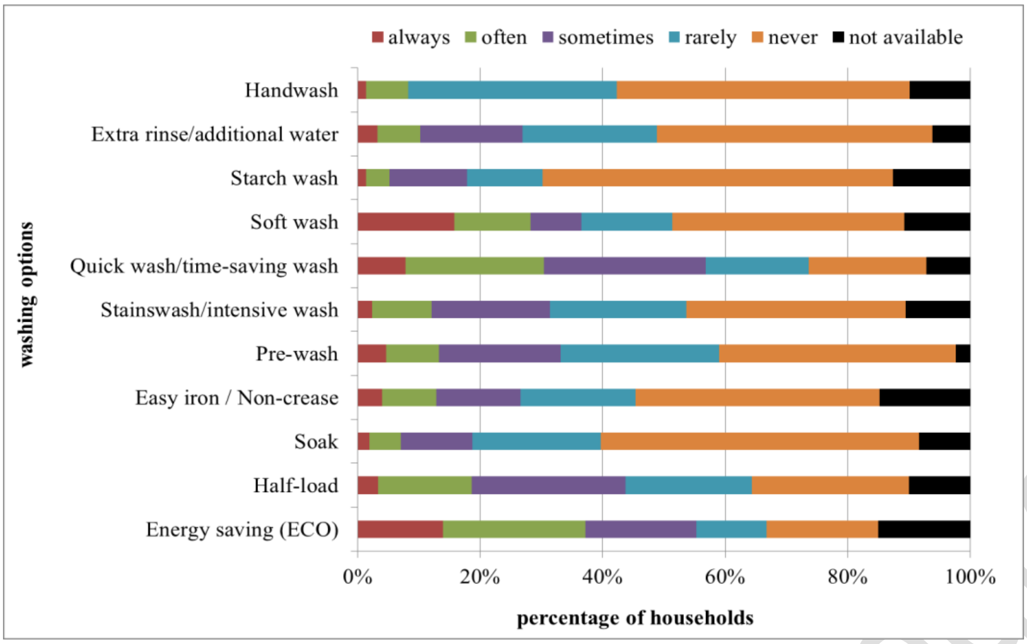


Figure 3-9 **Washing options chosen in 2011 (n=2,290 households) (according to (Schmitz & Stamminger 2014))**

According to the "Omnibus" study (VHK et al. 2014), the UK consumer organization 'Which?' asked 949 people about the kind of washing programme were using and their frequency of use. The data is organised into people using programmes daily, every few days, once a week, etc. The following programmes are used once a month or more (VHK et al. 2014):

- 40 ˚C cotton programme: 52%
- Quick wash programme: 47%
- 40 ˚C synthetic programme: 46%
- 60 ˚C cotton programme and mixed load: 37%

Of these 949 people, 618 said that they had an eco-setting on their washing machine. 46% of this 618 (286) persons said they never used it and another 11% (71) said they use the eco mode once a month or less.

Loading

The information included in the Energy Label of a washing machine is based on a weighted average of full load and partial load cycles. The actual energy and water consumption of the appliance is related to the level of use of the capacity of the washing machine.

Results of the survey carried out by the University of Bonn in 2011 shows that almost 60% of respondents claimed to use the full capacity of their washing machine, although they normally do not have the possibility to check if this is really the case (Figure 3-10). Approximately 10% of the participants in the survey mentioned that the kind of laundry influences the amount of load that they wash. Around 13% of respondents mentioned that they don't usually fill the machine completely. It is important to note also that 10% of respondents admit to overload the machine.

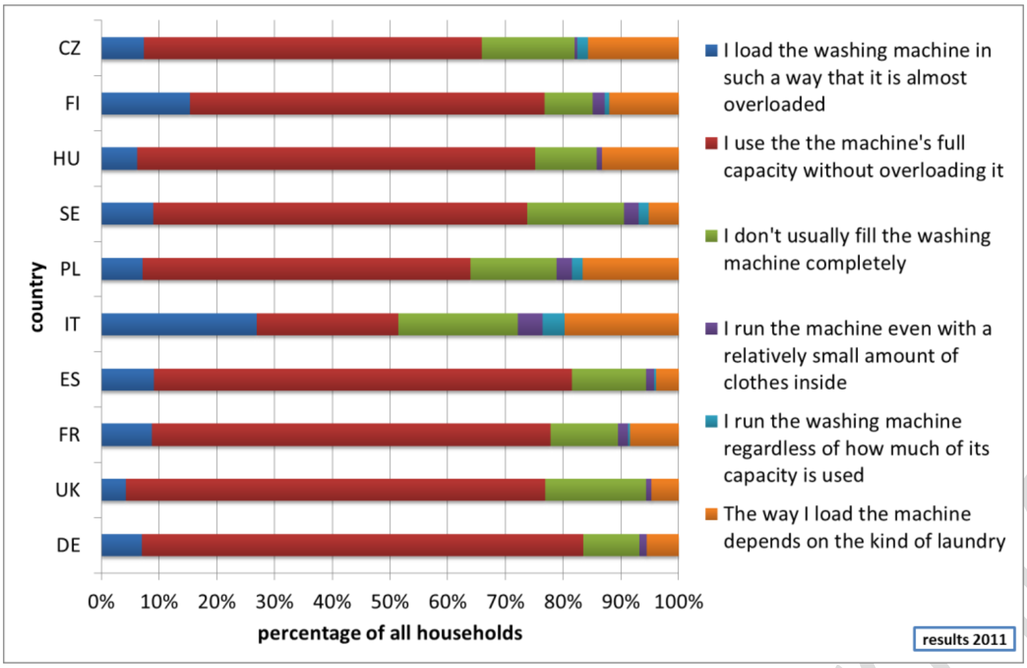


Figure 3-10 **Consumer loading behaviour (according to (Schmitz & Stamminger 2014))**

<u>Spin speed and drying behaviour</u>

The analysis of the responses related to the selection of the spin speed (options allowed in the 2011 survey from the University of Bonn: no spin and from < 400 rpm to > 1300 rpm) shows that a spin speed between 1000–1300 rpm is used in nearly 40% of all spin drying cycles (number of answers = 8033) (Figure 3-11). A spin speed between 600-900 rpm is chosen for over 30% of all spin drying cycles, while only in 14% of the cycles the laundry is dried with a spin speed over 1,300 rpm. On average, European consumers dry their laundries at a spin speed of 941 rpm (taking the average of a spin speed class for the calculation) (Figure 3-12).

The frequency of use of different spin speed classes has huge differences among countries. For instance, while in Italy, Spain, Poland and Hungary over 60% of the spin cycles are at 900 rpm or less, in Germany, Sweden and the UK more than 60% are above 900 rpm (Figure 3-11). Furthermore, it was indicated that "no spin" is applied to much less than 10% of all washes. This suggests that other ways of drying are sometimes used.

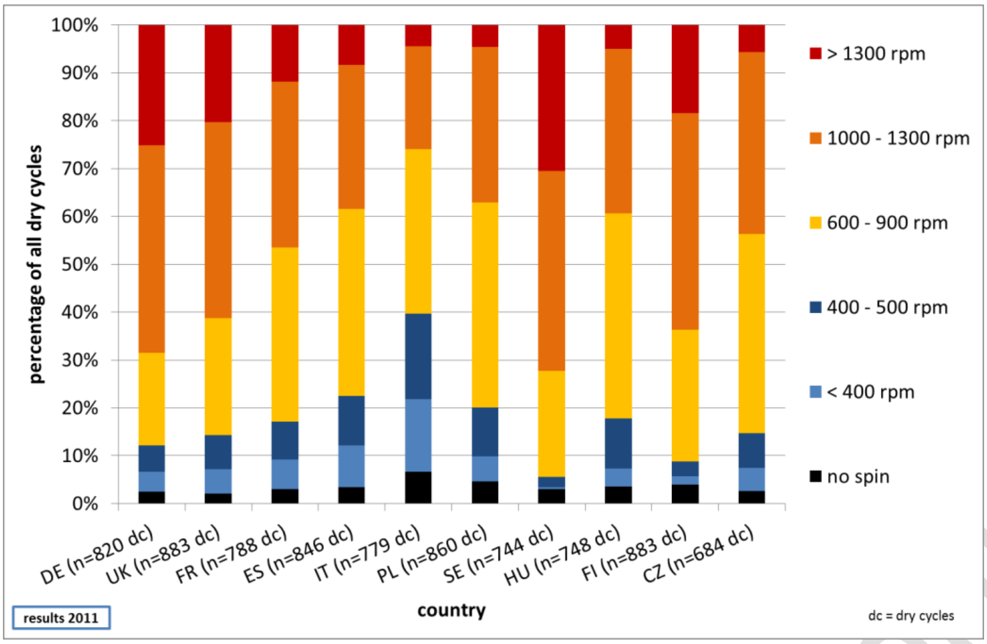


Figure 3-11 **Relative frequency of spin speed classes (according to (Schmitz & Stamminger 2014))**

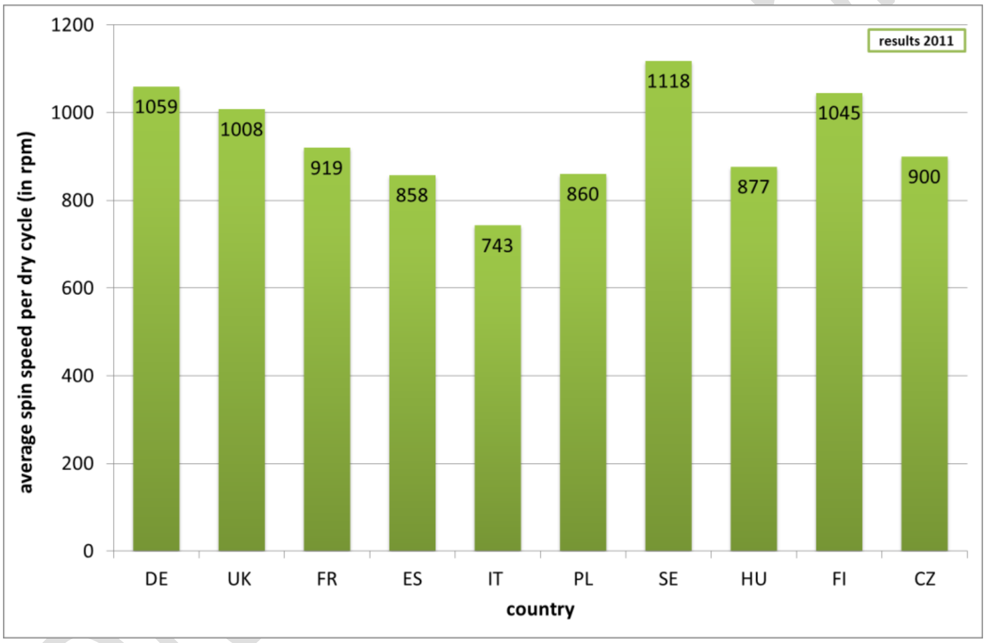


Figure 3-12 **Average spin speed per dry cycle for different European countries (according to (Schmitz & Stamminger 2014))**

There are different ways for drying the laundry. Participants to the 2011 survey from the University of Bonn were asked to indicate how they were drying their textiles in summer and in winter, assuming that the drying behaviour was the same for half of an year. As the answering options were given in terms of 'always', 'often', 'sometimes', 'rarely' and 'never', these choices were transformed into a percentage scale of 100%, 75%, 50%, 25% and 0%, respectively, and normalised to reach 100% for the sum of all answers given by an individual. In other words, this means that if a person indicated same frequency for two options, the same weight would have been assigned for the normalisation.

Large seasonal differences were registered as well as the difference in the drying practice between the analysed countries. According to the responses obtained, on average, 55% of drying in the summer takes place outside, on a clothes line (Figure 3-13). This method of drying decrease in winter to about 40%. In winter time the preferred option seems to be the drying of clothes inside the house, in a heated room (51%).

The differences between seasons and the drying behaviour per country show an apparent correlation with statistics related to the ownership and use of tumble dryers (Table 3.2). The largest use of tumble dryers take place in Germany, Sweden and the UK. The same countries present the highest rates of ownership of this appliance. The results for the UK are comparable with published statistics (Department for Environment 2009).

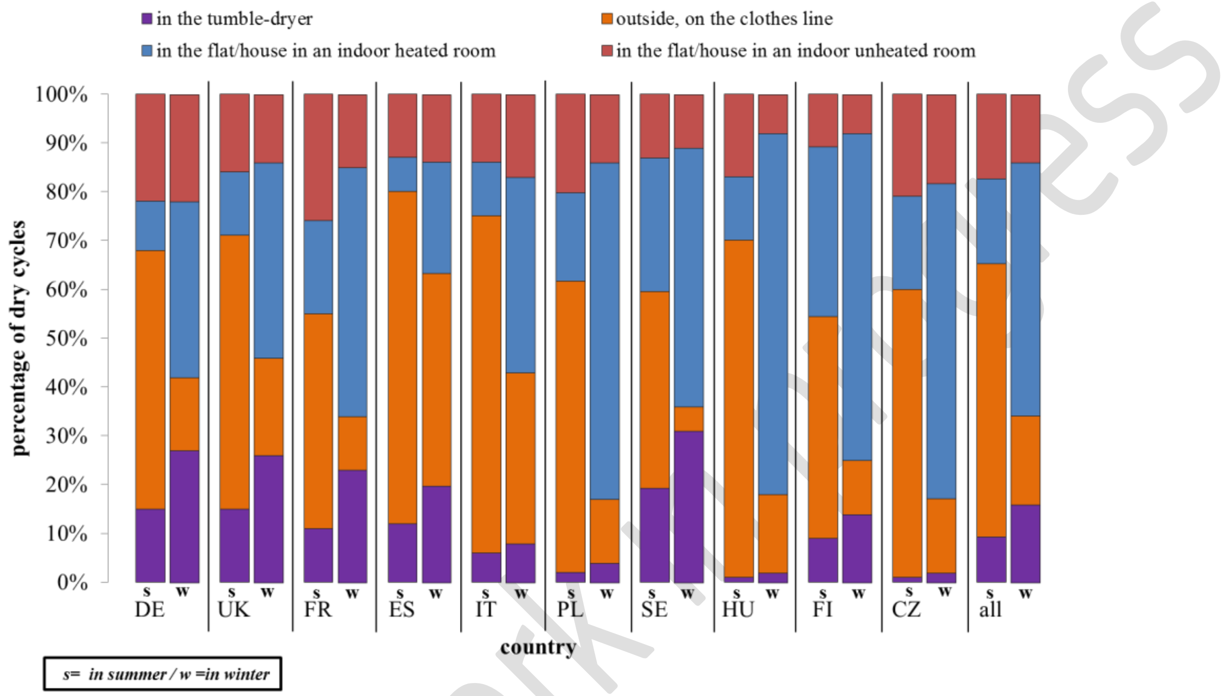


Figure 3-13 **Method of drying the clothes in summer (S) and in winter (W) for different European countries in 2011 (according to (Schmitz & Stamminger 2014))**

Table 3.2 **Equipment with a tumble dryer and the usage in winter and summer per country (according to (Schmitz & Stamminger 2014))**

Question: Which of the following appliances are existent in your household?	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
% of households being equipped with a tumble dryer	47	52	38	33	8	16	52	8	27	3
% of drying cycles of all households per country with using a tumble dryer (in winter)	27	26	23	20	8	4	31	2	14	2
% of drying cycles of all households per country with using a tumble dryer (in summer)	15	15	11	12	6	2	19	1	9	1

Calculated energy consumption

The analysis of the chosen washing temperature and of the number of wash cycles per week result in an average energy consumption of 2.32 kWh per household per week (number of answers =2290) or 120 kWh per year (Figure 3-14).

The lowest energy consumption was calculated for Spanish households, with 74 kWh/year as average. This can be explained by the fact that, among the whole European panel, the lowest average washing temperature was registered for Spain (Figure 3-15). All other countries resulted in an energy consumption of at least 100 kWh/year per household. The maximum values were observed for Poland and Finland (more than 130 kWh/year per household) as a consequence of the high average washing temperature and of the high number of wash cycles per week.

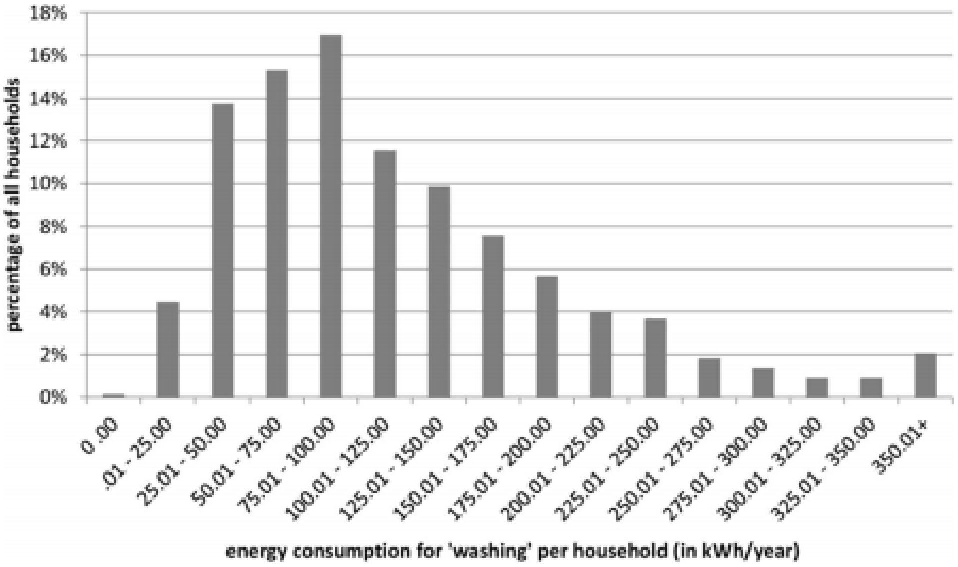


Figure 3-14 **Distribution of energy consumption for 'washing' per household per year (n=2,290 households) (Schmitz & Stamminger 2014)**

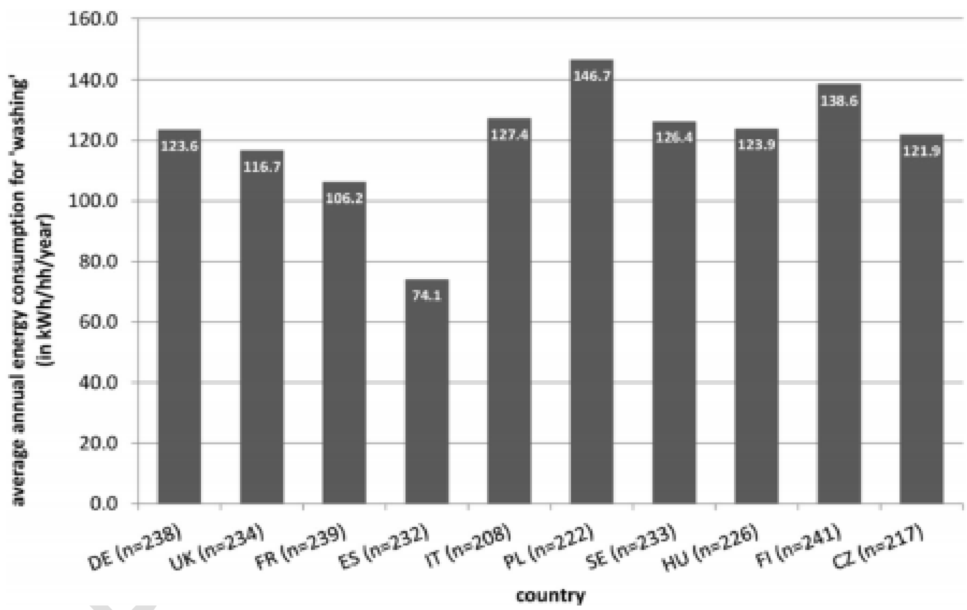


Figure 3-15 **Average annual energy consumption per country for 'washing' in 2011 (Schmitz & Stamminger 2014)**

Type and dosage of detergents

Based on the results of a survey which was carried out by the University of Bonn in 2009 among 334 private households in Germany, corresponding to the collection of information for 2773 wash cycles, it was confirmed that heavy duty detergent with and without bleach were used most frequently.

'Vollwaschmittel' (heavy duty detergent) was used in 50% of the wash cycles and 'Colorwaschmittel' (color detergent) in 43.1%. The use of special detergents was limited (5% for the 'Feinwaschmittel' (light duty detergent) and 1.6% for the 'Wollwaschmittel' (wool detergent)).

Concentrated detergents resulted to be the most frequently used (42.6%) followed by liquid detergents (37.1%). Tabs were indicated to be used only in 3.6% of the wash cycles.

For heavy duty detergents, the most commonly used types of detergents were those in powder ('Vollwaschmittel', 56.7%) and the liquid ones ('Colorwaschmittel', 48.5%). Liquid dispensing types were mainly used for special detergents, according to the recommended guidelines.

The soil level was recorded based on a subjective evaluation pf 2,662 wash cycles. According to this analysis, 63.5% of laundry was lightly soiled, 27.2% medium soiled and 9.2% heavy soiled.

Samples of tap water were also collected from each household in order to determine the water hardness. Based on the questionnaire, only 124 householders were able to provide an estimation of the prevailing water hardness of the area where they lived at that time, whereas the remaining 112 householders did not know the hardness of the water used. Approximately, only 65.3% of the person interviewed estimated accurately the local water hardness. 17.3% of the total stated their area had higher water hardness than determined by the measurements, whereas 17.4% believed they live in an area with less water hardness than was actually found. According to the detergent manufacturers the dosage should be about 20% higher for a moderately hard water (e.g. that has a hardness of 21°dH, corresponding to 3.80 mmol/l) than for an average hard water area. Nevertheless, the measured average dosage was significantly lower (Table 3.3).

The average amount of detergent which was used for laundry in areas with very hard water was significantly lower from that used in other areas (Table 3.3).

Table 3.3 Arithmetic average amount of detergent per wash cycle and water hardness area (n = 2867 wash cycles, with standard deviation) (Kruschwitz et al. 2014)

Water hardness area (in °dH)	Water hardness area (in mmol/l)	Number of wash cycles	Arithmetic average amount of detergent with standard deviation (in g per wash cycle)
Soft; <7.3	<1.30	583	74.2 ± 32.2
Medium; 7.3–14	1.30–2.50	1136	72.9 ± 35.5
Hard; 14–21.3	2.50–3.80	712	73.1 ± 33.3
Extra hard; >21.3	>3.80	436	69.5 ± 42.0

The amount of detergent used resulted to fluctuate depending on the soil level and on the water hardness of the area: from 58.2 g ± 25.0 g (medium soiled laundry, very hard water) to 81.4 g ± 36.6 g (heavy soiled laundry, soft water). Even if a difference was noted in the soil level of the laundry, this did not lead to adjusting the detergent dosage (Figure 3-16).

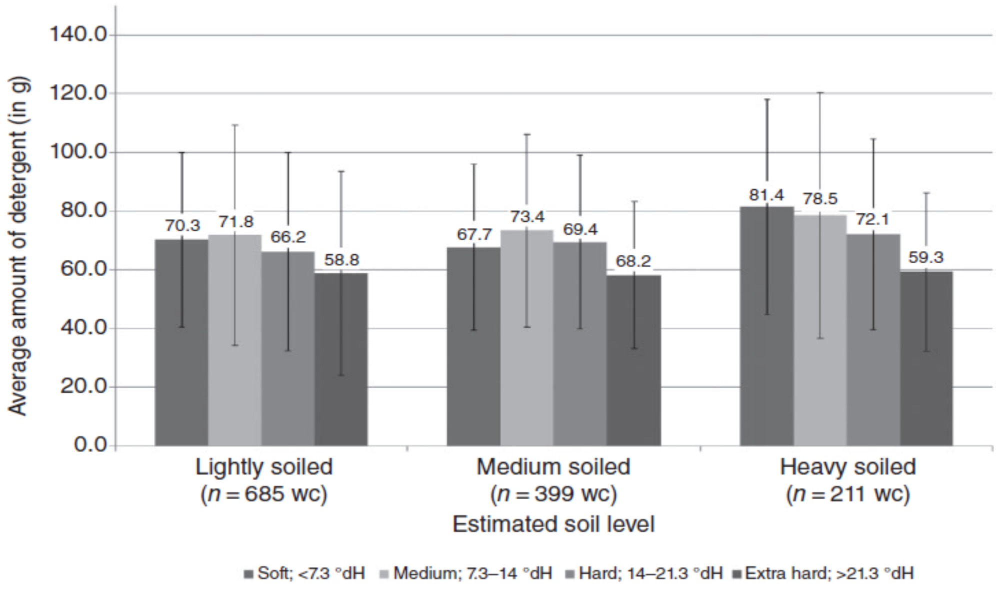


Figure 3-16 **Arithmetic average amount of detergent per soil level and water hardness area only of those households who chose every soil level at least once (n = 1295 wash cycles, with standard deviation). (Kruschwitz et al. 2014)**

Looking at the average dosage of different detergent types, comparable results were obtained for powdered and liquid detergents. Super compact and tab detergents were used slightly more moderately.

Table 3.4 **Arithmetic average amount of detergent in g per wash cycle and average dosage factor per type of detergent indicating misbehaviour in detergent dosage (n = 2773 wash cycles, with standard deviation) (Kruschwitz et al. 2014)**

Type of detergent	Number of wash cycles	Arithmetic average amount of detergent with standard deviation (in g per wash cycle)	Arithmetic average dosage factor with standard deviation
Powder	1183	74.6 ± 37.9	1.41 ± 0.91
Compact/pearls	460	64.4 ± 29.5	1.55 ± 0.87
Tabs	100	55.5 ± 25.2	1.38 ± 0.77
Liquid	1030	75.5 ± 34.7	1.38 ± 0.73

Nowadays all known European detergent manufacturers offer detergents designed for the washing temperature range of 15°/20°C to 60°C or 90°/95°C. Such detergents exist as heavy-duty detergent (with / without bleach) and colour detergent (Josephy et al. 2013).

Consumer survey by A.I.S.E

In 2008 and 2011 the International Association for Soaps, Detergents and Maintenance Products (AISE) has commissioned two online consumer studies about laundry and cleaning habits (A.I.S.E. 2011c) and Laundry Detergents (A.I.S.E 2008). The studies involved inhabitants of 23 European countries. The sample size for both studies was about 200 respondents per country for a total number of 5249 respondents, Results for questions about number of wash cycles, chosen temperature classes and loading behaviour are shown in the followings.

<u>Frequency of operation</u>

The average number of wash cycles per household resulted to be 3.2 times per week in 2011. Compared to the statistics from 2008, the number of wash cycle per week decreased slightly (-0.1 = -3%). Among the countries tested by AISE, households in Ireland and in the UK presented the highest number of wash cycle per week (about 4.5 and 4, respectively). On the opposite side, laundry appeared to be washed about 2.5 times per week in Turkey and in Czech Republic (Figure 3-17). In the survey from the University of Bonn presented above, the average number of washing cycle per household is 3.8 times per week. This indicates that there is high variability in this parameter.

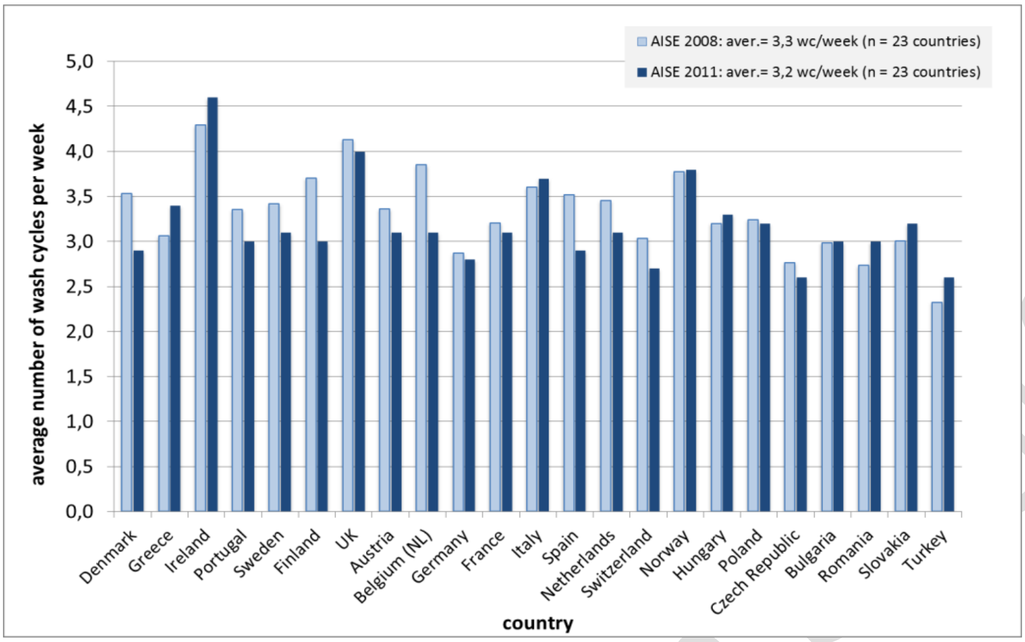


Figure 3-17 **Average number of wash cycles for different European countries (A.I.S.E 2008); (A.I.S.E. 2011c)**

<u>Wash temperatures</u>

The analysis of selected temperature classes shows that on average the laundry is washed with a temperature of 41.0 °C (Figure 3-18). A slight decrease is appreciable in comparison to the results for the year 2008 (41.7 °C).

Such result is consistent with the outcomes of the user survey conducted by the University of Bonn in 2011, where an average washing temperature of 43.3 °C was estimated. Both studies thus indicate that the average washing temperature has decreased, and 40 °C may be a good indicator. Additionally, this also means that the use of lower temperatures is becoming more and more frequent.

Figure 3-18 shows that the percentage of wash cycles for which a temperature below 30 °C was selected was significant and it reached 74% for Spanish households.

According to this study, differences in selection of the programme temperature appeared limited between 2008 and 2011. During the period 2008-2011, the number of wash cycles below 30 °C increased by about 3% at European level (Figure 3-18 and Figure 3-19). The frequency of selection of higher temperature classes decreased. This is particularly the case for the "≥ 60 °C" temperature class, which is selected especially in Scandinavian countries (about 30%) (Figure 3-18 and Figure 3-20).

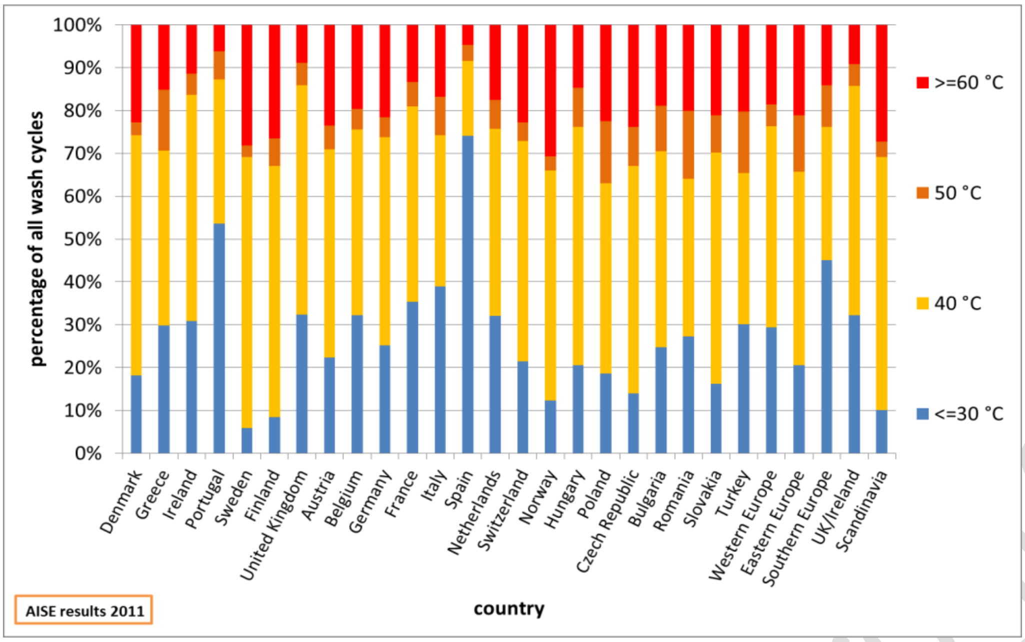


Figure 3-18 **Relative frequency of wash temperatures used in 2011 in different European countries (A.I.S.E. 2011c)**

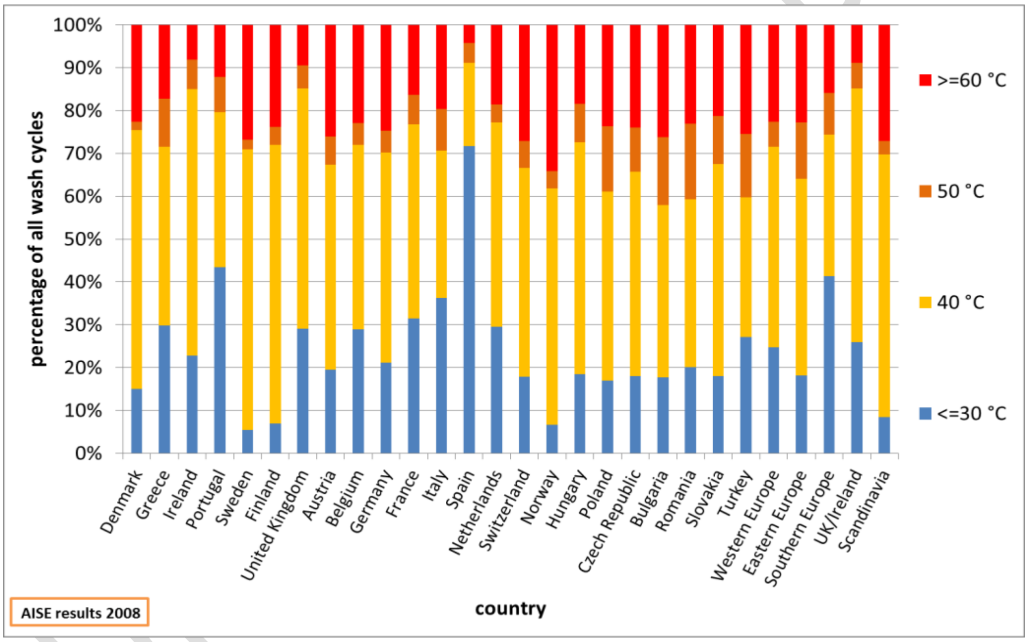


Figure 3-19 **Relative frequency of wash temperatures used in 2008 in different European countries (A.I.S.E 2008)**

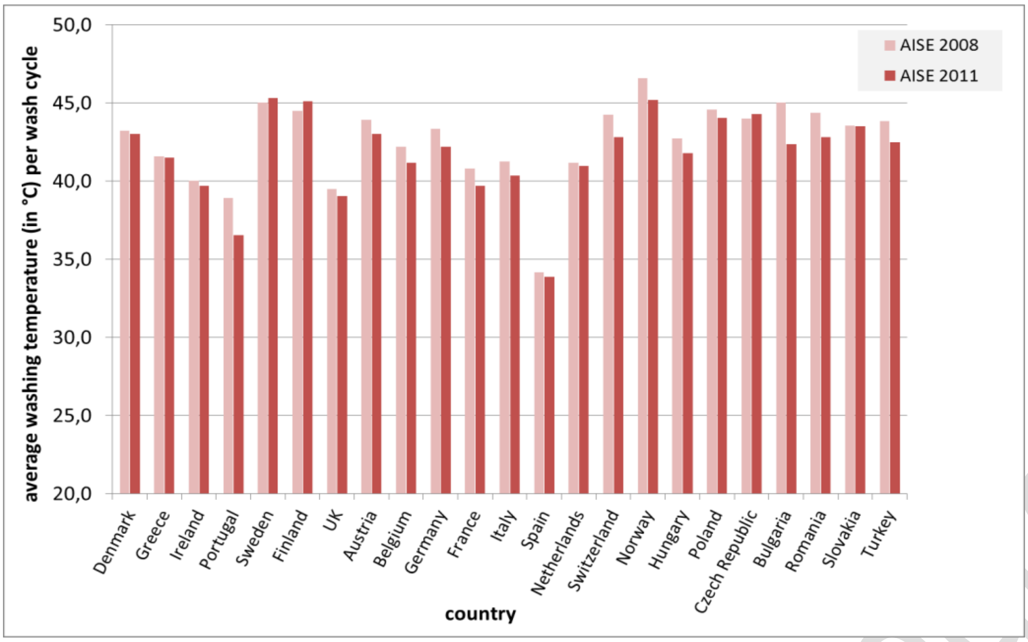


Figure 3-20 **Average wash temperature per country for year 2008 and 2011 using the nominal temperature values of 30 °C, 40 °C, 50 °C and 60 °C for calculating the average (A.I.S.E. 2011c)**

<u>Loading</u>

Figure 3-21 and Figure 3-22 show the loading behaviour of the participants to the surveys run in 2011 and in 2008, respectively. Results illustrate that the majority of consumers in various countries load their washing machines 75 up to 100% full, which seems to be consistent with the results from the survey run by the University of Bonn in 2011.

The only exception appears Slovakia, where over 35% of consumers fill their washing machine less than half full (Figure 3-21). Also, there is no substantial change in the loading behaviour of participants comparing 2008 and 2011 (Figure 3-22).

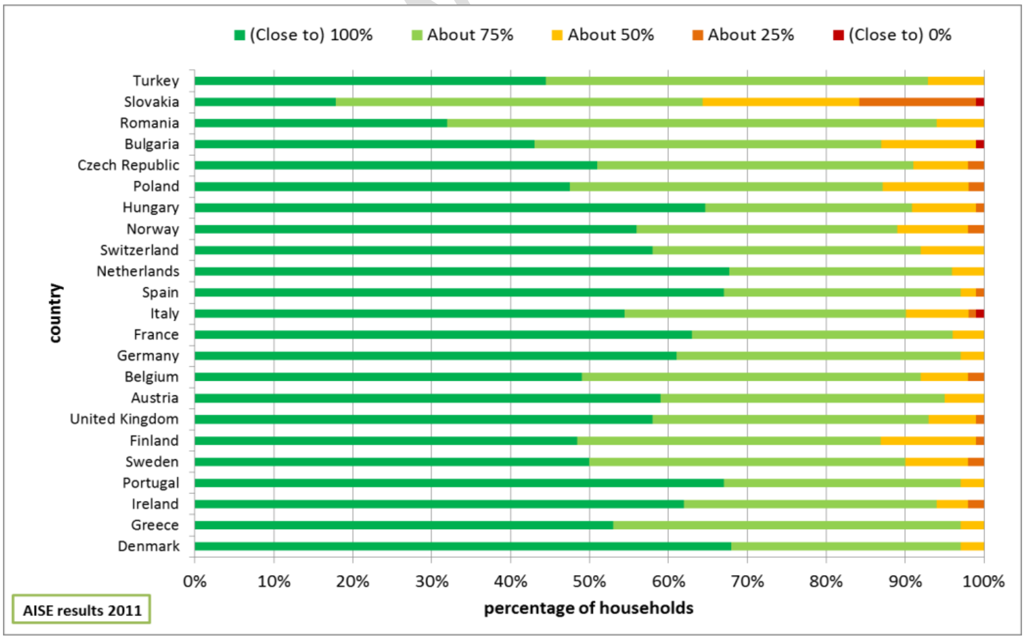


Figure 3-21 **On average, for normal laundry washes, for what percentage of your washes do you consider that the washing machine is "full"? (A.I.S.E. 2011c)**

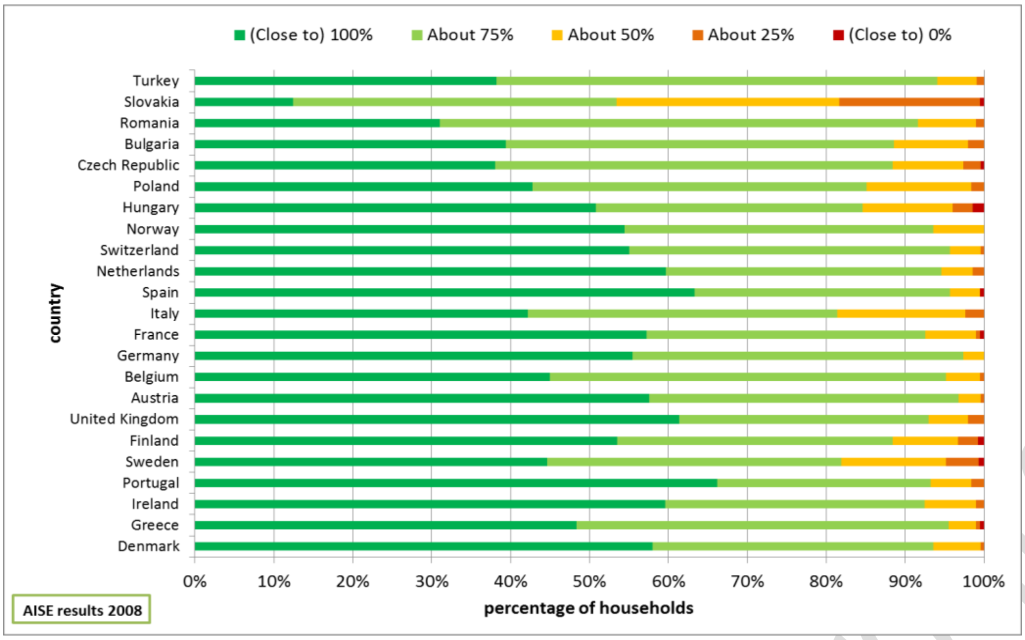


Figure 3-22 **On average, for normal laundry washes, for what percentage of your washes do you consider that the washing machine is "full"? (A.I.S.E 2008)**

Figure 3-23 and Figure 3-24 show respondents' opinions regarding the environmental effects of avoiding under-filling their washing machines. Respondents were asked "Which of the following statements do you believe will help reduce your impact on the environment?". One of the answering options was "Avoid under filling the machine".

In 2011, consumers from countries as Portugal, Poland or Czech Republic indicated that under-filling the washing machine has weak-neutral impacts on the environment. On the opposite side, consumers from other countries were very sensitive to this environmental issue. For instance, about 90% of the Finnish consumers indicated that the impacts can be significant (Figure 3-23). Results are comparable with those for 2008 (Figure 3-24).

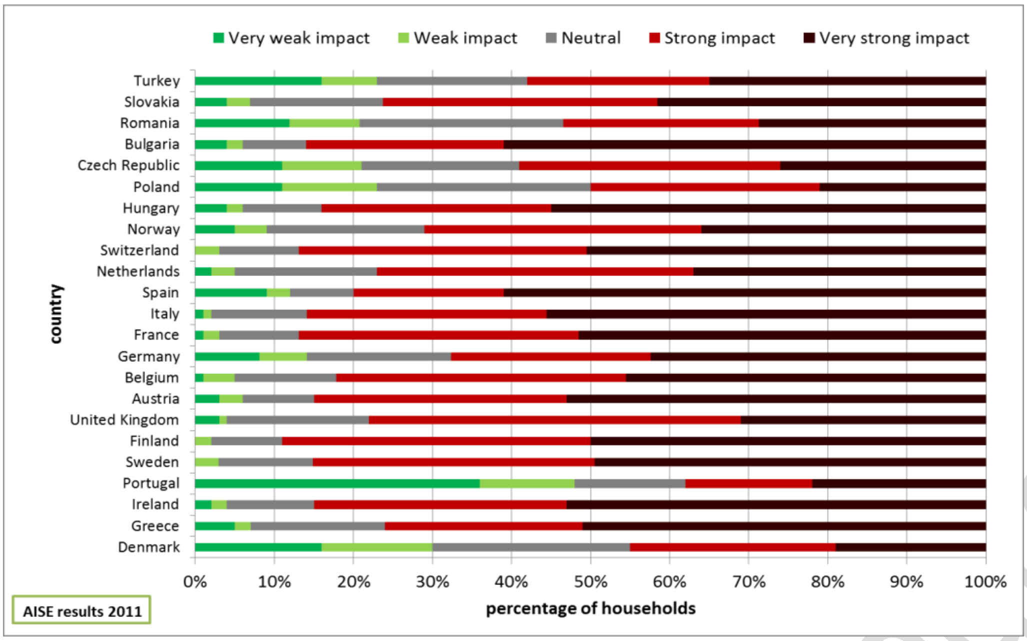


Figure 3-23 **Respondent's belief regarding the effects of avoiding under filling the machine on the environment (A.I.S.E. 2011c)**

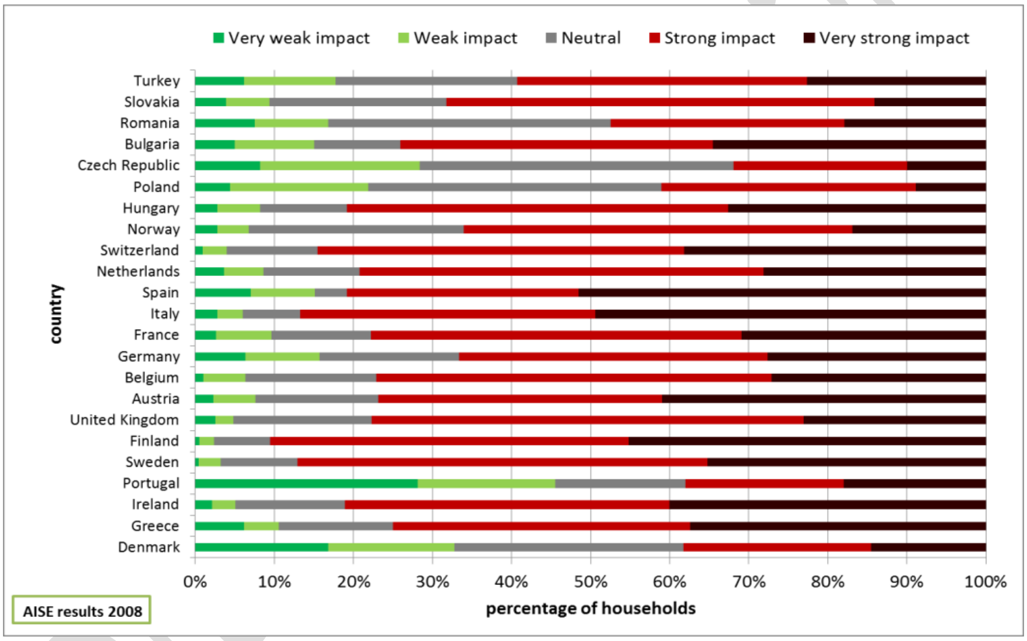


Figure 3-24 **Respondent's belief regarding the effects of avoiding under filling the machine on the environment (A.I.S.E 2008)**

Both studies gave the possibility to analyse the correlation between the estimated load of the washing machines and the consumer opinion about the possible consequences for the environment in case of under-filling. Results showed that there is no clear correlation between the consumer awareness about the environmental impacts associated to the filling rate and the actual practice (Figure 3-25). This can be a potential target for consumer information campaigns aimed at establishing the link between the two aspects and at promoting the increase of the washing machine's loading in those countries where it is currently low (e.g. Slovakia or Romania).

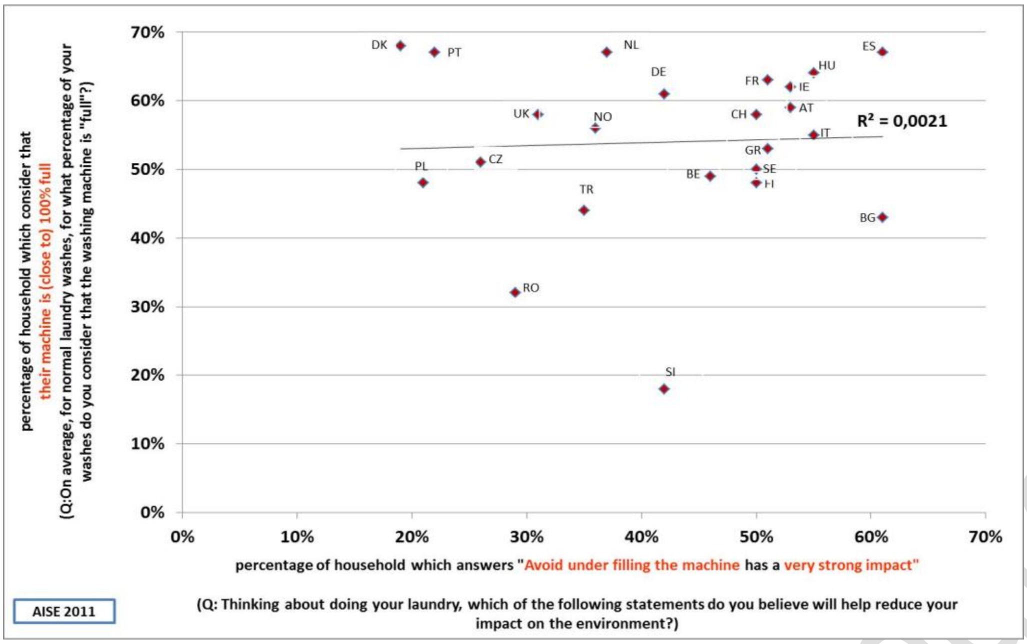


Figure 3-25 Correlation between estimated load level and impact of "under filling" the machine (A.I.S.E. 2011c)

Historical consumer behaviour information

In Germany, IKW (the industrial branch of the soap and detergent industry) has published historical data on the programme temperatures (Figure 3-26). (IKW 2011)

A drastic reduction of washes at 90 °C as well as a continuous increase of washes at low temperatures (e.g. 40 °C and below) can be observed from 1972 to 2010 (Figure 3-26). Average washing temperatures (calculated using the nominal washing temperatures) have dropped from 63 °C to 46 °C in almost 40 years. A linear regression (Figure 3-27) gives a gradient of -0.43 °C per year for the reduction of the average washing temperature in Germany. This is supportive of the indications provided by the Universtiy of Bonn and by AISE.

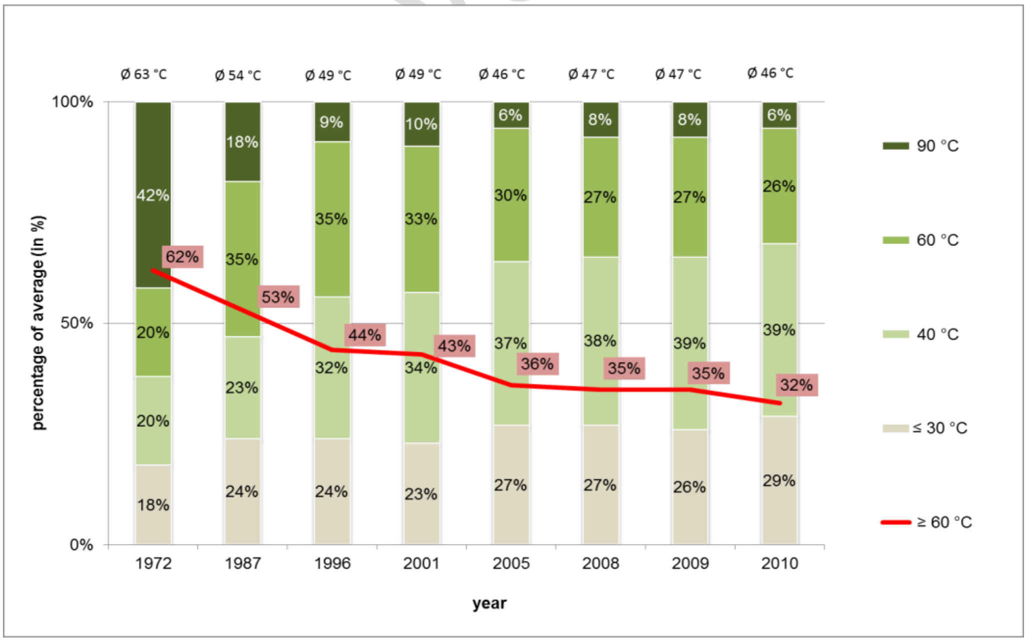


Figure 3-26 Historical data on washing temperature from 1972 to 2010 for Germany (IKW 2011)

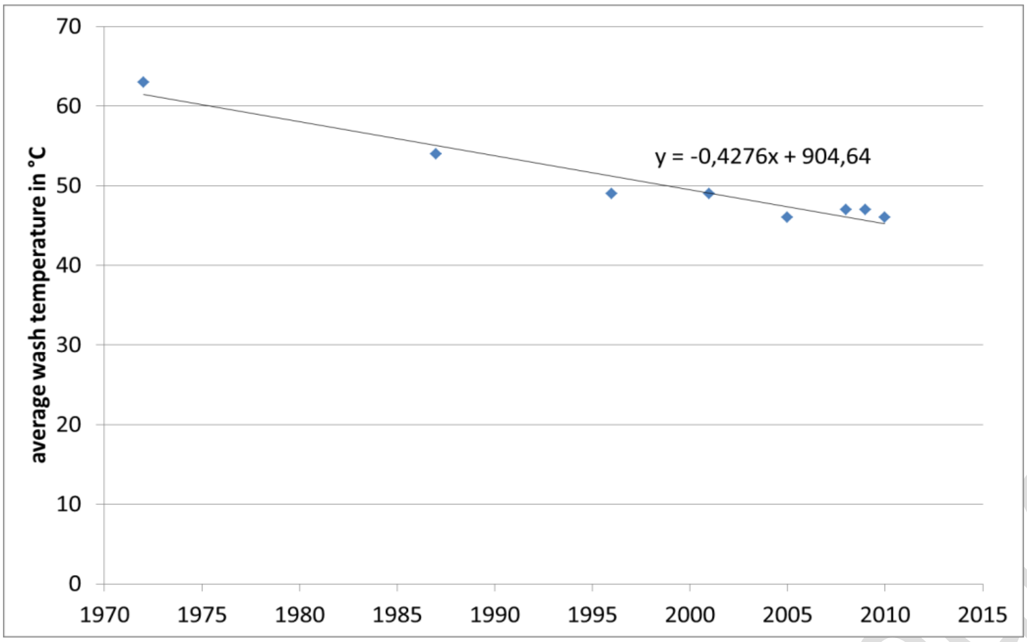


Figure 3-27 **Historical trend of average wash temperature in Germany (compilation by Bonn University based on data from (IKW 2011))**

Also, historical data for 17 European countries has been found in former surveys done by AISE in 1996 and 2001 (IBM 2002). This information has been coupled with AISES's analyses carried out in 2008 and 2011. Figure 3-28 shows the washing frequency for different ranges of temperature and different European countries. Trends toward reduced use of higher washing temperatures (above 40 °C) can be observed in most countries, with the exception of Spain. In Spain, washing at temperatures above 40 °C have slightly increased. In some other countries (e.g. Greece, Ireland, the Netherlands, the UK) the practice of washing at temperatures below 40 °C has increased. For other countries, washing at 40 °C is the most used temperature.

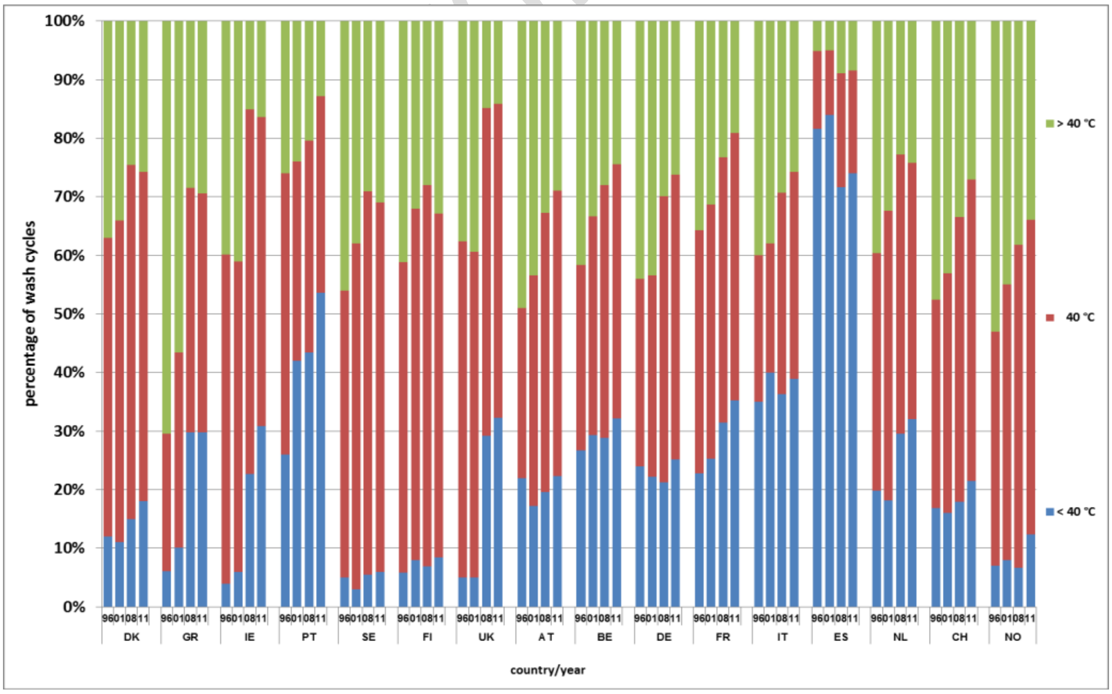


Figure 3-28 **Comparison of the washing frequency for temperature ranges < 40 °C, 40 °C and > 40 °C for various countries (compilation by Bonn University based on data from AISE surveys of 1996, 2001, 2008 and 2011)**

The average washing temperature, calculated based on the nominal values of the programs, has also decreased from 1996 to 2011 for most countries (Figure 3-29).

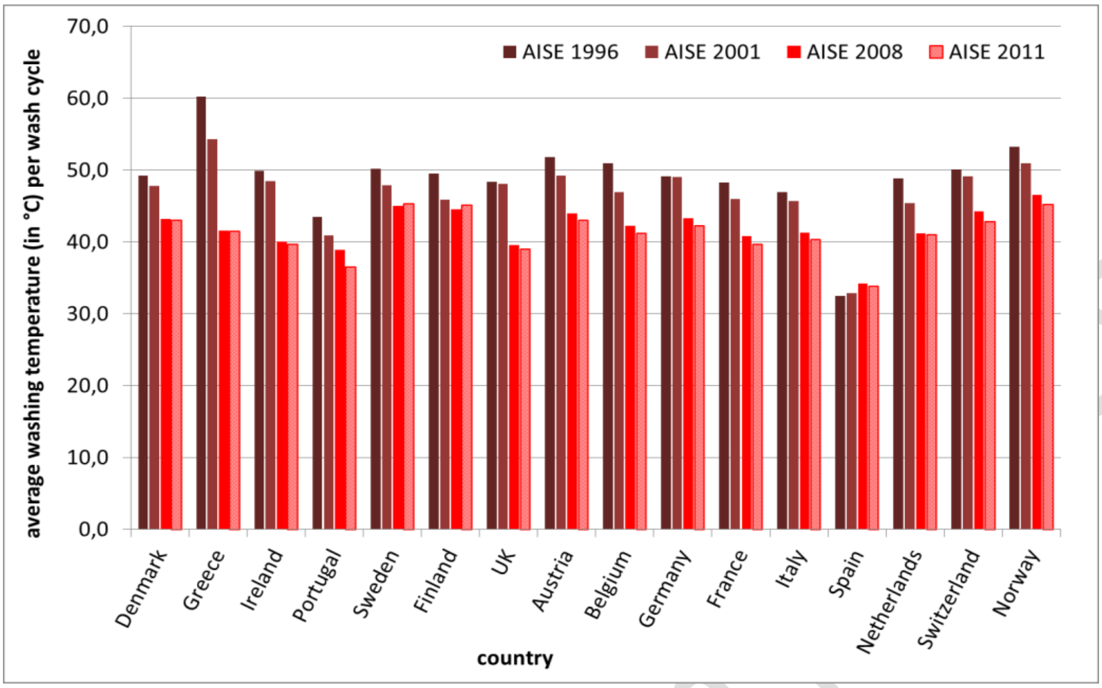


Figure 3-29 **Average wash temperatures for AISE studies from 1996 to 2011 (compilation by Bonn University based on data from AISE surveys of 1996, 2001, 2008 and 2011)**

Consumer attitudes and perceptions regarding the lifetimes of electrical products

In a study commissioned by WRAP, current British consumers' views, attitudes and perceptions of the lifetimes of electrical products were explored. Inter alia, the study covered washing machines as large household appliances, "workhorse products", being heavily and prolonged used. The findings are based on desk research, interviews to focus groups and a nationally representative survey carried out in England and Wales. (WRAP 2013a)

- <u>Consumers' knowledge about the product lifetimes</u>: According to the results of the study, consumers were not knowledgeable about how long washing machines can last. Evaluation of the lifetimes of products was based on a combination of 'general knowledge', sources of knowledge available during the purchase process, and proxies to make assessments about the lifetimes of comparative products. Younger respondents were less likely to have personal experience about how long these products can last, and some consumers also had doubts about whether the lifetime of products can be accurately measured. The main sources of information consumers thought they can access during the purchase process to evaluate and compare the lifetimes of different products are online reviews made by other consumers. However, consumers primarily relied on brand and to a lesser extent on price as proxies for the lifetime, expecting that well-known brands and more expensive products will last longer. Manufacturer warranties were also considered positively as indicating trust of producers on the durability of their products. The participants of the study were interested in long guarantee/warranty periods because these would ensure that products can be quickly repaired or replaced if they break down. (WRAP 2013a)
- <u>Importance of product lifetimes for consumers</u>: The WRAP study revealed that product lifetimes are not primary aspects considered by consumers when buying products, although acknowledged to be important. Typically, product lifetimes are not expressed directly but are inferred through other elements as quality, reliability and durability. When asked, consumers said they do consider

product lifetimes of washing machines important, and this is common to different socio-demographic groups. Lifetime was considered an aspect of quality to avoid inconvenience and costs due to repair or replacement of broken appliances. Older consumers and persons with lower income or with a savings-driven mind-set appeared to give particular importance to the product lifetimes. (WRAP 2013a)

- Consumers' expectations on product lifetimes: On average, consumers expected washing machines to last for six years. Older consumers and consumers living alone or without children, expected products to last longer than other consumers, which may reflect the lesser frequency and intensity with which they use these products in comparison to consumers living in larger households and with children. Consumers were not oriented to replace domestic appliances, inter alia washing machines, before the end of their functional life and wanted them to last as long as possible. Equally, the majority said they were satisfied with how long current products last, although the level of satisfaction was lower for washing machines. Satisfaction with lifetimes of current products was linked to how long consumers expected these products to last. Those with high expectations were also generally those who were most satisfied, suggesting previous experiences have shaped both expectations and satisfaction. (WRAP 2013a)

Consumers' pull for longer product lifetimes: According to the findings of the WRAP study, the key barriers to the uptake of products with longer lifetimes are the secondary attention given in general to this issue by consumers, the current lack of information and advertising on product lifetimes, and consumers' distrust on manufacturers. The key opportunities for increasing the pull for longer lifetimes are the underlying importance of lifetime for consumers, their appetite for more information about product lifetimes, and the malleability of consumers' priorities during the purchase process. Examples of clearly communicated product lifetimes were identified by participants (Kia cars 7 year guarantee and Ikea in-store product testing demonstrations). Interest in products with longer lifetimes is not confined to a small subgroup of consumers: around half of consumers indicated they would be willing to pay more for products that are advertised to last longer (on average, they would be willing to pay 10% more). More than eight out of ten consumers also indicated they would be willing to pay more for products that are advertised to last longer and have a longer standard guarantee or warranty. The future uptake of more durable products could be maximised if these are accompanied by longer standard guarantees or warranties – both as element of trust for consumers and as advertisement hook. Consumers were also receptive to advertisements emphasising the benefits of longer lasting products, and to the provision of sound information on product lifetimes through mainstream channels. (WRAP 2013a)

3.1.1.2. Washer-dryers

A user survey was designed in 2011 by the University of Bonn to collect information on the use of washer-dryers in Europe. European consumers were asked about their household equipment, the frequency of use of washing and drying cycles, the chosen washing temperature, the typical practices of drying depending on weather and the availability and use of the 'wash+dry' option (continues washing and drying in a row). The results of this consumer behaviour study were published in 2012 (Schmitz & Stamminger 2012). So far, to the knowledge of the authors of the present report, this represents the only study covering washer-dryers.

For this study, answers from 1,000 consumers of 10 European countries were collected via internet with the support of a market research institute. Pre-requisite was that participants of the study owned a washer-dryer and were mainly involved in the household activities. ; additionally half of all participants had to be female.

On average, more than a half of respondents lived in family households. The share of family households was very high especially for Italy, Czech Republic, Hungary and Poland (Figure 3-30). Family households were followed by couples households (about 30%) and single-person households (about 16%). Just a minor share of of respondents (2%) said that they live in a multi-person non-family household. The average number of individuals living in a household resulted to be equal to 2.8 people.

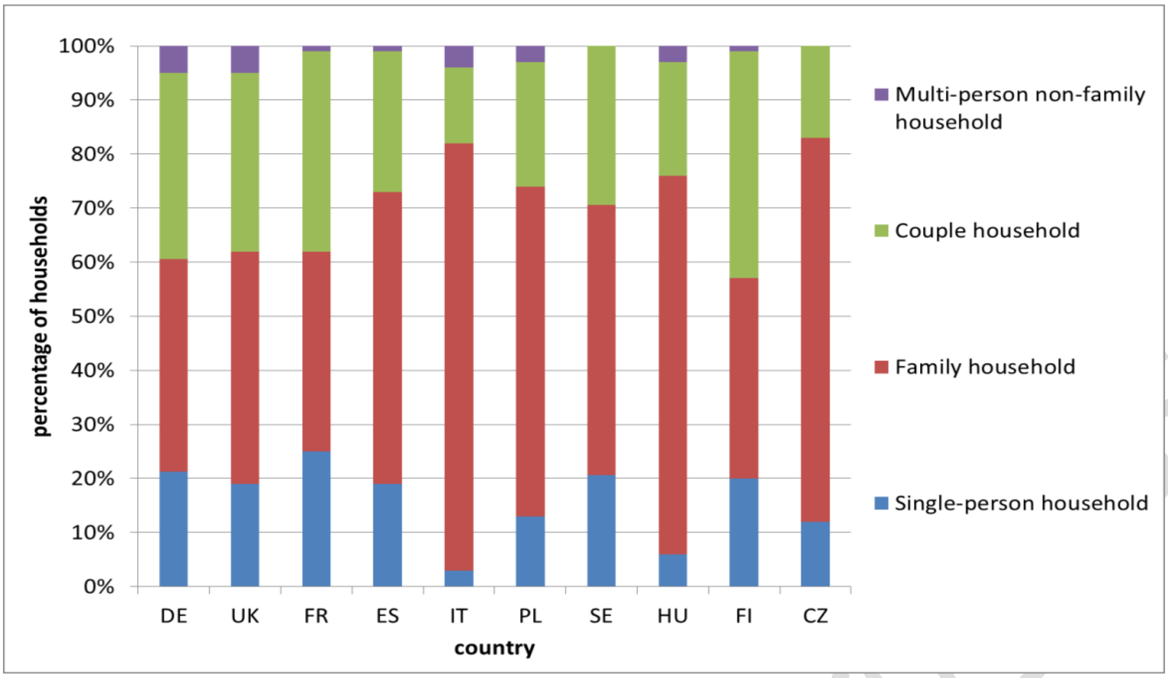


Figure 3-30 **Family size of households with a washer-dryer per country (Schmitz & Stamminger 2012)**

<u>Purchase reasons for a washer-dryer</u>

For more than a half of respondents, the main reason for purchasing a washer-dryer is in the lack of space for washing machine and tumble dryer (Figure 3-31). Nearly 40 % of the participants to the survey answered that the additional drying function was considered an important option when buying a washer-dryer. Also the price of one appliance in comparison to two separate appliances was a frequently mentioned argument (34%). About one quarter of the respondents indicated that they need the possibility of choosing a 'wash and dry' option (continuous washing and drying in a row).

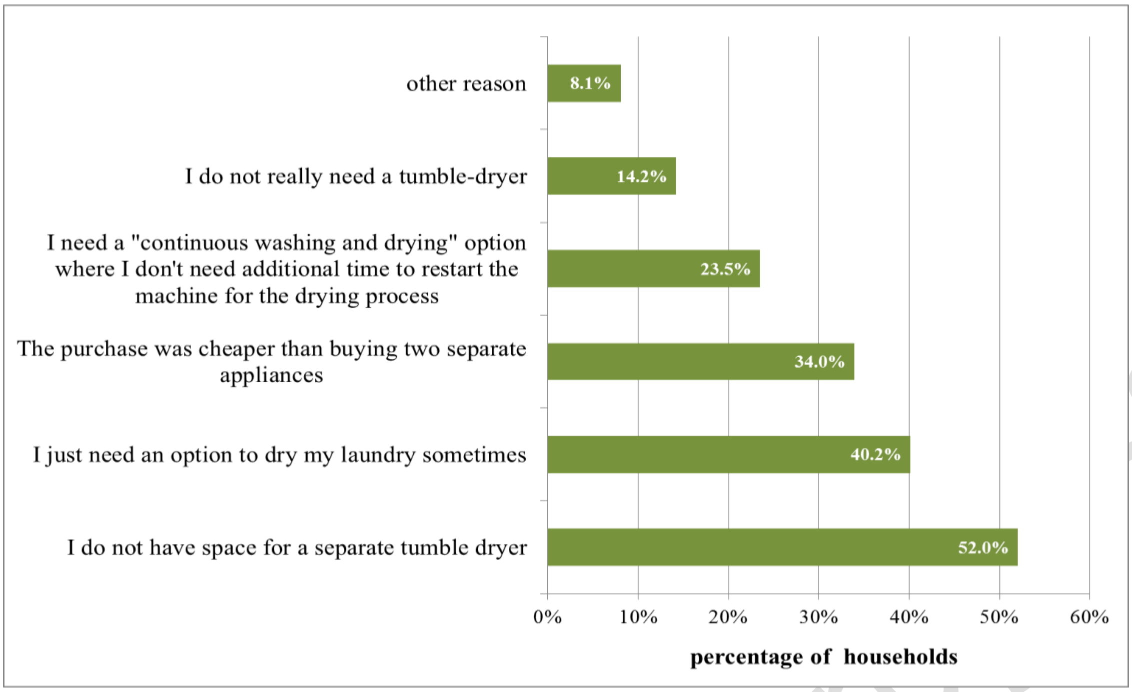


Figure 3-31 **Reasons for buying a washer-dryer instead of buying a washing machine and dryer, or just a washing machine? (Multiple answers allowed) (n = 1,001 households) (Schmitz & Stamminger 2012)**

According to the information gathered through this survey, a washer-dryer seems an appliance that is often owned in addition to a washing machine or tumble dryer, especially in country as Italy, Spain, Poland (Table 3.5). A washer-dryer and a washing machine were jointly present in nearly 37% of the households while 18% of the households seemed to have a tumble-dryer and a washer-dryer.

Table 3.5 **Share of additional appliances next to a washer-dryer in several EU Member States (Schmitz & Stamminger 2012)**

	country									
	DE *% of hh*	UK *% of hh*	FR *% of hh*	ES *% of hh*	IT *% of hh*	PL *% of hh*	SE *% of hh*	HU *% of hh*	FI *% of hh*	CZ *% of hh*
Washing machine	42%	27%	27%	48%	54%	46%	25%	40%	38%	26%
Tumble dryer	18%	22%	20%	30%	25%	19%	7%	14%	18%	9%

<u>Frequency of use cycles</u>

The results of the analysis show that the average number of washing cycle per household is 4. 3 times per week. This is 13% higher than the value estimated for washing machines y the Universaity of Bonn, again highlighting the uncertainty behind this parameter.

The frequency of washing cycles per week is high especially in country as Italy, Spain and Hungary (Table 3.6). There seems to be an apparent correlation between the size of household and the number of wash cycles (Figure 3-32).

Table 3.6

	country									
	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
number of households	99	100	100	100	100	100	102	100	100	100
total number of people	225	264	259	334	321	316	227	317	244	292
total number of wash cycles per week	367	458	362	484	627	440	337	478	347	441
wash cyles per week per household	**3.7**	**4.6**	**3.6**	**4.8**	**6.3**	**4.4**	**3.3**	**4.8**	**3.5**	**4.4**
wash cyles per week per person	**1.6**	**1.7**	**1.4**	**1.4**	**2.0**	**1.4**	**1.5**	**1.5**	**1.4**	**1.5**

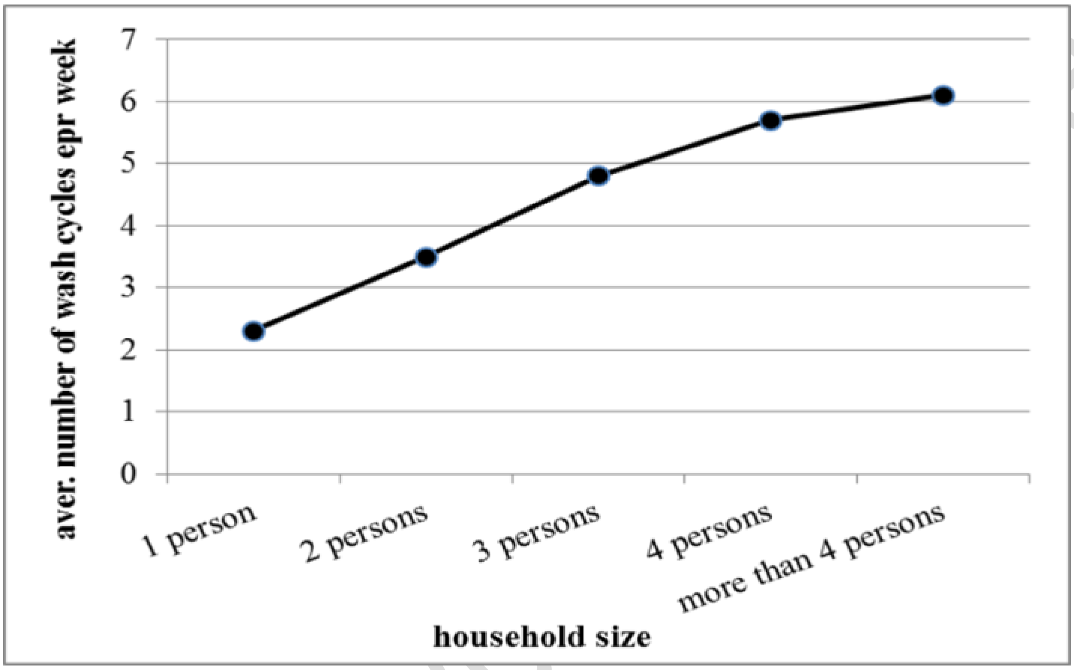


Figure 3-32 **Correlation between the size of household and the number of wash cycles (Schmitz & Stamminger 2012)**

<u>Programme temperature (washing)</u>

In a range from 20 °C up to 90 °C, the most frequently used washing temperature was the 40 °C washing programme, followed by the 30 °C and the 60 °C programme in similar percentages (20.4% and 18.2%, respectively). Results appear in general consistent with those obtained for washing machines.

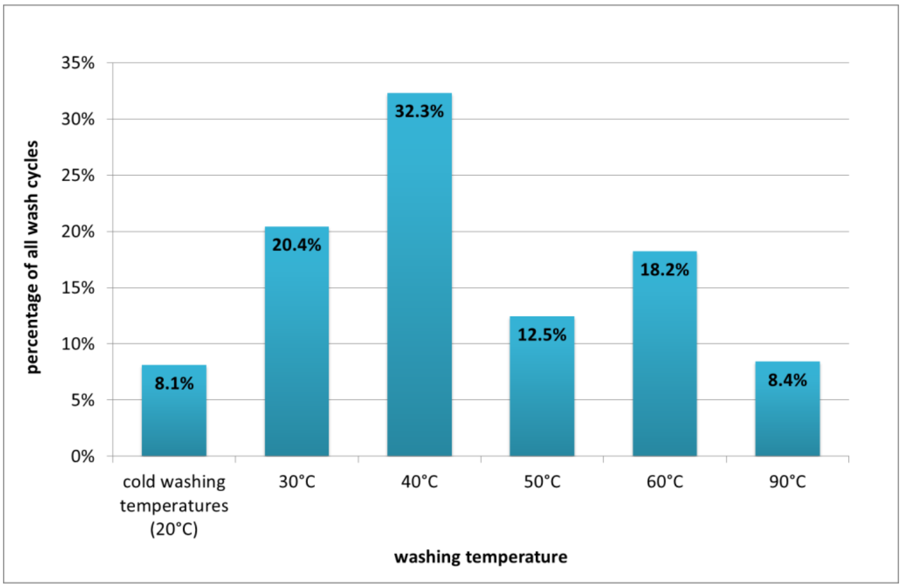


Figure 3-33 **Distribution of used washing temperature per week of a washer-dryer (n=4,341 wash cycles) (Schmitz & Stamminger 2012)**

<u>Drying behaviour</u>

The participants of the study were asked which practices of drying they use for their laundry. Difference was made between drying of clothes in summer (under conditions of fine weather) and winter (under conditions of foul weather) (Figure 3-34).

Visible differences in drying behaviours were registered depending on the season. In summer nearly 70% of respondents mentioned to dry their laundry outside on the clothes line. In comparison, only 16% answered to choose this option in winter (Figure 3-34). Results also suggest that the laundry is often/always dried in a heated room of the house when the outdoor temperature is lower. This was answered by approximately 60% of the participants to the survey.

The drying option of the washer-dryer is used rather sometimes, rarely or never. In winter the drying option is used of nearly 43% of all households often or always. In summer these results are minor with 23%.

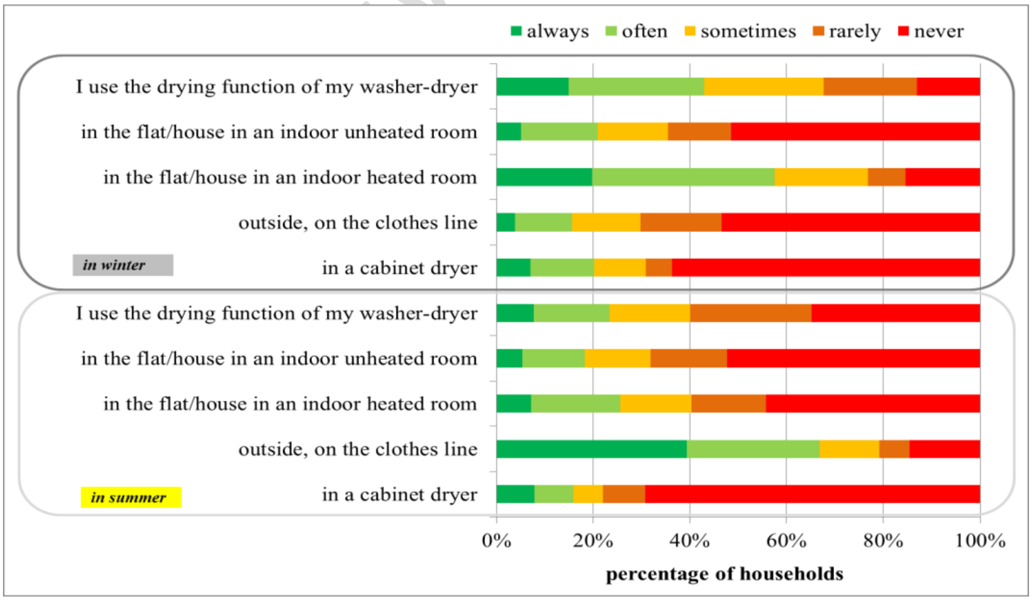


Figure 3-34 **Drying behaviour in winter (at foul weather) and in summer (at fine weather) valid n = 963 households (Schmitz & Stamminger 2012)**

The ‘wash+dry’ option, i.e. the possibility of washing and drying the clothes in one row, was mentioned by consumers to be an important purchase factor for washer-dryers. Nearly 71% of the owned washer-dryers had this option implemented. This was especially the case for Italy and Spain (Table 3.7).

Table 3.7 Percentage of washer-dryers having the option of continuous ‘wash+dry’ (Schmitz & Stamminger 2012)

	country									
	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
Yes	73 %	74%	74%	79%	82%	60%	59%	72%	62%	71%

On the other hand, it is interesting to observe that, although nearly one quarter of respondents indicated that this is an important option to consider for buying a washer-dryer, 20% of participants answered that they never used this option (Figure 3-35), although it is not clear if they do not use it because unavailable or because not interested in it.

This behaviour is visible especially in British and Swedish households, where the 'wash+dry' option was reported to have been never used in 40% of households (Figure 3-36). In comparison, the continuous washing and drying option is used more in country as Italy, Poland, Spain and Hungary, with an average of 1.4 wash cycles per week and household (Table 3.8). The average for all countries was calculated to 1.1 wash cycles per week and household.

Thus, the ‘wash+dry’ function was approximately utilised only in 24% of all weekly wash cycles.. Again, a small positive correlation between the average number of washing cycles using the ‘wash+dry’ option and number of individuals per household (r=0,218, p <0,001) is also visible (Figure 3-36). However, the frequency of using the 'wash+dry' option grows as the household size increases (Figure 3-37)

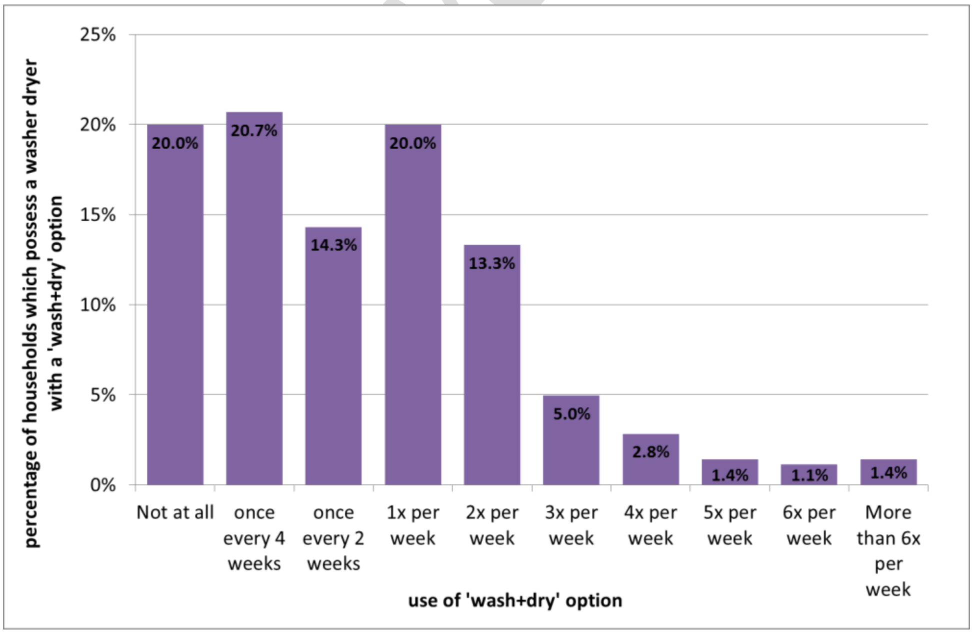


Figure 3-35 Use of wash + dry option (n= 706 hh) (Schmitz & Stamminger 2012)

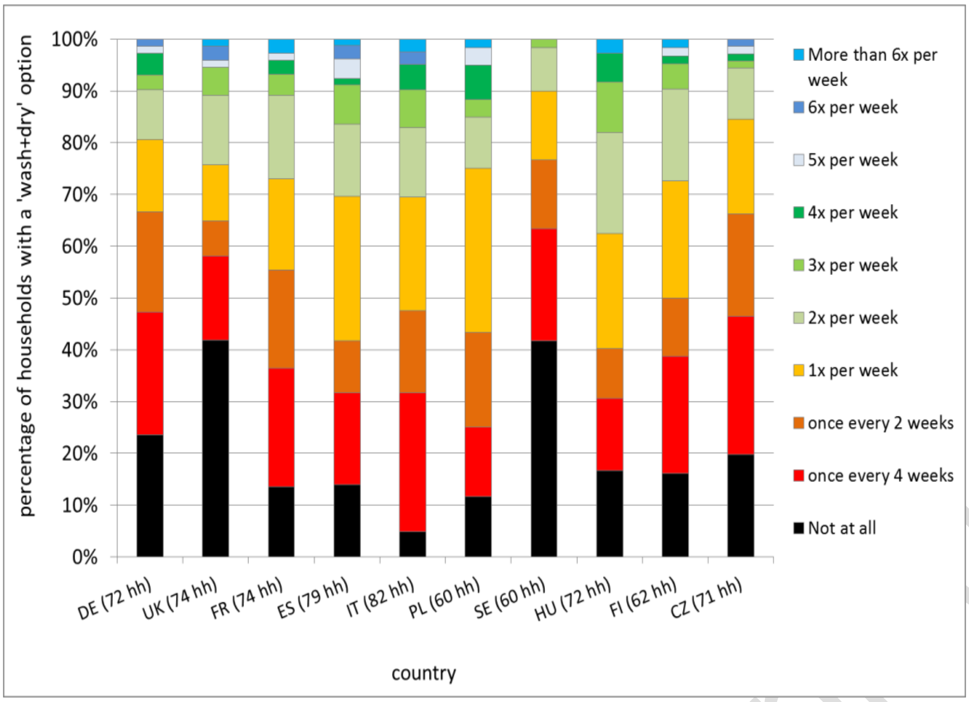


Figure 3-36 **Use of wash+dry option per country (Schmitz & Stamminger 2012)**

Table 3.8 Wash cycles with the use of 'wash+dry' option per country (Schmitz & Stamminger 2012)

	country									
	DE	UK	FR	ES	IT	PL	SE	HU	FI	CZ
number of households with washer dryer with "wash & dry" option	72	74	74	79	82	60	60	72	62	71
total number wash cycles per week	270	355	259	405	501	299	194	345	224	343
total number of wash cycles per week with "wash & dry" option	64	70	84	108	112	78	28	101	68	57
percentage of wash cycles with "wash & dry" option	24 %	20 %	33 %	27 %	22 %	26 %	15 %	29 %	30 %	17 %
wash cycles per week with "wash & dry" option per household	0.9	0.9	1.1	1.4	1.4	1.3	0.5	1.4	1.1	0.8
wash cycles per week per household	3.75	4.79	3.50	5.12	6.11	4.98	3.23	4.80	3.62	4.82

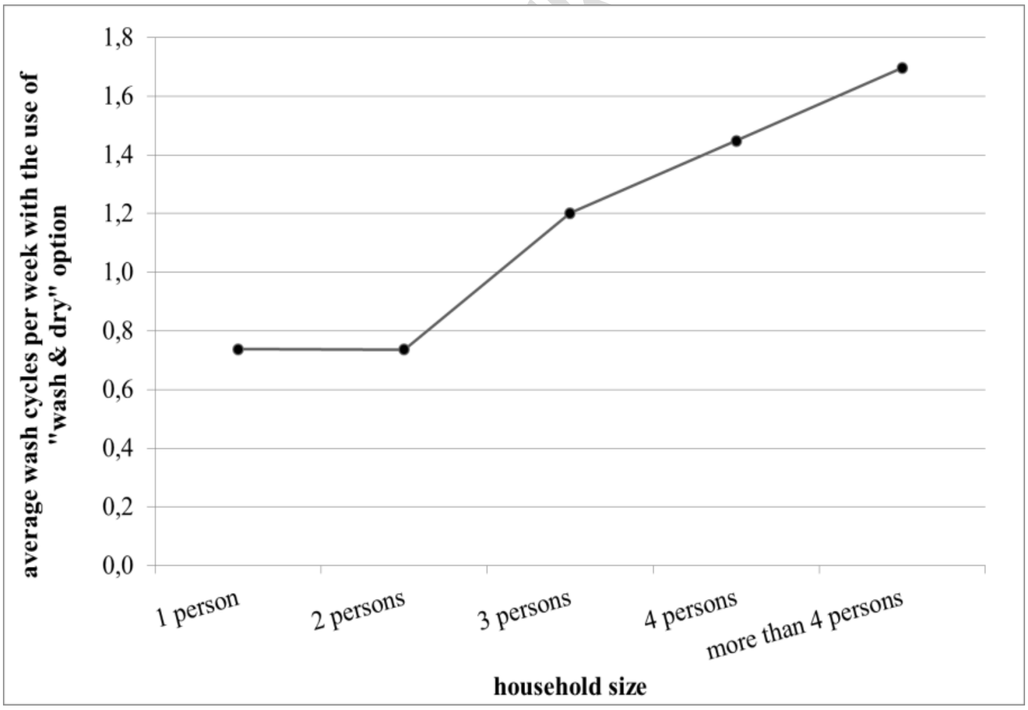


Figure 3-37 Average wash cycles per week with the use of "wash+dry" option depending on household size (Schmitz & Stamminger 2012)

The reason why consumers don't use the 'wash+dry' option (number of answers = 141 households) can be explained by the practices of drying preferred by consumers (Figure 3-34).

The 'wash+dry' option will not be used at all In households where it is preferred to dry laundry on the clothes line (Figure 3-38). However, 25% of users reported that they do not use such option to get better drying results or because pf the need to separate delicate clothes. Other reasons are the long duration of the cycle and the need to split the load to prevent wrinkles.

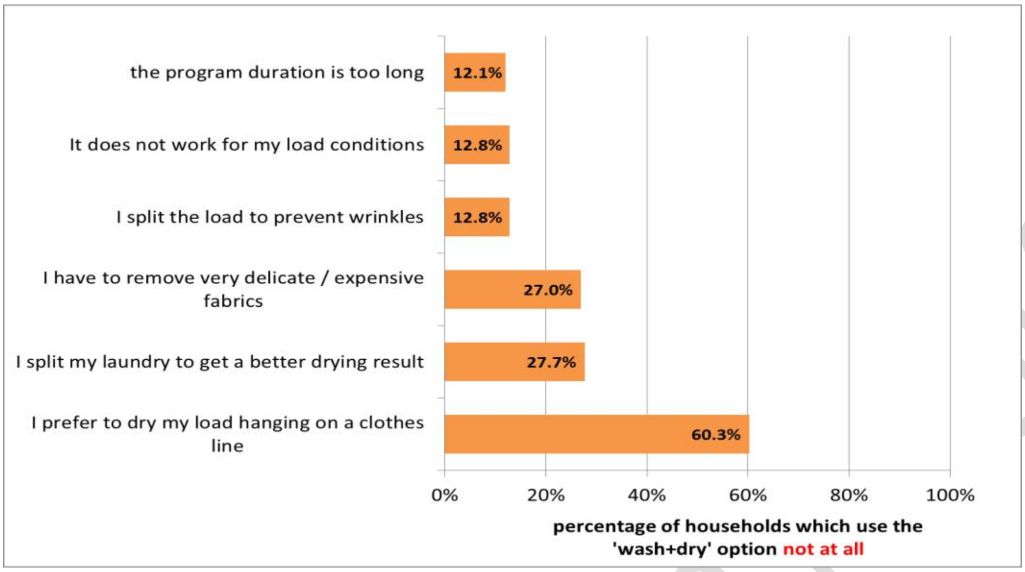


Figure 3-38 **Reason for 'not at all' using the 'wash+dry' option (n=141 households) (multiple answers allowed) (Schmitz & Stamminger 2012)**

The result of the drying behaviour depending on weather or season indicated that the drying (only) option of the washer-dryer is not frequently used (Figure 3-34). The answers showed that only in 29% of all wash cycles the drying (only) function of the washer-dryer was used by the consumers. With an average of 1.3 drying cycles per week, the frequency of use was minimally higher than the average number of 'wash+dry' cycles (1.1). Only minor percentage of consumers indicated they never chose this option (Figure 3-39) but rely on other ways of drying.

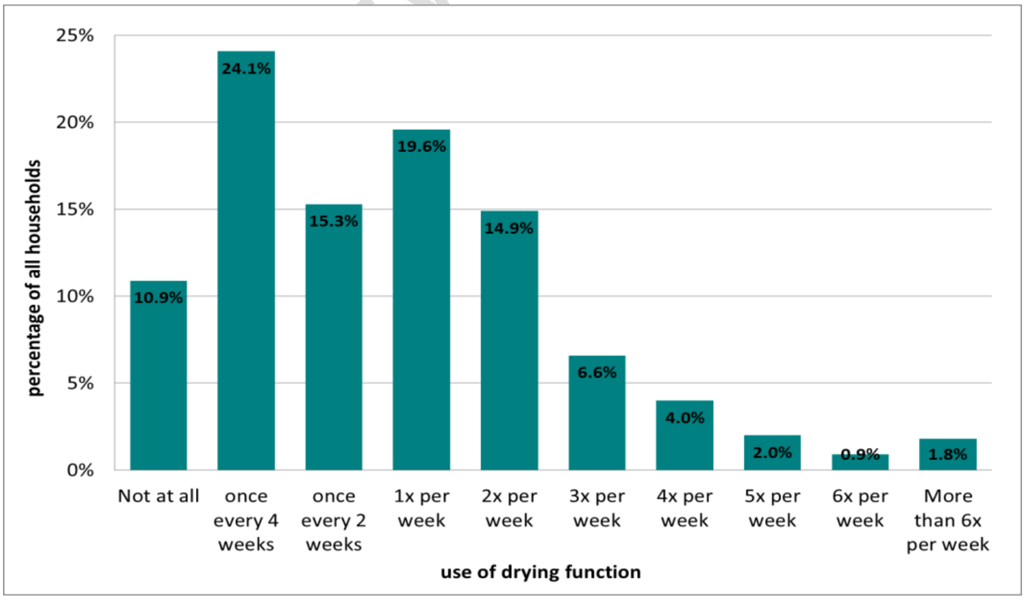


Figure 3-39 **Use of drying only function per week (n = 1.001 households) (Schmitz & Stamminger 2012)**

3.1.2. User behaviour influence on the "washing, drying and ironing" process

Numerous studies reveal that energy consumption (EIA 2009), (EC 2006), (IEA 2009b), (IEA 2009a) as well as the usage of water (Doll, et al. 2003) will increase globally in the next decades. Both will result in relevant changes to the earth and its ecosystems, for instance due to the effects of global warming and the increased drought and flooding conditions in some areas.

Traditional approaches allocate the origin of resources consumption among various sectors, like industry, agriculture, transport, or residential. As consumer activities indirectly impact the usage of resources in other sectors as well, this approach was challenged starting from late 1980s. Therefore, the so called lifestyle of consumers was analysed in more details to understand its effects on the total energy consumption. Predicting and trying to influence energy consumption and water use for household purposes needs in-depth knowledge and information about technologies and about the relationship between consumer behaviour and social, psychological and demographic factors.

Laundry processes in private homes do not involve only the use of washing machines or washer-dryers. For calculating the overall resources consumed during the laundry process, pre-treatments, drying and ironing of clothes are also relevant processes to take into consideration (IKW 2009).

Figure 3-40 shows the share of energy consumption through a laundry process. According to (IKW 2009) the highest amount of energy (52%) is used for tumble drying. As spin drying is more efficient than tumble drying in terms of energy consumption, improving the performance of spinning (remaining little moisture content) can save energy if consumers use both washing machine and tumble dryer. However, higher spinning speeds also have higher wrinkling effects on the other hand; thus it may increase energy consumption when ironing is applied.

Moreover, for households not equipped with a dryer or a separate laundry room with external ventilation, spinning is essential to prevent excess humidity and consequently formation of mould. Obviously, spinning performance plays an important role in saving energy. Ironing and washing is almost using the same amount of energy around 20 per cent. The share of detergent and fabric softener in energy consumption is around 6%.

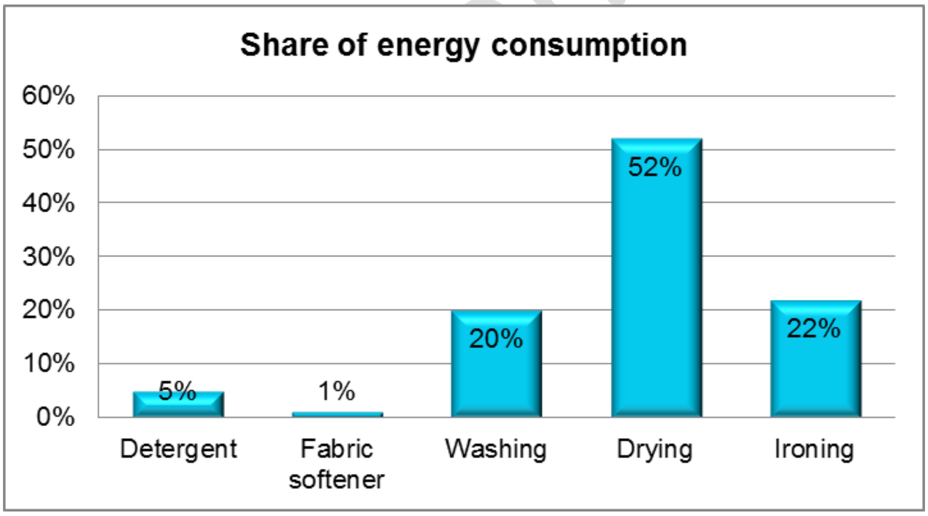


Figure 3-40 Share of energy consumption for washing, drying and ironing (Source: according to (IKW 2009))

In the following, each factors of the laundry process are explained separately. Furthermore, possible ways for reducing energy throughout the laundry process are described; meanwhile a model of predicting energy and water consumption of single households for completing the laundry process is elaborated based on (Stamminger 2011). This model is taking into account the established factors influencing the consumption of resources for laundry treatments and combining this with possible consumer behaviours. To simplify the number of combinations, six artificially created consumer segments () are created and used to show the range of consumption values (Stamminger 2011).

Table 3.9 Characterisation of consumer segments (According to (Stamminger 2011))

Consumer segment synonym	Characterisation of consumer behaviour
Modern	Average laundry behaviour
	Uses tumble dryer intensively
	Normal ironing behaviour
Do it yourself	Average laundry behaviour
	Line drying only
	Normal ironing behaviour
Careless	More than average laundry washing at higher temperatures
	Inefficient spinning process
	Uses tumble dryer
	More than average gets ironed
	Uses old and inefficient appliances
Wish-wash	More than average laundry washing at higher temperatures
	Line drying only
	Less than average ironing
	Uses old and inefficient appliances
Sustainable	Less than average laundry washing at lower temperatures
	Good spin drying
	Use of efficient tumble dryer (heat-pump technology)
	Less than average ironing
Pseudo-Eco	Less than average laundry washing at lower temperatures
	Line drying only
	Normal ironing behaviour

3.1.2.1. Detergents

Dosing detergent seems to be an easy process. However the optimal dosing volume depends on numerous factors such as water hardness, degree of soiling, type of textile, load volume and machine dimension. According to (Sanner 2011) approximately 90% of customers do not consider all these relevant dosing factors and therefore dose detergents incorrectly. The consequences are manifold.

Both over and under-dosage result in lower washing performance and in case of over-dosage both water and detergent are wasted, thus having a negative impact on environment. The waste of detergent is obvious and analysis shows that in average 4.8 kg of detergent is wasted per household and year (Sanner 2011).

In contrast, the waste of water is not as obvious, but it is a result of the excess use of detergent. Extra detergent leads to the foam creation inside the drum. The majority of washing machines on the market are able to detect foam and take counteractions. In order to get rid of excess foam, rinse cycles are added, rinse duration is prolonged and the water level in the tub is raised. When using a powder detergent, which includes a fraction of insoluble components (e.g. zeolites), it is also necessary to rinse out not only loaded soil but also detergent residues. Therefore, there is a need for an easier and more precise detergent dosing process, which allows the consumer to consider all relevant dosing parameters to achieve continuously perfect washing results and furthermore actively practice sustainability.

'Intelligent dosing system (i-DOS)' is one of the introduced technologies in this regard. The system allows automatically dosing liquid detergents and fabric softener in consideration of all relevant dosing parameters, thus using the optimal amount of detergent and water. Research into the saving potential of water shows that, compared to a manual dosage, the automatic dosing function of i-DOS helps to save up to 7062 litres of water and in average 32% of detergent per year (Sanner 2011).

3.1.2.2. Laundry washing

Laundry washing, in the sense of cleaning textiles in aqueous liquor, is a complex process involving the cooperative interaction of numerous physical and chemical influences. In the broadest sense, washing can be defined as both removal by water or by an aqueous detergent solution of poorly soluble residues, as well as the dissolution of water-soluble impurities (Jakobi & Löhr 1987), (Smulders et al. 2002)). Terpstra defines the primary objective of cleaning as "…restoration of the fitness for use and the esthetical properties of the textiles, e.g. removal of soil, stains, odours and creases and regaining surface smoothness and thermal isolation" (Terpstra 2001).

The washing process is described as a function of different: washing temperatures, length of washing cycles, types and amounts of detergent and applied mechanical works. It is best described by using a circle, which many researchers today refer to as Sinner's Circle (Sinner 1960). Stamminger adds a further fifth parameter, water (inner circle), which represents the combining element of all factors (Stamminger 2010). Each of these factors can be substituted to a certain degree by the others and the resulting washing performance remains the same. For example, a decrease of the temperature can be partially compensated by increasing either one or more of the other factors, i.e. chemistry, washing time or mechanical agitation (Wagner 2011), (Kutsch et al. 1997). The combination of different factors depends on the washing technique employed. In the case of washing laundry by hand, the portion of the mechanics is much higher than the portion of the washing time. Laundry washing in a washing machine at a higher temperature results in a higher contribution of the temperature in the washing process.

The total resource use for washing machine R in a consumer environment has been roughly estimated as:

$$R = n_W \times R_W \times eff_W$$ **Equation 3-1**

Where

n_w is the number of wash cycles per household per year,

R_w is an average resource consumption per washing machine and

eff_w is the efficiency correction factor depending on the age of the washing machine

Quite the same approach is pursued for the other processes where the following factors are used to calculate the annual consumption of resources.

3.1.2.3. Laundry drying

After washing, the garments need to get dry. For drying, different processes (i.e. drying on a line in a house / outside and drying in a tumble dryer) are considered as well the following factors:

- Spinning intensity and efficiency of the washing process as this defines the amount of water which needs to be evaporated by drying process.
- Number of cycles the laundry gets dried in a tumble dryer and its efficiency (=1.0 for a conventional dryer, 0.5 for a heat pump dryer and 1.1 for an old dryer).
- Remaining number of cycles (compared to the number of wash cycles): the laundry is assumed to be either dried on a line without resource use or in a house where heating energy is used for drying (Gensch & Rüdenauer 2004).

- Inefficiency of line drying process, where line drying without heat from the house has a factor 0.0 and drying in a heated room a factor 2.0. As seasonal average a value of 1.0 is assumed for those who dry outside on sunny days and inside else.
- Energy needed to evaporate 1 kg of water (=2260 kJ/kg).
- Nominal load size is set to 3.7 kg (IKW 2009).

3.1.2.4. Laundry ironing

Depending on user behaviour, not all garments are ironed. Therefore, only a fraction of the load is ironed. Depending on the drying process and type of cloth, the load needs different levels of flattening. Therefore different fractions are considered to be a realistic approach. Energy demand is reported to be 1.06 kWh per wash load (IKW 2009).

Not only the resources used have been calculated, but also the costs associated with them (basis: 4.20 €/m^3 water and 0.2589 €/kWh electricity).The applied model has shown to be able to provide relevant and plausible values for estimating the real life consumption of energy (Figure 3-41) and water (Figure 3-42) in a private household.

The calculations allow learning more about the influence that different consumer behaviours and installed appliances may have on energy and water consumption for complete laundry treatments in private homes in Germany. Differences of a factor 4 to 6 are much larger than as it resulted in other studies where a factor 2 to 3 was found for CO_2 emissions values between different life-style groups (Baiocchi, et al. 2010). Although CO_2 values were not calculated, energy and water usage are the driving factors for laundry care processes.

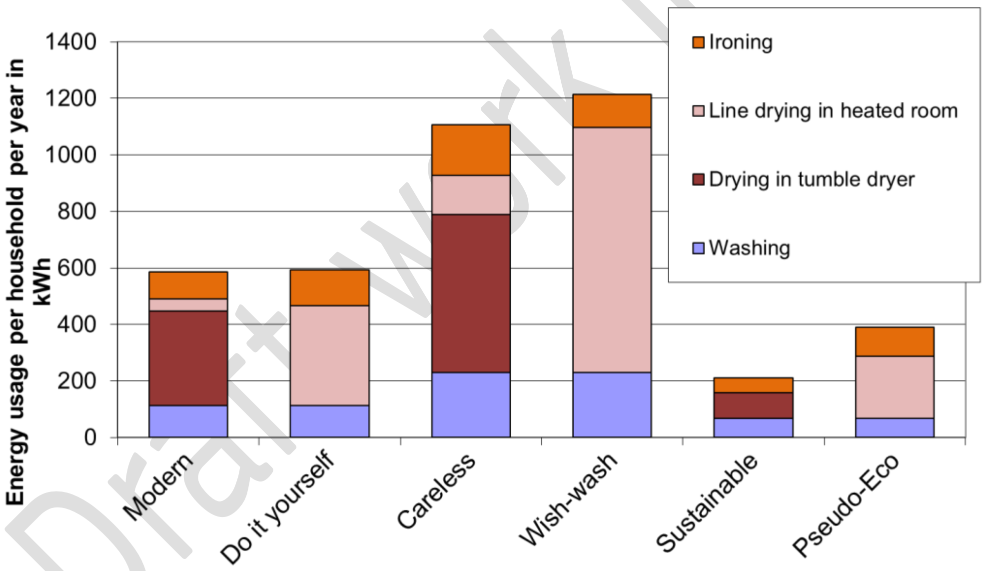


Figure 3-41 **Estimated energy usage per year for six consumer segments for laundry process (Source: According to (Stamminger 2011))**

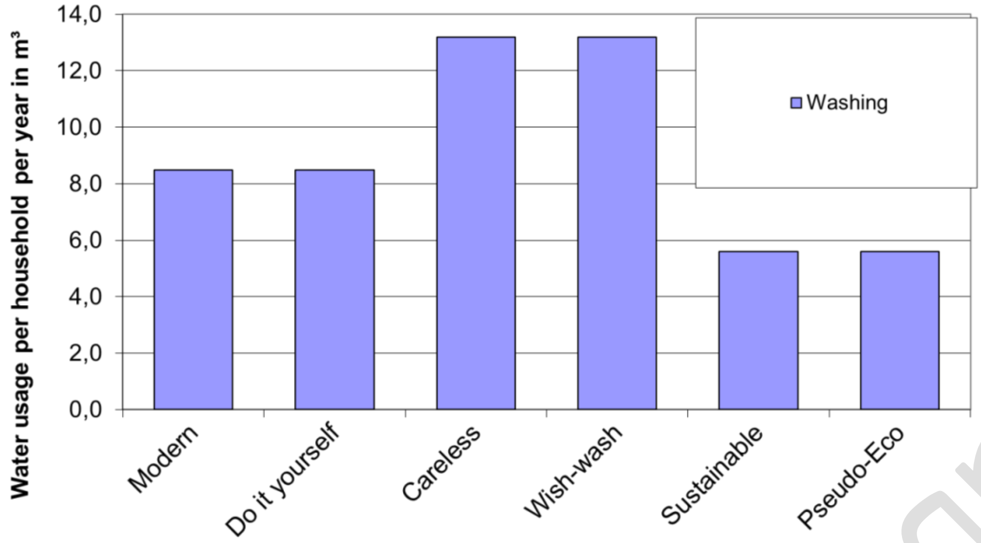


Figure 3-42 **Estimated water usage per year for six consumer segments for laundry process (Source: According to (Stamminger, et al. 2010))**

3.2. Local infrastructure

3.2.1. Energy

Around 70 to 90 per cent of the electric energy in washing machines is used for heating the water, the laundry and the machine which could be replaced by heat from other sources than electricity.

Technical options such as heating by hot water circulation loop ("heat-fed machines") or hot fill, i.e. connecting the machines to the domestic hot water pipe, are described in Chapter 4. For hot fill, research studies result that solar hot water combined with gas heating for hot water supply is the option resulting in the lowest GHG emissions (Saker et al. 2015).

According to Art.13 (4) of Directive 2009/28/EC on the promotion of the use of energy from renewable sources, Member States shall introduce in their building regulations and codes appropriate measures in order to increase the share of all kinds of energy from renewable sources in the building sector. (European Parliament 2009) Taking into account these increasing legal requirements on the use of renewable energy sources for residential heating in several MS, it might be assumed that the technical option of hot filling might become more relevant in future.

3.2.2. Water

With regard to infrastructure and system aspects, the following measures of reduced or sustainable use of water are to be mentioned:

Changing use patterns

Avoiding extra-rinse programmes would be another possible option to reduce the overall water consumption connected to clothes washing (except for consumers having very sensitive skin, who might use the extra-rinse function on their washing machine for better removing detergent from laundry).

Use of grey water and rainwater

Further, reuse of domestic greywater and rainwater has a significant role to play in water efficiency. A rainwater harvesting system can be attached to a tank where the water is finally stored until needed and using a pump the water can then be recycled through the water supply for washing machines. This is very useful as rainwater is what is known as soft water and therefore causes no limescale which can often cause problems with filters and elements in such appliances. (Claridge 2015) Rainwater harvesting systems can provide either a direct or indirect supply from the main storage tank to the appliances. In a direct system the pump sends the rainwater on demand straight to the appliance. In an indirect system, the rainwater is pumped up to a rainwater header tank, where it is gravity-fed to where it is needed. The advantage of an indirect system that pump wear and tear is reduced and 8 to 10 times less electrical power is used because the pump is activated only when the header tank is empty rather than every time an appliance is used (RainWaterHarvesting [n.d.]).

3.2.3. Telecommunication – smart appliances

The smart home has reached domestic household appliances as well and electronics companies are racing to offer Wi-Fi connected multi-featured washing machines. These connected appliances provide the opportunity to consumers to control them remotely. Consumers could have control over almost all operations of their machines including monitoring the washing process remotely, trouble shooting, setting the cycles and several other features, to be operated and controlled via smartphones, tablets and PCs.

LG, Samsung and Whirlpool have all announced smart washing machines in the International Consumer Electronics Show (CES) 2015 with special smart features (Griffin 2015). LG's headline one is that it has a bottom draw that can allow it to take two loads at once, Samsung's is that it has a built in sink and Whirpool's that it can connect with the consumer's thermostat. Moreover, other companies have several innovations in this area.

- The LG "Twin Wash" features have a smaller drawer at the bottom, which can take two separate loads. It means that any other washes, such as delicate, can happen at the same time as normal ones. The washing machine uses HomeChat, LG's smart home platform, to allow its owners to monitor its progress on their smart phone.
- Whirlpool's new washing machine was revealed alongside Nest's announcement that its thermostats and smoke detectors can hook up to yet more home appliances. The Whirlpool appliance can be controlled by a thermostat, asking it to launch when it thinks that the consumer has left the house, for example and will text or email him when the clothes are ready to dry. That is part of a range of smart features built into the Whirlpool, which can also be monitored remotely using its Wi-Fi connection. The washing machine can also time itself to turn on at the most cost-efficient times of day, using electricity during cheaper off peak hours (Griffin 2015).
- Samsung's innovation is called "Active Wash", and tied together a top-loading washing machine with a built in sink where delicate and pre-treat stains can be washed. Smart Control let the consumer remotely control and monitor the washing from anywhere by using a smartphone App. It can be instantly started or paused and cycle selections, remaining time and finishing alerts are monitored (Griffin 2015). Furthermore, easy troubleshooting is another feature of new Samsung washing machines. The Smart Check automatic error-monitoring system detects and diagnoses problems and provides easy troubleshooting solutions using a smartphone App. (Samsung).
- Siemens washing machines are equipped with "isensoric" control unit. The isensoric control unit can precisely identify the volume of the load, its characteristics, and even the degree of soiling on the clothes. One new feature of these machines is stain removal. Each stain is different and therefore has to be treated in a special way. Once attain was manually selected on the washing machine's display, the isensoric control unit collects data from each of the sensors and determines the ideal amount of water, temperature and drum speed. In this way, 16 of the most stubborn stains are automatically and reliably removed.

- Another feature is i-Dos. By this feature, the amount of laundry detergent is precisely adapted to the individual load of laundry (Siemens n.d.). German appliance manufacturer Miele announced a new Miele@Home brand that will take the company's connectivity even further when it launches in 2015 by allowing users control of compatible machines even outside of their home Wi-Fi network. According to Miele, the app will give users full control over all three machines, allowing almost all operation to happen remotely (Miele [n.d.]a).

According to (European Commission 2013a), increased frequency of internet usage, coupled with faster speeds and the growth of mobile access are accelerating recent trends in internet use and inducing new and different behaviour patterns by users. Mobile data traffic is driving an exponential increase in data transmission through the internet. Mobile devices like smartphones and tablets are increasingly moving away from being purely "utility" devices, with entertainment occupying more and more of a central role in the usage of internet on the go.

Smartphones were expected to account for more than half of all handset shipments in 2013, and the percentage was expected to continue to grow, mainly due to decreasing prices and the perceived value and greater integration of mobile apps into everyday life. However, adoption levels are not homogeneous across Europe: While in France, the UK and Ireland the penetration rate of smartphones already exceeded 60% in 2013, Greece, Portugal and Poland have adoption rates below 40% (30% in the case of Poland), all starting from below 10% in 2005. (European Commission 2013a)

Also, (European Commission 2013a) states that the mobile use of the internet is becoming increasingly popular: 27% of individuals now use their mobile phones to access the internet and 36% do so via a portable computer or handheld device. Most mobile internet users are frequent users, going online every day. Across the EU27 Member States, the percentage of people accessing the internet on the move in 2012 however varied substantially. The percentage of the population using the internet on mobile devices (portable computer or handheld device) away from home or work was higher than 60% in four Member States: Denmark (61%), Luxembourg (63%), the United Kingdom (63%) and Sweden (70%). However, it was less than 20% in Lithuania (18%), Hungary (18%), Italy (16%), Bulgaria (13%) and Romania (7%).

In general, the increasing trend to mobile access to internet via smartphone, tablet etc. might also drive the trend towards connected household appliances in future.

3.2.4. Shared washing machines and washing services

Community washing centres are well-known phenomenon in Sweden being practiced since 1920s, and therefore historical data are available, which will provide possibility to track evolution of these services at regulatory and normative levels. In other countries, majority of the laundry is washed in laundromats or by professional washing service companies. No community-based washing centres are usually available (Plepys and Mont).

In Sweden the establishment of washing services was primarily initiated in a governmental programme as a consequence of equality policies aiming at freeing time for housewives. From the middle of the 20th century a trend towards the so-called self-service economy could be seen. Following the chosen course towards integrating women into the work market, the question of assisting the washing activities got regulatory support. A number of studies followed this servicing strategy advocating collective way of doing laundry at the beginning of 60-ies, the countryside households started using private washing machines (Plepys and Mont).

However, in cities communal washing centres were rapidly spreading and commercial washing facilities became more and more common. Later, different national authorities provided a number of recommendations on how these centres should be equipped, how they should be designed so that households would be satisfied and similar. The regulation was so overwhelming that it gradually encompassed even standardising and guiding the design of washing centres and choice of equipment. In a few decades, communal washing centres became a standard feature in urban communities and at some point in time was even considered as an issue raising the prestige of the real estate (Plepys and Mont).

Today communal laundries are spread all over the country (Sweden), where typically 50-400 households share one washing facility with one or more machines. Studies have indicated high customer acceptance in terms of the distance to the washing centre (70%), availability of washing time (50%) and quality of equipment (75%). There are also some drawbacks associated with washing centres, such as low cleanliness in the premises (60% dissatisfied) and the increased use of electrical drum-dryers.

Even though, the long historic record and pervasiveness of laundry services make them interesting to study in more details, but surprisingly few studies on the environmental implications of these services have been made with the focus of product lifetime, energy consumption and other direct environmental impacts (Plepys and Mont).

3.3. Consumer behaviour with regard to end-of-life

3.3.1. Product use & stock life

Whereas this section describes the *consumer behaviour* with regard to the duration of the product use, in section 4.2.5 the product lifetime is analysed from a *technical* point of view (i.e. time to failure of critical parts).

(Prakash et al. 2015) analysed data of the Society for Consumer Research (GfK) for large household appliances in Germany with regard to the developments of the average "first useful service-life". This indicator is the timespan in which the product is *used* only by the *first* consumer; it is – however – not to be confused with the technical product lifetime. The technical product lifetime might be longer compared to the first useful service-life if the appliance is still functioning and is for example passed on within family members and/or to friends or resold to third persons. The GfK data is based on a consumer survey asking for the reasons in case of purchasing a new product (desire for such a product (because no such product was possessed until that moment); wish for an additional product; defect of the old appliance; desire for a better appliance despite functioning of the existing one). In case of replacing existing products, GfK asked for the first useful service-life of the existing product; the GfK data did not provide information about potential second-hand use of products still functioning, i.e. the overall technical lifetime. This can only be derived for those products that were replaced due to a defect (cf. section 4.2.5.1).

The results of (Prakash et al. 2015) based on these GfK data show that the average first useful service-life of large household appliances at all (covering washing machines, dryers, dishwashers, ovens, refrigerators and freezers) in Germany has declined slightly from 14.1 to 13.0 years between 2004 and 2012/2013. On an average, the product replacement of large household appliances due to a defect slightly decreased from 57.6% in 2004 to 55.6% in 2012. This means that a defect still is the main cause of the replacement; on the other hand. It is important to realise that almost one third of the replaced large household appliance was still functional. In 2012/2013, the proportion of devices that were replaced because of a desire for a better device, although the old device still worked, was 30.5% of the total product replacements. The remaining fraction instead had faults / defects which could be repaired.

Extracting the data specific for washing machines, the results show that the average first useful service-life of washing machines in Germany slightly decreased from 12.7 years in 2004 to 11.9 years in 2012/2013. Considering only those appliances still functioning but being replaced due to a wish for a better appliance, the average first useful service-life was 13.1 years in 2004 and 13.2 years in 2012/2013.

Attention has to be drawn to the aspect that the share of consumers replacing still functioning appliances *rather early* to get a better device, increases. For washing machines, 14% of those appliances being replaced on the basis of the wish for a better one were less than 5 years old in 2012 (2004: 10%).

3.3.2. Installation, maintenance and repair practices

The Reuse and Recycling EU Social Enterprises network (RREUSE) is a European umbrella organisation for national and regional networks of social enterprises with re-use, repair and recycling activities. They cover 42,000 Full Time Equivalent (FTE) employees and over 200,000 volunteers working throughout 22 member organisations across 12 EU Member States.

In 2013, RReuse has conducted an investigation into some of the main obstacles its members encounter when repairing products, inter alia for washing machines, to provide part of the basis for setting requirements within implementing measures to improve the reparability of products, and thus their material and resource efficiency. Based on a questionnaire sent out through their network, the findings are answers from 9 individual reuse and repair centres from four national networks of social enterprises namely AERESS (Spain), Repanet (Austria), Réseau Envie (France) and the Furniture Reuse Network (UK).

The study revealed the following common obstacles in repairing household washing machines (RReuse 2013):

Lack of access and cost of spare parts

- Respondents noted a lack of access to spare parts both from the point of view of their availability and price. For example, when ball bearings are pressed into the plastic casing of the drum, in order to replace them, not only do these have to be replaced but also at least part of the casing. However, in many cases reuse and repair centres are forced to purchase the complete casing including the drum which is very expensive, which makes it uneconomic to repair the machine.
- Replacement costs of the electronic card and timer are very expensive as one needs exactly the same component from the original manufacturer in order to repair a washing machine. Whilst reuse centres can repair the appliance using tested salvaged components from obsolete machines, stocking up key used spare parts such electronic boards, timers and pumps is very difficult due to the sheer volume of different types of makes and models of products on the market.

Lack of access to service manuals, software and hardware

- The exact documentation, service manuals and relevant software and hardware to diagnose the faults of the product are difficult to access for reuse and repair operators that are not official after sales service providers of the manufacturers.
- Today's increasing use of electronic instead of mechanical components means that one can often only identify the problem with the appliance by attaching it to a laptop using special hardware and using fault diagnosis software. Use of these tools requires training and are often only available to the after sales service providers of the manufacturers which makes repair of washing machines for reuse centres often impossible due to a simple lack of information.

Examples of design that hinders disassembly for repair:

- Control board: Finding the defect in the electronic board is becoming increasingly difficult, especially if some boards are sealed with resin. This means that electronic board components which are most known to fail the quickest can often be very difficult to access and replace.
- Door Hinges: Door hinges that are fused to the washing machine are extremely difficult and time consuming to replace due to accessibility
- Repairing the drum spider, seals, bearings and drum casing is often impossible, especially if the bearings are forced into the 'plastic' outer casing of the drum. This is especially because of the price needed to replace these components and also because there are some instances where the drum casing is impossible to open as it is physically sealed.

The Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) used following generic input data for the category "Maintenance, repairs, service" of washing machine models in 2007:

Table 3.10: Average input data for maintenance, repairs and service of a 5 kg washing machine model used by Lot 14 in 2007; source: (ENEA/ISIS 2007c)

Maintenance and repairs needs for a 5 kg washing machine	Amount
Number of km over the product life for the maintenance and repairs service	160 km / product life time
Spare parts (fixed value: 1% of product materials and manufacture)	723 g

According to stakeholders, maintenance and repair are very important, and more important with more efficient machines. Products are provided with extensive installation instructions to ensure that maintenance and durability are not impacted. For washing machines, for example, filter cleaning on a monthly basis is relevant for maintenance. General cleaning of surfaces including door gasket is recommended. Hot washes are also recommended every couple of months for avoiding build-up of detergent. He also assumes if products are installed in a kitchen that is used by more than one household (e.g. in student dormitory buildings), it can be expected, that product maintenance is on average not as good as for a product used by only one household. This will then also reduce the durability.

A stakeholder has provided examples of typical maintenance and repair instructions given in user manuals (cleaning of the washing machine, cleaning of the detergent dispenser drawer, cleaning the pump, use of descaling agents in case of very hard water). To facilitate repairs, certain tools are provided: technical assistance service; fault code in the user interface indicating the suspected cause of breakdown; PC diagnostic tool to detect faults by the technical assistance and to update the software.

According to feedback from one stakeholder, spare parts usually cost too much, leading consumers to buy new products instead of repairing the old one. High spare part costs are often combined with high labour costs and design options that impede repair. Another stakeholder points out that for essential household appliances such as dishwashers and washing machines consumers can usually not manage without them for a longer time. Offering a similar product as a loan to cover the repair time would make repair more attractive.

Regarding repairs, in September 2014, Portuguese consumer organization DECO Proteste published a study on washing machine repair services. In the context of the study, DECO contacted 29 different repair shops/services for a small repair of a specific washing machine. Many of the services made an incorrect diagnosis of the malfunction, others charged for pieces that were not replaced and others didn't present a correct invoice for the service. Such situations can create a feeling of mistrust from consumers regarding the repair services. DECO also investigated the price of replacement parts for washing machines and more specifically for parts that could be replaced by the consumer himself. For these parts, the costs vary from under 2 € to 50 €. For small repairs, consumers could even avoid a repair service. However, the lack of information on how they can repair the appliance themselves is an impediment to that.

3.3.3. Collection rates, by fraction (consumer perspective)

(Huisman et al. 2012) describe the following possibilities for consumers to get rid of no longer used (waste) electric and electronic equipment (W)EEE, inter alia large household appliances like washing machines and washer-dryers.

- Municipal collection point: Also called 'waste transfer station' or 'container park'. Households discard bulky household waste like furniture, hazardous waste and also WEEE at these container parks. By law, municipalities are obligated to have at least one location where households can discard waste like furniture, chemical waste and also WEEE. From these collection points, most

WEEE is handed over to the system of the compliance schemes (treatment plants being in compliance with at least the minimum standards required for accreditation). Another possibility is that municipalities sell WEEE or dismantled fractions like copper cables to metal scrap processors to receive more money than the reimbursement per ton collected from the compliance schemes.

- Retailers: When households buy new equipment, they can hand in the old item ('old for new'). Retailers having a contract with the compliance schemes will hand over the received equipment to recyclers that are under contract of the compliance schemes. Some of the contracted retailers, however still deliver such equipment outside the compliance scheme. Retailers without a contract can still legally sell WEEE to local or regional metal scrap processors.
- Door-to-door collection: Households can also choose to give or sell WEEE to door-to-door collection which mainly happens in cities or being announced by local collectors collecting metals and used EEE. Driven by high metal prizes informal collection pathways exist and obviously the collected WEEE will never be handed over to the system of the compliance schemes.
- Charity initiatives: Charity initiatives often work in close cooperation with municipalities and businesses. Their main function is to sell 2nd hand appliances, if still functioning, to other consumers.
- 2nd hand/internet market: Usable equipment will be sent from one household to another. Strictly speaking, this is not WEEE but it affects the amounts of WEEE since the equipment can be used for a longer period. In order to prevent double counting of equipment, it is necessary to exclude the 2nd hand market from the WEEE prediction model.

Due to the large size of devices, disposal via the municipal household waste is believed not to be relevant in terms of quantities.

For Italy, (Magalani et al. [n.d.]) state that for large household appliances the two main disposal paths are through municipal collection points and retailers. Regarding retailers, large household appliances are mostly picked up at consumers' homes 75-95% of the time, often in conjunction with the delivery of new equipment.

Table 3.11: Disposal channels for large household appliances used by consumers in Italy in 2012; source: (Magalani et al. [n.d.])

	Average disposal channel of large household appliances*
Municipal collection points	39.1%
Retailers	37.1%
Reuse (sold or given away)	8.0%
Bad habits (e.g. waste bin, plastic waste, other wrong streams)	5.8%
Life extension (old house…)	5.3%
Do not know, do not remember	4.1%
Warranty replacement	0.6%

* Note: In this study large household appliances subsume: dishwashers, washing machines, wash dryers and centrifuges, furnaces and ovens, and microwave ovens. The rates within these waste streams might vary, e.g. the re-use rate is 1.5% for boilers and 20% for microwave ovens. Further, the likelihood of improper disposal practices appears negatively correlated with the size of the equipment, i.e. for washing machines and washer-dryers the values might be smaller.

According to stakeholder feedback via questionnaire, about two-thirds of e-waste is managed by commercial actors without the involvement of producer responsibility schemes.

3.3.4. Estimated second hand use, fraction of total and estimated second product life

According to (WRAP 2011a), washing machines are thought to pass through a wide range of pathways once they have reached the end of their first life. This may be via direct reuse (e.g. passed on to friends and family, sold in online networks, or given to a charity), retailer „take-back" schemes, bulky waste collections and drop off at Household Waste Recycling Centres. Owing to their bulk, washing machines are not thought to be disposed of through regular household waste collections. In their case study on benefits of reuse, WRAP indicates that 97% of the washing machines are sent to either recycling (43%) or landfill (54%), meaning that 3% might be reused.

In section 3.3.3 above, (Magalani et al. [n.d.]) estimate the re-use rate (appliances sold or given away), of large household appliances in Italy 2012 to be 8%. However, this data covers dishwashers, washing machines, wash dryers and centrifuges, furnaces and ovens, and microwave ovens. Especially for re-use, the rates vary, e.g. the re-use rate is 1.5% for boilers (fix installed) and 20% for microwave ovens (smaller appliances). This leads to the assumption that the rate for large household appliances such as washing machines and washer-dryers might be lower than 8%.

Refurbishment for reuse only takes place in cases where it is economically viable. According to (WRAP 2011a) , on average, of the machines received by reuse organisations, 25% are sent to recycling immediately, with another 10% sent to recycling after initial testing. The result is a low level of reuse of washing machines. In the UK approximately 100,000 washing machines (6,700 tonnes) are reused in some form every year. This represents 3% of all washing machines reaching the end of their life each year. Preparation for reuse by charitable and private organisations currently accounts for just 1.5% of discarded washing machines in the UK, while 1.3% are reused directly via online exchanges or otherwise.

(WRAP 2011a) identified that typically, a washing machine donated to a preparation for reuse organisation is 4-5 years old. This is likely to be the point at which the item has reached the end of its economic life for the first owner (e.g. it requires a repair the owner has decided not to undertake). With a life of 12 years, this suggests that a reused item may last up to 8 years in its second life. The technical lifetime can typically be extended by refurbishment. Data describing refurbishment periods are limited, but the WRAP study assumed that refurbishment occurs once and extends the lifetime of a washing machine by 6 years (1500 cycles).

For washing machines, stakeholders describe that the market for reused and remanufactured products or components has the character of a "grey market", which is not well-organized; some retailers offer this "service". It has been also reported that re-used washing machines and washer-dryers are mainly reconditioned in charity like operations and offered for sale to target customers with lower incomes.

3.4. Summary and discussion: users

This section provides a summary of the findings related to user behaviour, as well as a number of discussion points. An important complement to the information provided will be the results of an on-line survey launched in April –May 2015, which will be available mid-June, and whose preliminary findings will be presented at the first stakeholder meeting.

3.4.1. Summary

3.4.1.1. Frequency of operation

Washing machines

According to a user survey carried out throughout Europe by the University of Bonn in 2011, the average number of washing cycles in Europe has decreased from 4.0 to 3.8 cycles per week, in 2011 the average number of wash cycle per week ranged from 3.5 (France, Czech Republic and Sweden) to 4.1 (Italy, Poland and the UK). Furthermore, the average of wash cycles per person per week is 1.3 for the year 2011.

Based on the survey of AISE in 2011, the average number of wash cycles per household resulted to be 3.2 times per week.

Data from the Water Energy Calculator reports that households use the washing machine on average 4.7 times each week, lower than previously used data (5.5 times per week).

In summary, although there are differences in the data gathering methodologies, these surveys confirm that there are about 4 wash cycles done per household per week in Europe.

Washer-dryers

Based on the survey of University of Bonn in 2011, the average number of washing cycle per household is 4.3 times per week and the average use of 'wash+dry' cycle is 1.1 wash cycles per week and household.

3.4.1.2. Selected programme temperature

Washing machine

Based on the survey of University of Bonn, on average, around 40% of washes are done at 40°C. However, the washing temperatures are quite variable in different countries. The second most used temperature is 60 °C (19%). About 5% of the washes are done at 90 °C programme. The weighted average of these nominal washing temperatures is 43.3 °C (actual temperatures may be lower).

The analysis of selected temperature classes by AISE shows that on average the laundry is washed with a temperature of 41.0 °C.

Results of IKW illustrate that the average washing temperatures (calculated using the nominal washing temperatures) have dropped from 63 °C to 46 °C in almost 40 years (1972 to 2010).

These results show that the average temperature of the wash cycle has decreased and that lower temperatures are getting more important. The average lies probably at about 40-45°C. Programmes at higher temperature have higher energy consumptions.

Washer-dryers

Based on the survey of University of Bonn of 2011, the most frequently used washing temperature is 40 °C (32.3%), followed by 30 °C and 60 °C in similar percentages (20.4% and 18.2%, respectively).

3.4.1.3. Loading

Results of the survey carried out by the University of Bonn in 2011 shows that almost 60% of respondents claimed to use the full capacity of their washing machine.

Results of AISE in 2011 illustrate that the majority of consumers in various countries load their washing machines 75 up to 100% full.

3.4.1.4. Spin speed and drying behaviour

Washing machine

The 2011 survey from the University of Bonn shows that on average, European consumers spin dry their laundries at a spin speed of 941 rpm.

According to the responses obtained, on average, 55% of drying in the summer takes place outside, on a clothes line. This drying method decreases in winter to about 40%. In winter time, the preferred option seems to be the drying of clothes in a heated room inside the house (51%).

Washer-dryers

In line with the results of washing machines presented above, there is a tangible difference in drying behaviours depending on the season. In summer, nearly 70% of respondents mentioned to dry their laundry outside on the clothes line. In comparison, only 16% choose this option in winter. Results also suggest that the laundry is often/always dried in a heated room of the house when the outdoor temperature is low (66%). The drying option of the washer-dryer is used only sometimes, rarely or never. In winter, the drying option of the washer-dryer is used often or always in nearly 43% of all households. The frequency of use of this option is lower in summer (23%).

3.4.1.5. Further results

- Laundry processes in private homes do not involve only the use of washing machines or washer-dryers. For calculating the overall resources consumed during the laundry process, pre-treatments, drying and ironing of clothes are also relevant processes to take into consideration (IKW 2009).
- According to IKW (2009), the highest amount of energy (52%) is used for tumble drying through a laundry process.
- The optimal detergent dosing volume depends on numerous factors such as water hardness, degree of soiling, type of textile, load volume and machine dimension. According to Sanner (2011), approximately 90% of customers do not consider all these dosing factors relevant, and thus likely dose detergents incorrectly.
- Based on these GfK data, Prakash et al. (2015) show that the average first useful service-life of large household appliances (covering washing machines, dryers, dishwashers, ovens, refrigerators and freezers) in Germany has declined slightly from 14.1 to 13 years between 2004 and 2012/2013. On average, the product replacement of large household appliances due to a defect slightly decreased from 57.6% in 2004 to 55.6% in 2012.
- WRAP (2011a) identified that typically, a washing machine donated to a preparation for reuse organisation is 4-5 years old in the UK. This is likely to be the point at which the item has reached the end of its economic life for the first owner (e.g. it requires a repair the owner has decided not to undertake). With a technical life of 12 years, this suggests that a reused item may last up to 8 years in its second life. The technical lifetime can typically be extended by refurbishment. Data describing refurbishment periods are limited, but the WRAP study assumed that refurbishment occurs once and extends the lifetime of a washing machine by 6 years (1500 cycles). The share of consumers replacing still functioning appliances to get a better device is increasing. For washing machines, 14% of the replaced appliances were less than 5 years old in 2012 (10% in 2004).

3.4.2. Discussion points: users

The following points will be discussed with stakeholders at the first Technical Working Group Meeting:

3.4.2.1. Programme duration

Programme time is an important parameter for balancing the information on the energy efficiency of a washing machine and a washer-dryer. As described in this Chapter, it is possible to achieve low energy consumptions by prolonging the programme time. Also, market research reveals that currently there is a trend by manufacturers to supply the market with appliances with longer average duration of the standard Eco programme (cf. section 2.2.6.3). This effect is not so clear for washer-dryers so far.

On the other hand, consumer research reveals that one of the reasons for not using the standard Eco programme is exactly this. The most accepted programme duration by average users is generally not longer than 3 hours, while an increasing number of Eco-programmes exceed currently 4 hrs.

However, also communication plays a role. Research indicates that acceptance of (longer) "eco" programmes can increase when consumers are informed about the role of the washing cycle duration (i.e. why "eco" programmes have long programme durations and still are the most efficient).

To allow customers at the point of sale to make a well-informed purchase decision and to let them choose the most appropriate washing programme for their daily needs, it is proposed to discuss which, when and how information should be provided on the programme duration.

Discussion point 3.1

a) Do you think consumers would select longer programme times if they were better informed that longer cycles can have lower energy consumption values (but can have higher water consumption values)? Please explain why / why not

b) How should the consumer be informed about this?

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3.4.2.2. Facilitate the selection of the tested programme(s)

The sections above provide evidence that the standard programmes are currently not always chosen by consumers, because of their long duration and in some cases also for not reaching the indicated temperature of 40 °C or 60 °C. Additionally, some stakeholders indicate that the standard programmes are not always easy to find and select in the appliances, and that the standard programme indicator (an empty arrow) might not be well understood by all consumers.

The ambition of the ecodesign and energy label Regulations shall be that the set of programmes which the consumer select most often to wash normally soiled clothes, and thus result in the largest energy consumption in the EU annually, should be the programmes tested for Ecodesign and Energy Labelling. These programmes shall also be easy to identify when operating the machine.

The revised requirements shall facilitate those goals.

The standard shall continue to define, in an updated manner, the conditions of testing of the programme that is associated to the attribution of the label class.

On the other hand, reference to "standard programme" might create some confusion. In this respect, for dishwashers the use of the name ‘Eco’ has proven to help the consumers to identify the most efficient washing programme. Therefore, it might be discussed the appropriateness of:

- Keeping/revising the definition and the name of this programme in the revised ecolabel and energy labelling regulations, and in the associated standards.

- Requesting that the energy efficient standard programmes are selected by default when the machine has such capability (e.g. default setting when starting the machine);

Discussion point 3.2

a) Should the energy saving programme(s) for washing machines / washer-dryers be called "standard programmes", "eco-programmes" or do you have a different proposal for definition and name to use? Please provide your answer with an explanation.

Moreover, see

Discussion point 1.3 and points below

3.4.2.3. Consumption values of ALL programmes and information to the consumer

The information that consumers get about energy and water consumption values at the point of sale via the energy label is based on one specific program, the 'eco' programme. To help consumers make better informed purchase choices, and once the appliance is bought, programme selections, It could be recommendable that the appliances provide information on the consumption values of other programmes before and after the purchase of the appliance.

Therefore, it could be recommended that the user manual contains, besides the information on the eco programme, also detailed information on energy consumption, water consumption, programme time and the preferred usage of this programme for each individual programme. Some appliance models are already providing such information. Similarly, the functioning of options could be described by figures, e.g. how much more or less energy is used.

It is proposed to discuss if information about all programmes could be indicated on the machine itself (e.g. before it starts the programme and/or once the programme has finished). By doing this, the consumer has access to the information easily and at any time the machine is used. This would encourage consumers to choose the most suitable appliances and programme for their needs.

Given the large amount of information already provided to consumers, any proposal of additional information has to be carefully analysed as not to overload with information, especially if of technical character, as this may generate confusion.

Discussion point 3.3

a) Would it be possible to indicate the consumption values of every programme available in the user manual, in a cost-effective manner? Please explain why / why not

b) Is it possible to indicate directly on the machine the expected consumption values before the programme starts, and the actual consumption once it finishes? Please explain why / why not

c) Do you think that the information provided in the user manual should be simplified? Please explain why / why not, and which areas are most critical.

3.4.2.4. Use of hot water

If a user has a hot water supply, especially if based on renewable energy sources, this can be used to feed the appliance. To support consumers in using alternative hot water supplies, manufacturers could include clear statements about the fitness of their appliances for a hot water connection, be it in the user manual, the energy label, or the product data sheet.

It is proposed to discuss whether additional communication efforts shall be made (e.g. special symbols in the energy label) indicating if the appliance can be connected to an external hot water supply, and if additional advice with specific instructions on this (e.g. maximum temperature of the how water inlet) shall be provided in the user manual.

Discussion point 3.4

a) Do you think that the fitness for a hot water supply should be indicated on the energy label? Please explain why / why not

b) Which additional information could be necessary to help the buyer/user to save energy, and protect the functioning of the appliance?

c) Are there any additional constraints to the use of external hot water supplies that one could mention?

3.4.2.5. Supporting demand-response enabled appliances

This point has also been included in section 1.4.2.10.

As the energy system of the future is getting more and more variable due to fluctuating energy production by wind and solar PV stations, it is necessary and helpful to have some flexibility on the demand side as well. This can be realised by appliances which offer a demand-response possibility. However, a sufficiently large number of appliances need to be in the market before such a system can be launched. It is therefore useful for a more energy efficient power supply to support the introduction of demand-enabled appliances.

Discussion point 3.5

a) Should demand-response enabled appliances be incentivized, e.g. by a bonus-malus in the EEI? Please explain why / why not

b) Can showing information about the availability of such feature on the label be of any value? Please explain why / why not

3.4.2.6. Shared washing machines and washing services

Communal washing rooms and washing machine renting are also available in parts of the EU. Communal washing machines are normally heavy duty machines, i.e. professional or semi-professional machines. Little information is available on the characteristics and market relevance of rented machines, or the provision of washing services (i.e. a household signs a service contract with a company, which installs in the household a machine, replacing or repairing it when necessary, while the household pays a monthly fee).

Discussion point 3.6

a) Do you have specific information / examples of machine rental/leasing and the operation of washing services?

b) Do you have any information about their current diffusion, their frequency of use and the expected trends for the future?

4. Task 4: Technologies

This section aims at collecting information on technologies and preliminarily identifying the main product options for which it could be relevant to perform an environmental and economic assessment, as for instance:

- Typical reference products available on the market (for building Base Cases),
- Product (design) options with improved performance,
- Best available technologies on the market (BAT),
- Technologies for improving energy/resource efficiency not yet available on the market (BNAT)

4.1. Technical product description

4.1.1. General principles of washing and drying

4.1.1.1. Sinner Circle

The washing process is based on four factors: mechanics, temperature, chemistry and time. These factors depend on each other, i.e. one factor cannot be reduced without increasing one of the others (if the same washing performance has to be maintained).

4.1.1.2. The typical phases of a washing cycle

The typical phases of a washing cycle are:

- Pre-rinse: offered as additional option; a pre-rinse is carried out without detergent for taking out all kind of loosely bound soils.
- Main wash: depending of the chosen programme with different water levels and wash rhythms (from sensitive or hand-wash to intensive)
- Main Rinses: 2 to 4 rinse phases and different water levels; an additional rinse is carried out when for example a temperature below 60°C is selected, if there is too much foam in the drum, a spin speed lower than 700 rpm has been selected or no spin has been selected.
- Spinning: final spinning in all programmes for water extraction; depending on the chosen programme additionally an interim spinning phase

  Anti-crease: At the end of every programme, with the exception of the Wool programme, the drum continues to turn at intervals for up to 30 minutes to help prevent creasing. The door can be opened to remove the laundry at any time during the anti-crease phase.

The different programme types mainly differ in the reached temperatures, the levels of water consumption, the intensity of wash rhythms, the number of rinses, the length of different phases, and the number of spinning and their speed. The panorama of washing programmes is broad and various. Example of typical washing programmes is provided in the following:

- Cotton 20°C/ Cold wash
- Cotton 30°C
- Cotton 40°C
- Cotton 60°C
- Cotton 90°C
- Synthetic / Easy care 30°C

- Synthetic / Easy care 40°C
- Standard cotton 40°C (Eco)
- Standard cotton 60°C (Eco)
- Quick wash / Short
- Wool / Hand wash
- Mix / automatic (all fabrics)
- Other wash programmes

4.1.1.3. General approaches to reduce the energy (and water) demand of washing machines and washer-dryers

The energy breakdown in a washing cycle can be split into 3 main contributions:

1. Heating: By far the most energy consuming component for both washing machines and washer dryers is the electrical heating system. The energy for heating can be divided into energy for heating water (based on heat capacity of water) and energy for heating the laundry and machine parts (estimation: about 50% of the energy for heating water; specific heat of laundry is about 1/3 of that of water). Therefore washing at low temperatures has a high energy saving potential.
2. Motion: With much lower energy consumption per cycle, the motor is the second contributor. The exact share mainly depends on the motor efficiency and programme type. The absolute consumption may vary between 0,1 and 0,4 kWh.
3. Other aspects: All other components' energy consumption is negligible. Spinning uses little energy especially compared to the energy consumption that is needed by a tumble dryer when the laundry is insufficiently spun (e.g. with an efficiency B instead of A).

According to one stakeholder, in a cycle where the total energy consumption is 1.5 kWh, 55% is used for the heating phase, 25% for the mechanical action and 20% for the rinsing and spinning phase.

Another stakeholder splits the total energy of a 60 °C washing programme into around 68% for heating, around 30% for motor and pump, and around 2% for controls.

Due to the interrelation of the four factors of the sinner circle (see above) one possibility to reduce the energy demand of a washing machine or washer-dryer is to reduce the temperature and compensate it by extending the duration of the washing cycle. Therefore today's most energy efficient programmes have very l ong cycle duration. Special low-temperature detergents have been developed which can ensure good washing performance. However, this comes with some consequences:

1. It is important to consider hygiene aspects especially with regard to lowering the temperatures reached during the washing cycle.
2. Long washing programmes increase the mechanical action on the textile and thus cause wear and tear.
3. Waiting time may be not satisfactory for consumers.

Also reducing the amount of water can help to reduce the energy demand as less water has to be heated. There are various technical possibilities that contribute to lowering the amount of water which were utilised during the last decades, e.g.:

- Sensors adapting the water consumption to partial loads
- Improved drenching of the laundry
- Reduction of the number of rinse cycles or improved rinsing.

According to market research, the water consumption already has decreased to a large extent during the past years; while in 1997 water consumption of the majority of machines was 66.8 litres per cycle in 2013 this value reached 45.1 litres per cycle (compared to around 50 litres taken as standard Base Case for washing machines in the EuP Preparatory Study Lot 14 in 2007). A further reduction of water consumption is partly seen critical and should only be achieved in combination with a good rinsing performance to avoid residues of detergents on the laundry, especially for people with sensitive skin.

Another way to reduce energy demand is to **recover part of the heat** which otherwise would escape as waste heat. Possible options are e.g.

- Use of heat exchangers,
- Use of heat-pumps.

Also the **drying process can be optimised.** Possible options are e.g.

- Higher spin speed at the end of the washing cycle can reduce the residual moisture content of the laundry resulting in lower energy demand for a subsequent drying process
- Use of heat pumps to reuse the heat during the drying process in washer-dryers.

4.1.2. Existing products

4.1.2.1. Evolution of the product and preliminary environmental considerations

Nowadays, main innovations take typically place every 8-10 years. However, no general answer can be given since it depends on market conditions and technological evolution.

New developments are introduced on the market after extensive environmental impact assessments, market relevance studies and consumer acceptance studies.

In terms of environmental impacts, it can be generally agreed that the use phase is the main source of environmental impacts. Manufacturers have reported that they constantly investigate on possible improvements which may lead to lowering the environmental impact of their appliances. However, some stakeholders consider that improvement potential for this technology may be close to its technical limit, although there could be the possibility to influence positively user behaviour. With respect to water saving, it has been pointed out that in some regions this might lead to additional water consumption for cleaning the public drainage systems.

Noise has been indicated also a source of concern by some stakeholders, as well as material resource efficiency (e.g. detergents and other material use, durability, reparability and recyclability) although some of these aspects are already regulated through other legislation (e.g. RoHS, REACH, WEEE, F-gases).

4.1.2.2. Basic product types

According to the definition given by Commission delegated regulation No. 1061/2010 (European Commission 2010) and Commission regulation No. 1015/2010 (European Commission 2010b), a "'household washing machine' means an automatic washing machine which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes." Besides this general definition, both regulations further use various sub-categories of washing machines (built-in appliances; different requirements related to capacity of the machines, cf. section 0).

The same regulations define 'household combined washer-dryer' as "a washing machine which includes both a spin extraction function and also a means for drying the textiles, usually by heating and tumbling".

In the following, these basic types of washing machines and washer-dryers shall be introduced systematically.

Basic differentiation of washing machines and washer-dryers by the way of installation

The washing machines on the market can be divided in various sub-categories according to the type of construction and the way they are installed. (HEA n.d.)

- *Freestanding front loaders* have a preinstalled countertop and are loaded from the front. Depending on the capacity their dimensions are: height 85-96.5 cm, width 59.5-60 cm, depth 55.5-64.5 cm.
- *Freestanding top loaders* are loaded from the top; this means they cannot be put under the countertop. Their lid can partly be used as work surface. The typical dimensions of top loaders are height 85-91 cm, width 40-45.6 cm, depth 60-65 cm, i.e. they are usually smaller than front loaders. They are not common to washer-dryers.
- *Under counter*: Usually the preinstalled countertop of the freestanding front loaders can be removed to put the device below the general countertop (e.g. if it is installed in the kitchen).
- *Integrated*: Besides the freestanding machines there are machines that are capable of being integrated in the kitchen cabinets. In these cases the front door of the appliance is hidden behind a kitchen cabinet front. Either they are semi-integrated which means that the control panel is still visible or they are fully integrated which means that the control panel is hidden behind the door and thus invisible from the front. The front looks identical as any other kitchen cabinet. The dimensions of integrated washing appliances are: height 82-87 cm, depth 54-58 cm, width 60 cm.

Basic differentiation of washing machines and washer-dryers by capacity

With regard to capacity there is a wide variety of household washing machines and washer-dryers on the market (from 3.5 to 15 kg). An overview of capacities is provided in section 2.2.4.1 for washing machine models and in section 2.2.4.2 for washer-dryer models.

4.1.3. Improvement options

The following sections describe different areas of technological progress which have an influence on energy, water and/or other resources consumption (e.g. materials, detergents). Main sources of the description of the development were the WASH II study (Novem 2001), the preparatory study on domestic dishwashers and washing machines ("Lot 14") of 2007 (ENEA/ISIS 2007b)(ENEA/ISIS 2007c) and new information based on stakeholder feedback, scientific publications and other web sources (e.g. www.topten.eu).

These are the improvement options preliminary considered:

1. Machine construction
    - Tub-drum geometry
    - Increased rated capacity
    - Multi-drum washing machine
    - Fiberglass drum construction
    - Increased durability
    - Use of recycled plastic (washing machine)
2. Increased motor efficiency
    - High efficiency motors
    - Optimised materials in motors
3. Time-temperature trade off

- Decrease of reached temperatures in the washing programmes
- Low temperature programmes: introduction of 20°C cycle
- Programmes handling hygienic aspects

4. Improved thermal efficiency
   - Design optimisation
   - Washing machines with heat pump technology
   - Washer-dryer with heat pump technology
5. Alternative heating systems
   - Hot-fill-feature:
   - Heating by hot water circulation loop ("heat-fed machines")
6. Reduction of water consumption
   - Rinsing optimisation
   - Use of rain/well water
   - Water recycling
7. Optimised mechanical action
   - Ecobubble™technology
   - Internal water circulation
   - Spray-technology
8. Spin speed and alternative drying systems
   - Alternative drying systems
   - Increase of spin speed
9. Sensors and automatic controls
   - Unbalance control
   - Automatic load detection
   - Automatic detergents dosage systems
10. Anti-crease mechanisms
    - Steam Care/Steam finishing
    - Anti-crease systems
11. Alternative washing systems
    - Ultrasonic cleaning technologies
    - Polymer bead technology
12. Consumer feedback mechanisms
    - LCD with actual load indication
    - Display of consumption of resources
13. "Smart" appliances
    - Internet connectivity

- Electronic update of the programmes /diagnostics:
- Smart grid ready (SG ready) products

14. Others

- Noise reduction
- Single stain removal system
- Delay start
- Voice controlled appliances
- Mixed appliances.

4.1.3.1. Machine construction

Tub-drum geometry:

As described in the WASH II study this option means diminishing the tub drum clearance and increasing the drum volume (without increasing the declared load, thus increasing the volume-to-load ratio). This reduces the suds volume and, because of better washing performance, allows saving energy.

Manufacturers were expecting little to no benefits by reducing the clearance and increasing the drum volume versus load capacity. This was considered debateable because of the recent introduction of washing machines with a larger drum volume (with rated capacities of up to 7 kg, which was then a really big machine). Also between 1993 and 1998 the volume-to-load ratio of the average washing machine has increased by around 10 to 15% (from 42-44 litres drum to 48 litre drum without changing the rated capacity of 5 kg).

The tub drum clearances had been reduced significantly with values found as low as 10 mm. Both factors have led to an improved washing performance (thus enabling decrease in time or energy input) and a reduction in the suds volume (directly leading to lower energy demand).

In Lot 14 it was considered that the tub drum geometry had been fully optimised in the machines on the market. Today the rated capacity has increased even further. The average capacity has increased from about 4.8 kg in 1997 to 7.04 kg in 2013, with capacities up to 15 kg (see section 2.2.4) without increasing the outer dimensions of the appliances. This means that, although the drums have increased and the tub drum clearance is very low, the volume to load ratio has decreased. Further optimisation with regard to tub-drum geometry to reduce the suds volume seems not possible. This is also reflected by the fact that manufacturers try to reduce the suds volume while maintaining the drenching of the load by other means, see section 4.1.3.5).

Increased rated capacity:

In 2007, according to the “old” Energy Label, larger washing machines, i.e. with a higher rated capacity, were allowed to consume more per cycle as the allowed energy demand for a certain efficiency class was based on a “per kilo” basis. The additional water and energy needed for an additional kilogram of laundry however was usually lower than the average consumption per kilo of the smaller machine. Thus it was easier for larger machines to reach certain energy efficiency classes. In Lot 14 an increase of the capacity of 1 kg (from 5 kg to 6 kg washing machines) was considered as improvement option.

Meanwhile the average capacity has grown even further with 7 kg machines being the average, but also models with larger capacities (from 8 to 15 kg) are available on the market (cf. section 2.2.4.1).

The method for calculating the Energy Efficiency Index (EEI) has been adapted to the evolution of the market. Larger machines are allowed to have a higher absolute energy demand than smaller machines, however, the allowed energy demand per kilogram of laundry is slightly lower, i.e. larger machines have to be slightly more efficient on a per kg basis.

It is unclear however if people use the bigger machines up to full capacity. Especially with the decrease of household size and the increase of special programmes offered by the machines (and the respective detergents offered by the detergent industry), like “black”, “jeans” or “outdoor”, the amount of specific types of laundry washed per cycle should be even smaller than for an half load. On the other hand, larger machines might increase the total amount of laundry that is put into the machine. The user surveys by University of Bonn and A.I.S.E described in section 3.1.1 show that the number of washing cycles per person and week are decreasing, probably suggesting that the larger capacity of washing machines might have been exploited, at least partly.

All in all, there is a drawback for high rated capacities: even if larger machines can wash more efficiently per kg of rated capacity, more and more partial load washing will occur. This makes that the relative savings per kg of nominal load are lost. Ideally, half load should lead to a reduction of electricity consumption per cycle by 50% compared to a full load in the same programme. However, according to results of the ATLETE II project (cf. in section 2.2.1.2), the reduction ranges from 0% to 41% in practice, which leads to an increase of the energy consumption per kg of laundry.

This might also indicate that more emphasis should be given to partial load cycles for the calculation of the EEI.

Multi-drum washing machine

“Multi-drum washing machines”, introduced for example from Haier and LG, have been a new trend. It has two side-by-side or above washing drums where each drum could either work together or separately and each could finish a complete washing process.

Multi-drum washing machines could be used to wash different clothes which need to be washed separately in one time by putting them in different drums. Consumers can select the proper washing drum according to the weight of the laundry; water could be reused between drums which might reduce the use of water, electricity and detergents. However, such machines are quite voluminous.

Fiberglass drum construction

Integrated fiberglass housing with a counterbalance moulded directly into the shell of the outer drum was described as technological option in Lot 14. However the potential benefits of fibreglass compared to traditional counterbalance materials (like concrete or steel) was not clear. No savings in energy and water consumption were foreseen. Today there still seem to be one manufacturer offering washing machines with this kind of drum.

Increased durability

Some manufacturers are producing appliances which present increased durability. This is usually achieved by selection of materials (e.g. using higher amount of metals). As a result products generally result heavier and more expensive for consumers. Environmental impacts embedded in the product might also be higher than in case of use of cheaper materials, although the lifecycle impacts would be compensated thanks to the possibility of using the appliance for a longer time. This appears an interesting area for further investigation.

Use of recycled plastic (washing machine)

According to (WRAP [n.d.]a), Indesit has produced a back panel for two of its washing machine models using 100 per cent recycled content with similar characteristics to the previous part that was made from virgin material. The access panel is made by using recovered fridge waste, which is then shredded and made into a high grade polymer pellet. The plate being developed in a pilot project first, is now being integrated into the back of the premium Hotpoint Aquarius and Ultima Washing Machines. According to (WRAP [n.d.]a), Indesit has achieved the same production cost for the recycled plates by achieving the same cycle time in the moulding process. This is combined with a 5 per cent saving on raw material costs.

In its Sustainability Report 2013, Indesit Company informs that it has developed technological solutions and recycled materials or biopolymers or materials from renewable sources that can potentially reduce amounts of bitumen dampening material, soundproofing felts and, in certain models, also eliminate metal side panels and reinforced concrete counterweights. Over and above the obvious benefits in terms of energy savings for the industrial process (elimination of gluing in "hot melt" ovens) and the thermodynamic and acoustic performance of the product, the achievement of such objectives makes it possible to significantly increase the use of recycled materials (currently only 3% of the total) and facilitates dismantling at the end of the product's life (as well as improving the quality of the recovered materials). The project aims to limit, eliminate or replace certain materials habitually used in home appliances (and in particular direct oil derivatives in dishwashers). (Indesit Company 2014).

However, the use of bio-materials is still a controversial. Materials based on biomass are in principle considered to save fossil fuel resources because of their renewability. However, embracing a system perspective may in some cases result in environmental trade-offs, for instance due to the additional demand for land, water, energy and chemicals for the production of biomass. Spatial and technical differences between different production chains can result in a complex range of environmental performances (Börjesson and Tufvesson, 2011, Buchholz et al., 2009, Cordella, 2010, Cordella et al., 2013 and Fiorentino et al., 2014). The selection of materials based on biomass may be supported in the future by standards and sustainability criteria currently under development (European Committee for Standardization, 2011).

Sharp and Kansai Recycling Systems Co. Ltd. jointly developed a closed-loop plastic material recycling technology that repeatedly recovers plastic from used consumer electronics and reuses it in parts of new consumer electronics for the Japanese market. This technology has been in practical use since fiscal 2001. By combining of a high-efficiency metal removal line, high-purity PP (polypropylene) separation and recovery technology, and other property improvement/quality control technologies, Sharp has been able to recover recyclable plastic, as well as to find applications for its use, such as in the exterior panels of home appliances and as flame-retardant materials. Because recycled plastic can be reused numerous times, the practice has been adopted for use inter alia in washing machines (base frame and washing tub), and other similar home appliances sold within Japan which are subject to the Home Appliance Recycling Law. (Sharp 2012)

According to the study "Material recycling without hazardous substances – experiences and future outlook of ten manufacturers of consumer products" of the Swedish Chemicals Agency cited in (Dalhammar et al. 2014), the main barriers for increased use of recycled materials include risk of contamination, costs associated with avoidance of such risks, and limited availability. For some recycled materials, most notably plastics, it is difficult to find material that complies with quality requirements. The companies interviewed in the study see future opportunities in overcoming the barriers: Increased use of recycled materials depends on the development of cleaner material streams, which require cleaner input materials, development of better separation/cleaning technologies, and standards for recycled materials.

4.1.3.2. Increased motor efficiency

In Lot 14 three different motor options were described, which were seen as alternative systems (i.e. not additive), see the following table.

Table 4.1: Possible motor efficiency improvements in 2005; source (ENEA/ISIS 2007b)

Motor options	Market share in 2005	Motor efficiency (compared to AC phase motor)
Brushless DC (+control)	0,5%	+6%
Brushless DC direct drive (+ control)	0,5%	+6%
Three-phase (+control)	5%	+6%

High efficiency motors

For washing machines and washer-dryers, the main motor is responsible to drive the washing drum. According to (Stekl 2006), the drive has to be designed to run a very wide range of drum speeds from 0 to 2,000 rpm, depending on the modes of operation: (a) Tumble wash (typical low drum speeds reversing the direction of the drum rotation every few turns; the speed of the drum for a tumble wash is typically 30-45 rpm depending on the type of clothes and determined by the washing programme. (b) The out-of-balance detection and load displacement being performed until an equal distribution of the drum load is achieved before starting spin drying. (c) The spin drying phase with up to 2,000 rpm of the drum depending on the machine and chosen programme.

According to stakeholder information, motors of washing machines and washer-dryers have a rated power input of up to 950 W during spin-drying peaks, whereas their typical operational power input is usually lower (around 100 W). Further, the water circulation pumps in washing machines and washer-dryers are operated by separate, mainly synchronous motors, however with a comparatively low rated power input of around 15 to 30 W. In household appliances such as washing machines and washer-dryers, different types of motors are applied.

- Initially, universal motors (commutator motors) with brushes were common. They can be operated at direct current (DC) as well as alternating current (AC); driven through pulse width modulation, they are also called PWM motors. According to stakeholder information (personal communication), their efficiency is low with up to 50%, (i.e. only 50% of the power input is effectively used for moving the drum, the rest is dissipated) they are prone to wear, and noisier compared to other motors. They are still used in the low-price segment.
- In the medium to upper price segments of household appliances, brushless, inverter driven asynchronous DC motors are often applied. With about 50-60% their efficiency is higher compared to universal motors; also, they are more reliable and more silent due to absence of brushes and commutator.

Brushless, permanent magnet synchronous DC motor (PMSM)

These motors have found application where compactness (lower volume and weight compared to the above motors), high torque per unit volume, better dynamic response (due to the low inertia of the rotor), reliability (no brushes), low-noise machinery and high efficiency are primary requirements. Lifetime of both brushless asynchronous inverter driven motors and permanent magnet motors is similar and being higher compared to universal motors with brushes as only the bearings are prone to wear. According to stakeholder information, the motor efficiency of PM motors is high with between 65% and 80% depending on the operational mode; also, they are smaller and lighter (around 3.5 kg compared to 6.5 kg for asynchronous inverter driven motors).

According to estimation of one stakeholder (personal communication), around 50% of washing machines might already be equipped with PMSM motors, and rather 60% at superior appliance manufacturers; for washer-dryers, the implementation of high-efficiency motors is still delayed compared to washing machines.

Permanent magnets contain rare earth elements (REE) having been identified as critical raw materials. According to (Dalhammar et al. 2014), the employment of REEs substantially contributes to achieving better energy efficiency in PM motors. The production of these magnets commonly entails the use of power metals of rare earth elements, which are classified as chemicals under REACH, such as Dysprosium (Dy), which is a less abundant heavy rare earth element, and Neodymium (Nd), and Praseodymium (Pr), light rare earths, whereby Pr can substitute Nd by up to 6% in these magnets. Dy is used to keep the magnetic properties of Nd at high temperatures.

(Dalhammar et al. 2014) assume that the potential in terms of the improved energy efficiency level which can be attained by PM motors means that their market share is expected to increase with further commercialization, resulting in increased supply, and a price decrease for such motors.

Regarding the drive construction, further belt driven and direct drive motors can be distinguished. According to (Freescale Semiconductor 2012) the most common washing machines contain belts. This mechanical construction consists of two pulleys with the belt transmitting the power, torque and the speed from the motor to the drum. The smaller pulley is mounted on the motor shaft while the larger pulley is mounted on the drum shaft. Whereas direct drive washing machine construction does not include pulleys and belts, therefore the motor shaft is directly mounted to the drum shaft.

Optimised materials in motors:

According to Lot 14 the motor can also be optimised by optimising the amount of construction material. Less iron and copper have no impact on energy/water consumption but reduce the material composition of the machine and the costs for manufacturers which can compensate the raw material price increase. 5% less material with no modification of the other motor characteristics were seen as feasible. However, this does not seem applied yet to the models on the market and also the nature of the materials used is an important characteristic to take into consideration. It has to be discussed if optimisation of materials still is to be seen as possible improvement option, especially in light of high efficient, brushless, permanent magnet motors.

4.1.3.3. Time – temperature trade off

Decrease of reached temperatures in the washing programmes

Lower wash temperatures lead to lower energy consumption for heating. However, in accordance to the Sinner Circle, this has to be compensated by another factor. The mechanical action and the chemistry cannot be influenced easily thus the main factor that has been used to compensate lower wash temperatures is the time, i.e. the washing cycles became longer during the past decades.

Already the WASH II study described an increase of the cycle time of 10 to 20% between 1993 and 1998. In 1998 a total cycle time of 120 to 130 minutes was common whereas in 1993 the cycle time was 100 to 110 minutes. Manufacturers claimed by that time that there was zero benefit from time-temperature trade-off referring to the situation from 1998 onwards. It was concluded that for the immediate future this would be a saving option only for low-range machines.

In Lot 14 (2007) the possible savings due to this option were considered to be implemented in all machines on the market with no further improvement potential.

Nowadays the common cycle time for the standard 60°C cotton cycle is at least around 180 minutes, i.e. much longer than the cycle time in 1998. Some machines even have a much longer cycle time in the standard programmes. This results from strongly lowered wash temperatures in the standard programmes of as low as 35°C (in the 60°C standard programme) and 25°C (in the 40°C standard programme). Thus only the names of the respective programmes remain.

A washing machine guarantees the required washing performance (>1.03) despite these lower wash temperatures. However, in some cases (e.g. *in specific situations (vulnerable people, contagious diseases))* this approach might lead to hygiene problems.

As indicated in this section, there are also other possibilities to reduce the energy demand than just lowering the wash temperature of the standard programmes and increasing the time. However these are usually connected to certain technologies that are more costly (lowering the washing temperature does not have any significant implications on the cost of products). The advantage however is that such technologies not only reduce the energy demand of the standard programmes but also of other programmes.

Low temperature programmes: introduction of 20°C cycle:

During the past decade new detergents and bleaching agents, active already at low temperatures, were introduced into the market allowing washing at lower temperatures. This has led to the introduction of a cold wash programme (20°C programme) which is now mandatory for all washing machines on the market by Ecodesign Regulation 1015/2010. At the moment washing at 20°C is not part of the current measurement standard procedure and the calculations of the related EEI.

Programmes handling hygienic aspects

Already in Lot 14 an increased attention to hygiene problems and the respective possibilities of micro-organism reduction, like high temperatures or silver ions release was registered. The latter was rather seen as a marketing tool than as an effective means to reduce micro-organisms. An increase in washing temperature implies an increase in energy consumption.

Today, this topic becomes more important to consumers, both to ensure a clean washing machine and for certain types of laundry (towels, underwear) or in specific situations (vulnerable people, contagious diseases). Some manufacturers already offer special programs (e.g. anti-mite option, anti-allergy options, hygiene or machine cleaning programmes,) that promise to effectively reduce microbes and allergens in the laundry and/or biofilms in the machine. Such programmes/options obviously increase the energy and water consumption as higher wash temperatures are necessary which also have to be maintained for a longer period of time and/or the laundry is rinsed more often partly outweighing the achievements in the standard programmes.

4.1.3.4. Improved thermal efficiency

Design optimisation

The WASH II study described the improvement of the thermal efficiency. The total energy consumption for machine heat up, heat-up of the glass door, radiation and convection losses had been reduced from 276 Wh/cycle in 1993 to 175 Wh/cycle in 1998. A further reduction of 50 Wh/cycle was seen possible for the future.

In 2007 Lot 14 stated that this total energy consumption for machine-heat up, heat up of the glass door, radiation and convection losses have been optimised and thus no further reduction was considered possible.

It is assumed that today no further optimisation of the thermal efficiency is possible. Especially with lower wash temperatures (both chosen by consumers and reached in otherwise declared programmes) the energy for heat up of machine, glass door, radiation and convection is lower anyway compared to the situation in 1993, 1998 or even 2007.

Washing machines with heat pump technology

Through heat-pumps in washing machines it is possible to (partly) replace the electric energy usually used to heat the washing machine, the laundry and water with the heat of the ambient air and the wastewater. Currently, it seems that there is one washing machine with heat pump technology on the market, the VZUG Adora SLQ-WP, which was introduced by V-ZUG in 2013. The washing machine is equipped with both conventional heating elements and with a heat pump. The wash water is heated by the heat pump that takes the heat from a wastewater tank, which serves as latent heat storage. Thus part of the waste heat can be recovered.

The consumer can set heat pump utilisation in three levels: 1) heating only by the heat pump (up to wash temperatures of 45-50°C) leads to lowest energy demand but longer washing cycles; 2) heating mainly by the heat pump increases the electricity demand and shortens the wash cycle; 3) heating by the heat pump and conventional heating elements in equal shares, leading to the relative shortest washing cycle and highest electricity demand. The savings in electricity compared to the same model without heat pump is supposed to be 50-70% (level 1), 40-50% (level 2) and 10-20% (level 3) (V-ZUG 2013; V-ZUG operating instructions 2014b). The energy demand of the model with heat pump (under standard conditions) is 50% lower than the current A+++ threshold.

The following table compares the main characteristics of 2 equivalent washing machine models under standard conditions (Adora SLQ with heat pump and Adora SLQ without heat pump).

Table 4.2: Comparison of heat pump washing machine with equivalent washing machine without heat pump under standard conditions; source: (V-ZUG operating instructions 2014a, 2014b)

	Adora SLQ WP	Adora SLQ
Energy Efficiency Class	A+++ (-50% of the current threshold)	A+++ (-30% of the current threshold)
Capacity (in kg)	8	8
Recommended retail price	6,240 CHF (approx.. 6,000 EUR)	5,180 CHF (approx.. 5,000 EUR)
Per annum (220 cycles)		
Annual energy consumption (in kWh/annum) (threshold A+++: 197)	98	136
Annual water consumption (in L/annum)	9,800	9,900
60°C cotton cycle (full/half)		
Energy demand (kWh)	0.52/0.41	0.78/0.62
Water demand (litres)	55/36	55/36
Duration (min)	190/180	225/220
40°C cotton cycle (half)		
Energy demand (kWh)	0.36	0.37
Water demand (litres)	36	36
Duration (min)	180	215

Apart from costs, a possible environmental drawback of this technology is the refrigerant used in the heat pump. Currently the most used refrigerant in heat pumps is R134a (tetrafluoroethane), which is also used in the heat pump washing machine by V-ZUG. The amount of refrigerant needed for such a heat pump is approximately 150 to 200 g (i.e. similar to that of a dishwasher, less refrigerant is necessary compared to heat pump tumble dryers). R134a however has a very high specific global warming potential of 1,430 kg CO_2eq / kg which could be released during the end-of-life phase if the appliance is not properly collected and/or depolluted (cf. section 4.2.6.2). The following table shows the global warming potential of the refrigerant per appliance.

Table 4.3: Global warming potential (GWP) of refrigerant used in washing machines with heat pump

	Used amount per washing machine	Specific Global Warming Potential R134a	Total GWP in case of 100% loss per washing machine
R134a (Tetrafluoroethane)	0,150-0,200 kg	1,430 kg CO_2e / kg	215-286 kg CO_2eq

In principle also the use of other refrigerants is possible (e.g. R290 (propane) or R600a (isobutane)) which have much lower global warming potentials. However this would require other compressors than those currently available on the market which is therefore associated to higher costs.

Washer-dryer with heat pump technology

In 2014 Electrolux introduced a washer-dryer with heat pump technology (model name "ÖkoKombi", both Electrolux and AEG). The heat pump works equivalent to that of a regular heat pump dryer, i.e. a small amount of air is heated and passed through the wet laundry. The hot, humid air is then passed through a heat pump where the moisture is condensed. The heat is reused for heating the dry air which is passed again through the wet laundry. In comparison to a condenser dryer without heat pump thus up to 50% of energy can be saved (Rüdenauer et al. 2008b).

According to the manufacturer the washer dryer model equipped with this technology needs 40% less energy and 15% less water compared to a standard A-class washer-dryer (i.e. compared to the threshold for class A which is 0.68 kWh per kg and full cycle). It has a capacity of 9 kg (only washing) and 6 kg (drying/non-stop washing-drying). (AEG 2014a)

Table 4.4: Comparison of heat pump washer dryer with equivalent model without heat pump

	Electrolux WTSL6E200 (L99695HWD, with heat pump)		(AEG 2014)AEG L77695WD (without heat pump)	
Recommended retail price (Germany)*	1919,- Euro (offer: 1089 Euro)		1369,- Euro** (offer: 968,66 Euro)	
	Washing only (standard 60°C cotton)	Washing + drying (standard 60°C cotton + dry-cotton drying cycle)	Washing only (standard 60°C cotton)	Washing + drying (standard 60°C cotton + dry-cotton drying cycle)
Capacity	9 kg	9/6 kg	9 kg	9/6 kg
Per cycle				
Energy consumption (kWh)	1.09	3.67	1.04	5.86
Water consumption (litres)	69	69	59	103
Programme duration (min)	238	580	209	471
Per annum (200 cycles)				
Energy consumption (kWh)	218	734	208	1172
Water consumption (litres)	13,800	13,800	11,800	20,600

*the prices are the recommended retail prices given on the respective websites. The recommended retail price may vary according to the Member State in which the appliances are sold.

**the recommended retail price is that of the very similar model AEG L77685WD

Source: (AEG 2014, 2015a, 2015b, Electrolux 2015a, 2015b)(AEG 2014, 2015a, 2015b, Electrolux 2015a, 2015b) price info: (Amazon 2015)(Computeruniverse 2015)

As the table shows the energy consumption for a full cycle (i.e. washing, spinning and drying) is 3.67 kWh with heat pump and 5.86 kWh without heat pump, which is a reduction of about 38%. The threshold energy consumption for class A for a rated capacity of 9 kg is 6.12 kWh/cycle; i.e. in comparison to this value the reduction is about 40%. The energy and water consumption of the heat pump model of washing only is slightly higher than that of the model without heat pump. As the model without heat pump uses water condensing drying technology the water consumption of the heat pump model in the full cycle is about 35% lower than that of the model without heat pump.

The difference in the recommended retail price is very high (550 Euro), however usually the appliances are offered (and sold) for prices that are often far below the recommended retail price (as illustrated by the offer prices given below the recommended retail prices). On the other hand the current price difference reflects the fact, that so far this washer-dryer with heat pump currently is the first and only appliance with this technology.

So far no washer-dryer is equipped with a heat pump for the washing process. The inclusion of heat pump technology for the drying process seems to be easier to realise as it exists in tumble dryers for a much longer time already compared to heat pumps in washing machines, which were introduced only recently. It also leads to higher energy savings than the heat pump for the washing process. This suggests that in washer-dryers the heat pump technology may be applied to the drying process first. Moreover, space constraints of washer-dryers may create technical challenges for the potential extension of the heat pump use for the washing process.

4.1.3.5. Alternative heating systems

Hot-fill-feature:

In Lot 14 the option was described as declining, as several producers in the UK no longer offered it and it was offered in no other country of the European Union. The main reasons for the decline of this technology were seen in the general trends towards reduced water consumption and lower washing temperatures, which results in energy saving potential. Indeed, if. less water is needed per cycle, also the amount of (hot) water is reduced, and if less water has to be heated up to lower temperatures, the energy consumption for heating decreases as well as the possible savings through hot fill, which would be the main reason for replacing electrical devices for heating water with more efficient external heating systems).

In principle however, it is possible to connect certain washing machines and washer-dryers to a hot water line, as shown in studies by (Bush & Nipkow 2005), (Gensch et al. 2009), and (Saker et al. 2015).

This is a standard technology but it is not widely implemented in Europe as only rarely appropriate connections are available in households. However, this may be an interesting option since in many countries more and more households use solar energy. Hot fill can potentially allow for high electric energy savings but saving depends on the selected cycle, the selected temperature, and site specific conditions like the temperature of the externally heated water and the source of energy used. Also the hot water supply needs to be well insulated and distance between hot water source and the appliance connection point must be short. Possibly a circulator would be needed (which also uses electricity).

In contrast to dishwashers, two inlet valves or a separate mixing device outside of the washing machine are needed as for example some textiles cannot be washed with high temperatures (delicates, wool), certain stains need to be soaked with cold water first to prevent fixing (e.g. protein stains) or to enable cold rinsing. It is therefore not possible to connect a washing machine or a washer-dryer only to hot water. Therefore specially designed appliances are necessary in case of washing machines (and washer-dryers). In cases where / under the assumption that the hot water delivery of the dwelling is more energy efficient than the heating of water within the machines using electricity, this measure could result in energy savings. However, there are few scientific studies assessing these savings on a quantitative basis.

While (Saker et al. 2015) consider both dishwashers and washing machines equipped with an additional hot-fill connection, (Gensch et al. 2009) focus on several types of dishwashers only, one of them specifically designed for hot-water filling. The authors of both studies conclude that the potential benefits of hot filling appliances depend on the specific site conditions and parameters, like the length and the insulation of the hot water pipe, efficiency and control characteristics of circulation pump, water heating sources (e.g. gas boiler, off-peak electric, solar combined with gas or electric).

Both studies conclude that under certain conditions the additional connection of washing machines to hot water can help to reduce household GHG emissions, and provide the possibility to reduce and shift electricity demand. (Saker et al. 2015) recorded a high share (80% of washes) of washing programmes at 30°or 40°C, resulting that no electric heating was required for virtually all these washes with hot fill use. (Gensch et al.

2009) and (Saker et al. 2015) agree that solar hot water combined with gas heating for hot water supply is the option resulting in the lowest GHG emissions for hot water generation and consequently for washing machines (and washer-dryers) using the hot fill option (if site conditions and parameters are beneficial).

The option not necessarily results in lower water consumption but mainly saves electric energy.

As drawback, washing machines with two water inlets are more expensive because of the need of additional components and adaptations (e.g. valve, hoses, controls).

Today still several manufacturers offer washing machines with two water inlet valves enabling to connect them to two types of water (e.g. hot and cold water or tap water and rain/well water, see section 3.2.2). (Gorenje [n.d.]a; Miele [n.d.]b) This option should principally be applicable also to washer-dryers however so far there is no such model on the market.

Heating by hot water circulation loop ("heat-fed machines")

This option describes the possibility to replace the electric heating elements with a hot water circulation loop using a heat exchanger to transfer the heat from the hot water to the machines. This means in contrast to the "hot fill" option, the appliance itself is connected to cold water which is then heated NOT by an electric resistance heater but by a hot water heat exchanger. The hot water heat exchanger is fed by the hot water generated by the hot water delivery of the dwelling (central or district heating).

The advantage of this option compared to the hot fill option is that not only the heating of the water can be replaced (which according to stakeholder information accounts for approximately 1/3 of the heating energy consumed by a dishwasher) but also the heating of the machine itself and the laundry.

The saving potential depends on the temperature of the hot water. According to (Persson 2007) with a hot water temperature of 70°C (or above) the whole electricity demand for heating can be replaced by the heat from the hot water circulation loop, i.e. the electricity demand for a 60°C standard washing cycle could be reduced to about 0.27 kWh.

It was reported by stakeholders that products implementing this technology would require specific standardization needs for aspects not covered by existing standards.

4.1.3.6. Reduction of water consumption

Rinsing optimisation:

Rinsing optimisation means to achieve a certain rinsing performance (amount of detergent residual in the washed laundry) with as little water as possible. The WASH II study already describes the improvement that took place in the period between 1993 and 1998: through improved rinsing efficiency and intermediate spinning the number of rinses could be reduced to 3 and also the amount of water used per rinse decreased. The WASH II-study notes a general acceptance of 3 rinses instead of 4 or 5, with a higher number of intermediate spins. Lot 14 does not describe in much detail a further rinsing phase optimisation that was supposed to be applied to 20% of the market.

Today, with a much smaller volume to load ratio (see section 4.1.3.1) rinsing performance is an important aspect to take into account. A standard on rinsing efficiency is currently under development which is an important prerequisite to further optimise the rinsing phase (see section 1.2.2.8)

Use of rain/well water

There are some washing machines on the market with two water inlet valves that can work with two water sources. Besides cold water it can also be connected to a second water source, either hot water (see section 4.1.3.5 on hot fill) or alternative water supplies such as rain or well water. In the latter case tap water is always used for the last rinse for hygienic reasons. When used with rain or well water the consumption of tap water can be reduced and partly also the consumption of detergent, as rain water usually is softer than tap water.

This option does not lead to energy savings but only to water and, possibly, detergent savings. Beside designing the washing machine with two water inlet valves also equivalent infrastructure in the house is needed.

This option should principally be applicable also to washer-dryers however so far there is no such model on the market.

Water recycling

The storage of the last rinse water in a water tank to be used during the next cycle is an option that would allow for saving water since the water of the last rinse could be used in the next cycle. This is an "old" solution on the market, but not very much used for different reasons, e.g. increased costs, space constrains, especially in case of washer-dryers, risk of bacterial growth in the storage tank and more complex internal controls and extra costs for the products. Several attempts to launch this technology in the market have failed due to the described drawbacks.

Currently no machine with this technology could be identified on the market.

4.1.3.7. Optimised mechanical action

Different systems seem to be available on the market that mix air, water and detergent for improving the process of detergent dissolution, distribution and penetration in the fabrics. This results in improved washing performance although also costs increase compared to appliances without such technologies implemented.

Ecobubble™technology:

Before the normal wash cycle begins, bubbles are generated to dissolve and activate the detergent. According to the manufacturer, energy can be saved by this technology as washing with cold water (15°C) is supposed to be as effective as washing with 40°C. (SAMSUNG UK 01.09.2012) Consumer testing organisations reported that they could not detect an additional effect on the cleaning performance coming from this technology and other manufacturers are also sceptical regarding the benefits of this technology.

Internal water circulation:

Through internal water circulation (e.g. like PowerWash/"spin-and-spray-technology" by Miele) the drenching of the laundry by repeatedly spraying water on it and spinning at the same time is improved. Thus less water is needed which also results in a lower energy demand. According to the manufacturer, machines with this technology need up to 40% less energy than the A+++-threshold, and is realised with washing times below three hours. Usually the water and energy demand per kg laundry is much higher if the washing machine is not fully loaded compared to full load. This technology is supposed to effectively reduce also the water and energy demand with partial loading.

Spray-technology:

In 2014 Whirlpool introduced this technology that aims at reducing the free water beneath the drum. A hydraulic system allows spraying a mixture of detergent and water directly to the laundry by the help of a specially developed nozzle. The (known) principle behind the Spray technology is to fill in only the water that is needed for the wash process by an improved water distribution system. The reduction of water leads also to energy and possibly detergent savings. According to the Spray project (an EU funded project to demonstrate the feasibility of the new technology) the following savings can be achieved: water saving 27%, energy saving in average 10%, detergent saving 5%, while maintaining the rinsing efficiency; however, the data basis for these indicated reductions have not been disclosed so far. First washing machines should be put on the market (upper market segment) from March 2015 onwards. (Spray project 2015a, 2015b)

4.1.3.8. Spin speed and alternative drying systems

The spin speed (and efficiency) influences the residual moisture content of the laundry which decreases the energy demand of the subsequent drying process. To remove an equal amount of humidity the thermal process in a tumble dryer needs more energy than the mechanical process in washing machines.

According to the German Energy Agency Dena spin speeds above 1,200 rpm require between 5% (at 60°C) and 10% (at 40°C) more energy in the washing cycle than lower spin speeds (DENA 2006). However as the remaining moisture content of the laundry is reduced the subsequent energy demand for drying is reduced leading to a lower overall efficiency of the washing drying system when a dryer is used or the laundry is dried in heated rooms (Rüdenauer et al. 2008a; Rüdenauer & Gensch 2004).

A high spin speed might however increase the wrinkling of the laundry which increases the subsequent energy demand of ironing if the laundry is ironed. There are several factors that influence the wrinkling of the laundry and thus the potential effort for ironing:

- High spin speeds, storage of the laundry after drying and over-drying increase wrinkling and/or increase the effort for subsequent ironing
- Low spin speeds, immediate ironing after drying, a certain residual moisture content and drying in a tumble dryer in general decrease wrinkling and/or the effort for subsequent ironing.

Therefore, depending on the type of final finishing of the clothes different spin speeds are recommendable. If the laundry is to be ironed after drying, the spin speed should be as low as possible.

To better understand the influence of the spin speed on the drying process alternative drying systems are shortly described.

Alternative drying systems

Clothes can either be dried on a clothes line or in a tumble dryer.

If clothes are dried on a clothes line outside or in not heated rooms no additional energy is needed.

If the clothes are dried on a clothes line inside heated rooms, at least during the heating season additional energy is supplied by the space heating system. The room should be ventilated to remove the moisture out of the room as otherwise there could be the risk of mould formation. The warm and humid air of the room is replaced by cold and drier air from outside and the room has to be heated to adjust the temperature.

There are two basic typed of tumble dryers: air vented dryers and condensation dryers.

Air vented tumble dryer draw cold, dry ambient air, heat it and pass it through the wet laundry. The warm, humid air is vented through a hose outside. Besides the electricity demand needed for circulating and heating the process air, air vented dryers might have an additional effect due to balancing the room temperature and humidity.

Condenser tumble dryer also take cold, dry ambient air, heat it and pass it though the wet laundry. Instead of being vented, the warm and humid air is cooled down and the steam is condensed. The tumble dryers warm up and give this heat to the ambient air thus replacing a certain amount of space heating.

Heat pump dryers are condenser dryers that are equipped with a heat pump to actively recover the heat contained in the warm and humid air and reuse it for heating up of new cold, dry air. Thus less electric energy is needed and also less energy dissipates to the ambient air. As refrigerant, approximately 270 g of R134a (tetrafluoroethane) is used.

In all cases the effort for drying (time, energy) is lower the lower is the residual moisture content of the laundry. Generally speaking one can say that the higher the spin speed of the washing machine the lower is the residual moisture content.

Thus, the spin speed should be as high as possible if the laundry is dried a) on a clothes line inside heated rooms, b) in a tumble dryer. As a drawback, higher spin speed may produce higher wrinkling.

Increase of the spin speed:

In Lot 14 an increase from 1,200 to 1,600 rpm was considered as improvement option. As outlined above, higher spin speeds lead to a lower energy demand in the subsequent drying process which mainly is of importance when laundry is dried inside heated rooms or in a tumble dryer (or in a washer dryer). They lead however to a higher effort for ironing.

Usually washing machines with very high (maximum) spin speeds do not apply it for each programme type but only in the cotton programmes. For delicate laundry, wool or other special programmes usually lower spin speeds are set.

According to stakeholder feedback it has to be considered however that higher spinning speeds also bears the risk of earlier failure of certain parts of the washing machine (mainly the shock absorbers and the ball bearings); or they require higher costs for better quality parts.

Moreover, from a system perspective, the effects of spin drying on ironing should be considered as well, taking tumble drying as a basis of comparison.

The impact on ironing depends mainly on the final moisture after drying. The effort for ironing is less, if the textile is damp and not over-dried. In order to reduce the energy consumption of the ironing, it has to be ensured that the wrinkling of the laundry is minimal. This can be done by avoiding that the laundry is stored (in laundry baskets) over a longer period of time after drying and before ironing. The laundry should be ironed immediately after the drying (when the laundry is taken off the line or taken out of the dryer).

Spin drying has an effect on both tumble drying and ironing needs. However, also the drying method and the handling of the laundry between the different steps of the laundry treatment process have an influence on the ironing.

From an energy point of view, mechanical extraction of water is more efficient than evaporation in a tumble dryer. In case of tumble drying, higher spinning speeds reduce tumble drying time and energy consumption. In order to reduce the energy consumption of the dryer, the laundry is best spun at the highest possible spin speed. For instance, it has been reported that moving from a washing machine with a spin-drying class B to one with a spin- drying class A saves three times more energy (in case that a tumble dryer is used for drying) than moving from a washing machine with energy class A to one with energy class A+. The spin-drying efficiency is of high importance for the overall efficiency of the total laundering process (see: http://www.topten.eu/uploads/File/039_Barbara_Josephy_final_Washing.pdf).

In case of line drying, higher spinning speeds reduce drying time, but increases the need for ironing. This is a well-known fact, which leads many consumers to reduce the spinning speed whenever possible.

High spinning speeds machines are more sold in countries where tumble dryer penetration is higher.

Table 4.5: Recommended spin speed / spin drying efficiency of washing machines depending on the type of final finishing (own elaboration based on stakeholders feedback)

Type of final finishing of clothes	Recommended spin speed / spin drying efficiency of washing machine
Drying in a tumble dryer	As high as possible, as minimum 1200-1400 RPM Spin-drying efficiency class A (remaining moisture content <45%) would need much less energy than a class B
Drying inside apartment (clothes line)	As high as possible, as minimum 1200-1400 RPM Spin-drying efficiency class A (remaining moisture content <45%) is needed

	to dry faster and avoid damage to the rooms due to humidity
Drying in in a special drying room (clothes line)	A) In a heated drying room: as high as possible B) In an unheated drying room, vented by outside air: as low as possible Spin-drying efficiency class A (remaining moisture content <45%) would allow faster drying Min 1200 / 1000-1400 RPM may be recommendable
Drying outside apartment	As low as possible to save energy Spin-drying efficiency class A (remaining moisture content <45%) would allow faster drying Min 1200 / 1000-1400 RPM may be recommendable
Ironing	As low as possible To judge – the wrinkling in the textile has to be respected Min 1200 RPM may be recommendable After having tumble dried ironing usually is obsolete.

4.1.3.9. Sensors and automatic controls

Today, as partial load is part of the standard testing procedure and the capacity of washing machines further increased efficient electronic controls to adapt energy, water and possibly detergent consumption to only partially loaded washing machines (and washer-dryers) is more important, both under standard and real life conditions. Electronic controls are applied to different elements of the washing machine and washing cycle phases.

Unbalance control

Unbalance control is achieved by the use of sensors for the motor, shock absorbers and machine mechanical construction. Shock absorbers can be mechanical (frictional) or high pressure (filled with gas or oil). In Lot 14 it was supposed that some sort of simple unbalance control was implemented in 90%, a more sophisticated unbalance control in 5% of the models.

It can be assumed that today a higher share of washing machines is equipped with a more sophisticated unbalance control.

Automatic load detection

There are mainly two possibilities to determine the actual load: directly and indirectly.

In case of indirect determination, the washing machine determines through the use of sensors the amount of water needed during the water intake. The water intake takes place in several steps. The more laundry is filled into the machine the more water is soaked by the fabric.

It is also possible to determine the load directly via an integrated balance. With this system, the machine weighs and indicates the actual load before starting the washing programme.

In addition to the load detection also electronic controls are needed to subsequently adapt the water and energy use as well as the programme duration to the amount of load. This is an important function since half-loads occur more and more (see also the section on the increased rated capacity in section 4.1.3.1.

This is a standard technology for washing machines and washer-dryers (for both washing and drying cycles). However, as a drawback, multiple sensor technology is more expensive than appliances without this capability. Moreover, the benefits provided by this option would be achievable only in practice and not under laboratory, conditions, where the levels of load and soil are always the same.

Besides simple electronic controls there are also sophisticated electronic controls (e.g. “fuzzy” controls) that enable the machine to determine a large part of the program by itself. In any case, there are substantial differences in the ability to adapt the consumption figures according to the actual load. Results of the ATLETE II project (cf. in section 2.2.1.2) show that in practice with an actual load of 50% the reduction of the energy demand ranges from 0% to 41% (only 1,6 % of the analysed models were able to reduce the energy demand by 40% or more).

In Lot 14 it was supposed that about 90% of the machines on the market have at least partial electronic control and that 50% of the machines on the market were equipped with more sophisticated electronic controls.

Automatic detergents dosage systems

With this option, detergent is dosed automatically by the appliance from a pre-filled reservoir based on water hardness, amount of load and soiling of the load. Users do not have to decide how much detergent to dose potentially leading to avoidance of overdosing or under-dosing of detergents, detergent spilling and foam excess, which would ultimately result in saving water as less water is needed for rinsing.

(Blepp & Gensch 2013) and (Gensch et al. 2010) quantify the reduction in detergent consumption to be 30% . This option would only provide benefits under real life conditions and not under standard conditions, where the dosage is defined by the standards. In real life however correct dosage becomes increasingly difficult as a consequence of the great variety of washing machines' capacities: The detailed dosage recommendations on detergents packaging are meant for fully loaded 4.5 kg machines, depending on water hardness and degree of soiling. Additionally the user should take into account the rated capacity and the actual load of the machine.

It can be assumed that the use of a washing machine with automatic dosage dispensing leads to a further increase of the share of liquid detergents consumed on the market. The environmental impacts of this improving option have not been evaluated yet.

Several manufacturers offer washing machines with automatic dosage of liquid detergent, with one or two detergent compartments (for two types of liquid detergent or for detergent plus fabric softener). According to stakeholder information the option is very successful in the upper market segment.

The option can be considered as BAT for washing machines. So far no washer-dryer is equipped with this technology, i.e. it can be considered as BNAT. Due to space constraints it might be difficult however to implement this options in washer-dryers.

The further discussion of this option requires the involvement of both detergent industry and producers of washing machines and washer-dryers.

4.1.3.10. Anti-crease mechanisms

Steam Care/Steam finishing

The laundry is treated not only with water but also with steam (mainly in the end of the wash cycle). According to (ENEA/ISIS 2007b) the steam was initially meant to reduce micro-organisms and thus compensate for the low washing temperatures. Another effect which is currently more prominent in the marketing is the reduction of odours and of wrinkles. The latter one would result in lower effort for the subsequent ironing (in terms of both time and energy). Some steam machines also offer a so called “refresh” programme, where slightly used and soiled laundry is only treated with steam. This offers the possibility to “refresh” garment which is usually not suitable for washing in a washing machine but which has to be cleaned by professional dry cleaning, which may come with higher environmental impacts.

Although being a standard technology, this function does not bring proven energy savings. The drawbacks are that in some cases additional hardware is needed (the steam generator) and that the use of the steam option in a wash cycle increases the energy demand, as the steam has to be generated. This is less the case for washer-dryers where this function can be offered without any additional hardware effort.

Anti-crease systems

After the wash cycle the drum is rotated periodically to prevent creases. This option has a certain energy demand, however reduces the effort for subsequent ironing. Significance of such option in energy terms is however questionable.

4.1.3.11. Alternative washing systems

Ultrasonic cleaning technologies

The first time ultrasonic sound was discussed as technology to wash laundry was in the middle of the 1980ies in the light of the strong environmental impacts of detergents at that times (e.g. over-fertilisation due to phosphates). In 2001 the Japanese manufacturer Sanyo then introduced such a washing machine, combined with water electrolysis to improve the washing performance. According to the wfk-research institute however, the washing performance of such machines is much worse than that of normal washing machines using detergents due to the fact that ultrasonic waves only clean good on hard surfaces (like eyeglasses or medical instruments). Also due the lack of detergent the dirt might be dissolved but then deposits again on the laundry resulting in greying. (Deutschlandfunk 2006)

In January 2015 an ultrasonic washing device was introduced in the market ("dolfie", see http://dolfi.co/). It is primarily meant to wash individual pieces of laundry when travelling or delicates that has to be washed by hand in the sink. The laundry pieces are put in water, detergent is added and the ultrasonic device which is then switched on. The ultrasonic sound waves form microscopic high pressure bubbles in the water (cavitation). When they implode "millions of micro-jet liquid streams" are created that wash away the dirt. It has been developed with the help of MPI Ultrasonics in Switzerland and is supposed to use "80 times less energy than a standard washing machine" (dolphi 2015). Delivery is supposed to start in August 2015.

Polymer bead technology

In 2010 a washing technology was presented that is supposed to clean the laundry mainly with nylon 6.6 beads as a 'solid solvent' plus a small amount of water to aid transfer of soils from the garment to the beads where it is absorbed. Under humid conditions, the polymer becomes absorbent. Dirt is not just attracted to the surface; after the water dissolves the stains, the dirt is absorbed into the centre of the beads, where it remains trapped. After the cycle is complete, the beads are spun out of the load through holes in the drum, where they then return back to a sump pump and are reused.

The company is called Xeros and is based in the UK. The system started as a way of scavenging dye in the fabric treatment industry (Prof Burkinshaw, Uni Leeds). According to stakeholder information it may be an interesting approach for commercial laundry where professional bead separation should be possible, but maybe not so attractive on the domestic side (although the manufacturer says they will launch in the US).

It is supposed to save up to 80% water (Financial Times 2015) (according to (Financial Times 2015; Süddeutsche Zeitung 2010) in 2010 even 90%: 5 litres instead of 50 litres for a standard cycle). As the residual moisture content after the washing process is also supposed to be much lower than in conventional washing machines also the energy demand for the subsequent drying could be reduced.

4.1.3.12. Consumer feedback mechanisms

LCD with actual load indication:

Due to improved load sensors the indication of the actual load could be displayed on the machine (via LCD displays). This option tries to influence consumer behaviour towards full or higher loading of the machine. In 2007 both LCD displays and the sensor for the load weight were present (in some high end-range machines, 0.5-1% of the market), however the loading was not necessarily displayed.

Meanwhile there are machines on the market with this option, i.e. machines displaying the actual loading detected while the user is loading the machine (see also section 4.1.3.8). Usually they also include a detergent dosage recommendation. Thus on the one hand consumers might be influenced towards higher/full loading of their machine or (at least) lower dosage of the detergent if the machine is not fully loaded.

Display of consumption of resources

Miele has developed appliances that provide indications on the estimated energy and water demand of the chosen programme via a TFT (Thin Film Transistor) display. Thus the user can directly see differences in the consumption values and might choose a more economic programme. After the cycle the exact consumption values are shown that might differ from the estimation due to the actual load and soiling. This option does not lead to direct savings in water and energy in the standard programmes but enables consumers to do informed choices and might enhance a more sustainable washing behaviour.

4.1.3.13. "Smart" appliances

Internet connectivity:

This option enables remote program updates and machine diagnostic (thus can be seen as evolution of option “Electronic update of the programmes /diagnostics”, see below). When connected to the internet the machine is linked to the company’s servers and automatically reports service issues. The machine can be started and stopped via the internet connection. In Lot 14 it was supposed that this technology was applied to none or only few (0.1%) of the models on the market. As a machine with this option has to remain in networked standby-mode legislation 801/2013 applies to these low power modes. This option was considered as BNAT in 2007.

Today this option is offered for some high end models. It offers various functions to the user, e.g. to connect different household appliances with each other (like hobs and kitchen hood). It also allows displaying the status information of connected appliances on a central display located on one of the appliances, e.g. the oven in the kitchen. Furthermore with a central gateway the user can remote control and manage the appliances with a pc via the internet or with a mobile phone, e.g. start or stop certain programmes or functions. The appliances are also able to communicate with a customer service unit of the manufacturer.

Electronic update of the programmes /diagnostics:

An update of the washing programmes can be done by connecting the machine to an assistance PC. This option can also be used for machine diagnostics in case of failure. It allows for more efficient washing cycle management if external conditions change (e.g. development of a new detergent), however it has no immediate effect on water and energy consumption.. In Lot 14 it was assumed that 20% of the models on the market have this option, to be used by an authorized after sale service. It can be assumed that today the share is much higher.

Smart grid ready (SG ready) products

Some "smart" appliances, i.e. appliances with internet connectivity also offer the possibility to communicate with the electricity grid enabling the integration of renewable energy via load shifting. (Vanthournout et al. 2015) The vision of such smart appliance operation is that they autonomously start operation according to signals from the grid regarding the availability of electric energy within a consumer-defined time range (because of cost and/or environmental reasons). Thus electricity use can be shifted accordingly. Also signals from local electricity production systems based on renewables (e.g. photovoltaic systems) can be received to adjust the starting time according to the availability of electricity. There are no direct water or energy savings but rather changes in the time when electricity is used with possible efficiency gains in the generation process. Besides a smart-grid ready appliance the consumers need a communication module (to be installed at the appliance) and a central gateway. The communication module communicates via powerline communication with the central gateway.

Currently certain models of household appliances, also washing machines, are equipped with this feature. So far, however, it seems that the potentialities offered by this option cannot be fully exploited as other prerequisites have to be ready as well, like smart meters and a flexible electricity tariff that communicates directly with the gateway. The shift towards a market driven approach for energy efficient appliances and demand response has not been reached yet. This would require implementing structural changes to the current energy market and creating a real market for smart energy and efficient demand. There would be a need to develop market-based instruments adapted to consumers as current mechanisms are tailored to match industrial and commercial demand response.

According to stakeholders possible drawbacks could be that the consumers would have no full control of the appliance anymore and would not be able to decide to run the appliance whenever needed. Also negative effects on the performance parameters of the appliance (e.g. cleaning efficiency, energy demand) might be possible if the washing cycle is interrupted intermediately by signals from the smart grid (e.g. additional heating energy might be necessary if the cycle was interrupted and the water temperature dropped). Appliances that are SG-ready are of course more expensive compared to non-smart products and the Wifi-module has an additional energy consumption.

4.1.3.14. Others

Noise reduction:

Noise is generally caused by the motor and the water circulation during the wash phase and by the spin during the spinning phase. Noise reduction can be achieved by the use of direct drive and three phase motors, the optimisation of the drain pump and by unbalance control (see respective options). Noise reduction can therefore be considered as positive side effect of other options to reduce water and electricity consumption.

Single stain removal system:

In June 2006 a washing machine with a special stain removal system was introduced by one manufacturer. The system allowed the washing machine to be set to one of 14 different stain types and the wash cycle was to be adjusted accordingly (e.g. length and temperature of certain wash phases, detergent-guidance to users).

Today similar systems still exists on the market and also further manufacturers offer a special stain removal option. The option was extended to more stains (16 to 23 different types of stains) and it is partly possible to choose up to 3 stain types in one washing cycle. The influence of this option on water and energy demand has not been evaluated, it presumably depends from stain type to stain type. The stated advantage is that no special detergent (stain remover) is needed.

Delay start:

This option allows starting the washing cycle after a certain number of hours (delay), leaving the machine loaded and ready for start. It does not have an influence on the water or energy consumption of the washing cycle but allows running the machine during off-peak times with lower electricity costs. The 'delay start mode' however consumes a certain amount of power for the timer and respective electronic functions, which is not regulated by Regulation 1275/2008 for standby and off-mode, as 'delay start' is not defined as standby mode as not lasting for an indefinite time.

A similar function was the then newly introduced option "time to end of the cycle" to end the cycle at a set time independent from the starting. In this case the user can set a certain end time or cycle duration and the program is adjusted accordingly. Faster cycles usually result in higher energy demand however.

In Lot 14 the option 'delay start' was supposed to be applied to 30% of the models on the market. It is supposed that today more models are equipped with this feature as it improves the convenience for the user.

Voice controlled appliances:

In Lot 14 voice controlled appliances were considered as BNAT. However there seems to be no effect on the water and energy consumption but rather an improved convenience for elderly or disabled users, especially with regard to the increasingly complex controls of the appliances. However there seems to be no direct (positive) effect on the water and energy consumption.

Mixed appliances:

Lot 14 described a combination of washer/dryer/air conditioner that had been presented by Toshiba Consumer Marketing in November 2006 .The integration of different functions was to be addressed in the system analysis and as BNAT.

4.1.4. Performance characteristics of the Base Cases selected in Lot 14

In the initial preparatory study "Lot 14: Domestic Dishwashers & Washing Machines – Task 5: Definition of Base Case" from July 2007, two base cases were defined for washing machines.

Table 4.6: Base cases defined for washing machines in Lot 14

Characteristic	Base case 1	Base case 2
Type of machine	5 kg load machine, front loading	6 kg load machine, front loading
Energy consumption	0.956 kWh/cycle (energy efficiency class A)	1.057 kWh/cycle (energy efficiency class A+/A)
Water consumption	50.4 litres/cycle	49.2 litres/cycle
Spinning speed	1073 rpm	1262 rpm
Washing performance	class A	class A
Drying performance	class B or C	class B or A
Noise	53dB(A) in washing / 70 dB(A) in spinning	53dB(A) in washing / 70 dB(A) in spinning

In response to the technical questionnaire sent on March 2015, stakeholders have provided some preliminary proposals for revising the base cases:

- Increase the capacity of the machine since 5-6 kg seems to be outdated;
- Increase the spin drying performance to A or B but not C.

4.1.5. Top models of washing machines and washer-dryers on the market

Topten (www.topten.eu) is a web portal guiding consumers to the most energy efficient appliances in European Topten lists (Topten International Group (TIG) 2015b).

(Topten International Group (TIG) 2015a) identifies the most efficient washing machines and combined washer-dryers among those available on the market. Some of these appliances may implement Best Available Technologies (BATs).

4.1.5.1. Most efficient washing machines listed at Topten.eu

All washing machines listed on Topten.eu have Energy efficiency class A+++ and spin-drying efficiency A, in accordance with the requirements set in the EU Energy Label. Moreover, the water consumption has to fulfil the EU Ecodesign requirements (minimum Topten.eu criteria for household washing machines). In addition, suppliers have to provide Topten also with following data:

- Energy Efficiency Index (EEI)
- Energy consumption per cycle in kWh (60°C full and half load, 40°C half load)
- Programme time (60°C full and half load, 40°C half load)
- Power consumption in left-on-mode and off-mode
- Maximum spin speed
- Availability of a 20°C programme (cotton)
- Availability of a water protection system (Aqua Stop, waterproof, water control system etc.)

According to (Topten International Group (TIG) 2015b), around 70 high efficient washing machines were listed on Topten.eu at February 2015. These present a capacity ranging from 6 kg to 11 kg and belong to 13 different brands. Their key characteristics are provided in the following table.

Table 4.7: Key data of household washing machine models listed on www.topten.eu with regard to energy consumption and programme duration; source: (Topten International Group (TIG) 2015b)

	Benchmarks: Range of washing machine models listed on www.topten.eu
Energy Efficiency Index (for comparison: A+++ threshold is EEI < 46)	Best EEI: 22.8 due to an integrated heat pump, i.e. 50.5% better than A+++). Other Topten-Models: 31.7 – 45.6
Energy consumption (kWh/cycle)	• 60°C full load: 0.52 – 1.35 • 60°C half load: 0.41 – 0.97 • 40°C half load: 0.36 – 0.72
Energy consumption (kWh/year), based on 220 cycles per year	98 – 261 kWh/year
Programme time	• 60°C full load: 2 h 20 min – 4 h 00 min/cycle • 60°C half load: 1 h 35 min – 3 h 40 min/cycle • 40°C half load: 1 h 30 min – 3 h 35 min/cycle

According to (Topten International Group (TIG) 2015b), the highest Energy Efficiency Index benchmarks of washing machines can be reached by the following means:

- Advanced technology:
  - Inverter driven motors and permanent magnet motors
  - Heat pump technology (first introduction to washing machines in 2014 by V-Zug)
- Effective load sensors capable of estimating the weight of the laundry load and automatically adjusting the water and energy consumption. In particular this is meaningful for larger-sized washing machines, which may be not fully loaded by users.
- High capacity: Since capacity is part of the EEI equation, a higher capacity with the same energy consumption lowers the specific energy consumption, which has a positive influence on the reached energy efficiency class on the Energy Label. However, there is a drawback: even if larger machines wash more efficiently per kg of rated capacity, more and more part load washing will occur, and the relative savings per kg nominal load then are lost. Ideally, half load (e.g. at 60°C) should lead to a reduction of electricity consumption per cycle by 50% compared to a full load (e.g. at 60°C). However, according to results of the ATLETE II project (cf. in section 2.2.1.2), in practice the reduction ranges from 0% to 41% which leads in practice to an increase of the energy consumption per kg of laundry.
- Elongation of programme times: The increase of energy efficiency often goes along with longer programme times and lower temperatures (see below). On the other hand, there are washing machines on the market with comparably short times of the 'standard' programmes.
- Lower temperature than declared which leads to a better EEI and better classification because then less water has to be heated. Nevertheless, all machines guarantee the required washing performance (>1.03) despite these lower wash temperatures. However, in some cases this approach might lead to hygiene problems.

4.1.5.2. Most efficient washer-dryers listed at Topten.eu

According to (Topten International Group (TIG) 2015b), washer- dryer must meet the following criteria in order to qualify for Topten.eu:

- Energy efficiency: max. 0.5 kWh per kg laundry (full wash and dry cycle / washing capacity)
- Water consumption: max. 12 litres per kg laundry (full wash and dry cycle / washing capacity)

These criteria are reached only when the appliance is equipped with an integrated heat pump. Due to this technology these high-efficiency models consume 40% less energy. The energy consumption for washing and drying of the Topten-models accounts for 3.67 to 3.8 kWh per cycle, while inefficient washer- dryers without heat pump use > 6 kWh for this process.

Due to the integrated heat pump furthermore no cooling water is needed anymore for drying. Therefore water only is needed for washing, which saves 30% of water compared to conventional washer-dryers without heat pump. On average, the Topten-models use 69 litres / cycle, while inefficient models use around 100 litres and more. (Topten International Group (TIG) 2015b).

4.1.5.3. Most efficient washing machine models with regard to standby and off-mode consumption

The European Union has decided in 2008 to limit the standby and off-mode energy consumption of a board range of products and equipment. This decision followed the '1watt' call from the international Energy Agency in the 2000's. According to EU Regulation 1275/2008/EC, household appliances, households IT equipment, consumer electronics, electric toys, leisure and sports equipment have to fulfil the requirements in Table 4.8 (Topten.eu 2013).

Table 4.8 **Power consumption requirements**

	Since January 2010	From January 2013
Maximum power consumption in off mode	1 Watt	0.5 Watt
Maximum power consumption in a passive standby mode without information display	1 Watt	0.5 Watt
Maximum power consumption in a passive standby mode with information or status display	2 Watt	1 Watt

Based on the (Topten.eu 2013) studies, Table 4.9 indicates the best available technologies presented in the market in September 2012 in aspect of standby and off-mode energy consumption.

Table 4.9 **Most efficient technologies presented on the market in September 2012 with regard to standby and off-mode energy consumption (Topten.eu 2013)**

Product group	TVs	Monitors	DVD players*	Washing machines	coffee machines	inkjet printers	laser printers	luminaires
Number of products in Topten sample	*118*	*48*	*11*	*24*	*24*	*19*	*37*	*61*
Average off-mode power (W)		0.34		0.25		0.36	0.34	
Best performer off-mode (W)		0.1		0.05		0.2	0.1	
Average passive standby (W)	0.24	0.41	0.51	1.3	0.43			0.47
Best performer passive standby (W)	0.1	0.1	0.2	0.75	0.15			0.2
% of products with a hard-off switch or quasi-0 W mode	*3%*	*15%*		*29%*	*24%*		*38%*	*43%*

It is noticeable that these figures are not representative of the entire market but give a good indication of what manufacturers are able to do. It appears that off mode and passive standby modes can technically go below 0.3 W (Topten.eu 2013).

Further data regarding the use of standby and off-modes has been derived by the ATLETE II project (cf. and in section 2.2.2.1). They show that for the so called "stable left-on mode", most of the analysed washing machines have a left-on mode power of 0.5 W; around 6% of the appliances under test did achieve left-on mode power values in a range of 0.01 to 0.1 W. For the off-mode, the lowest power values were in a range between 0.01 and 0.02 W, most of the analysed appliances had 0.07 to 0.08 W off-mode power.

Further, since 2013 household appliances have a power management system requiring the appliances to automatically switch from left-on-mode into off-mode (not exceeding 0.50 W) after each cycle after a certain time.

4.1.5.4. Comparison of the performance of different washing machines and washer-dryers on the market

Based on input from stakeholders, the performance of some appliances on the market has been reported in the table below for illustrative purposes.

Table 4.10 Performance of different washing machines and washer-dryers on the market

Programme	Appliance	Energy consumption (kWh/cycle)	Water consumption (litre/cycle)	Noise in washing / spinning (dB(A))	Programme duration (minutes)
Cotton 20°C/ Cold wash	WM, indicative range of one producer	0.25 – 0.32	67 - 87		129 - 163
	WM, Top10, 3 A+++ models, 8 kg	0.32 – 0.65	80 – 133		90 - 150
	WM, specific model, 8 kg	0.42	69		159
	WD, indicative range of one producer	0.23 – 0.27	73 – 76		165 - 169
Cotton 30°C	WM, specific model, 8 kg	0.62	69		159
Cotton 40°C	WM, indicative range of one producer	0.67 – 1.10	62 – 87		132 - 174
	WM, Top10, 3 A+++ models, 8 kg	0.96 – 2.0	79 – 132		120 – 180
	WM, specific model, 8 kg	0.98	69		159
	WD, indicative range of one producer	1.02 – 1.06	73 – 78		165 - 169
	WD, specific model, 6 kg	0.65	57		139
Cotton 60°C	WM, indicative range of one producer	1.03 – 1.37	69 – 87		128 - 167
	WM, specific model, 8 kg	1.35	58		119
	WD, indicative range of one producer	1.02 – 1.12	73 – 76		165 - 174
	WD, specific model, 6 kg	0.8	45		159
Cotton 90°C	WM, indicative range of one producer	1.94 – 2.25	72 – 97		132 - 158
	WM, specific model0, 8 kg	2.30	58		149
	WD, indicative range of one producer	20.6 – 2.17	83 – 88		165 - 169
	WD, specific model, 6 kg	1.9	45		139
Synthetic / Easy care 30°C	WM, specific model, 8 kg	0.40	49		119
Synthetic / Easy care 40°C	WM, indicative range of one producer	0.61 – 0.70	46 – 61		95 - 119

Programme	Appliance	Energy consumption (kWh/cycle)	Water consumption (litre/cycle)	Noise in washing / spinning (dB(A))	Programme duration (minutes)
	WM, specific model, 8 kg	0.60	49		119
	WD, indicative range of one producer	0.56 – 0.76	59 – 65		103 - 119
	WD, specific model, 6 kg	0.48	50		91
Standard cotton 40°C (Eco)	WM, indicative range of one producer	0.35 – 0.75	37 – 46		210 - 270
	WM, specific model, 8 kg	0.80	55		179
Standard cotton 60°C (Eco)	WM, indicative range of one producer	0.74 – 0.77	50 – 55		210 - 270
	WM, specific model, 8 kg	0.92	48	45 - 69	179
	WD, indicative range of one producer	0.70 – 0.87	49 – 74		285 - 427
Quick wash / Short	WM, indicative range of one producer	1.18 – 1.46	50 – 58		68 - 76
	WD, indicative range of one producer	1.11 – 1.20	49 – 59		67 - 72
Express 30°C, 3.5kg	WM, specific model, 8 kg	0.34	30		20
Quick wash / Short 3kg /40°C	WD, specific model, 6 kg	0.30	26		20
Wool / Hand wash	WM, indicative range of one producer	0.17 – 0.22	33 – 43		35 - 56
Wool / Hand wash 2.0 kg	WM, specific model, 8 kg	0.23	35		38
	WD, indicative range of one producer	0.18 – 0.19	39 – 40		36 - 45
Wool / Hand wash 2.0 kg / 30°C	WD, specific model, 6 kg	0.23	39		39
Mix/Automatic (all fabrics)	WM, indicative range of one producer	0.60 – 0.61	45 – 51		61 - 65
	WD, indicative range of one producer	0.44 – 0.62	46 – 53		63 - 66
	WD, specific model, 6 kg	0.50	55		87
Other wash programmes (please specify)	WD, indicative range of one producer	4.87 – 5.66	55 – 119		547 - 780

Programme	Appliance	Energy consumption (kWh/cycle)	Water consumption (litre/cycle)	Noise in washing / spinning (dB(A))	Programme duration (minutes)
Dry Cotton	WD, indicative range of one producer	2.37 – 2.82	3 – 24		147 - 201
Dry Cotton, 3.0 kg	WM, specific model, 6 kg	1.77	13		88
Dry Synthetic	WD, indicative range of one producer	1.44 – 1.49	3 – 25		118 - 125
Dry Synthetic, 1.5kg	WD, specific model, 6 kg	0.75	6		39

4.1.6. Summary on technologies

Table 4.11: Overview of technologies for washing machines and washer-dryers (own elaboration below summarises the technology options for household washing machines and washer-dryers. Further analysis is to be carried out to characterise these technologies. The overview shall be taken as basis for the following tasks to derive Base Cases of household washing machines and washer-dryers, as well as to define design options, and scenarios of analysis. The data for 2015 are first assumptions of the study team.

Feedback from stakeholders is kindly requested, in order to refine the information presented.

Table 4.11: Overview of technologies for washing machines and washer-dryers (own elaboration characterises the technologies currently applied to washing machines and washer dryers in terms of:

- Working principles
- Qualitative description and streamlined quantification of environmental benefits (e.g. savings of energy, water or materials) and drawbacks (e.g. costs / cost increase, other impacts at material level) associated to eachtechnology
- State of implementation and expected market and design trends for such technologies (both qualitative description and when possible, quantification)
- Relevance and selection of such technologies for Base Cases or as BAT/BNAT in the assessment of different design options.
- Practical examples of products implementing such technologies, also with indications of the effects in terms of Bill of Materials, energy performance, water consumption, costs, impact on end of life, etc.
- Other comments of relevance.

Additionally, according to Topten, the highest Energy Efficiency Index benchmarks of washing machines and washer-dryers can be reached by the following means:

- Advanced technologies:
  - Inverter driven motors and permanent magnet motors
  - Heat pump technology
- Effective load sensors capable of estimating the weight of the laundry load and automatically adjusting the water and energy consumption. In particular this is meaningful for larger-sized washing machines, which may be not fully loaded by users.
- High load capacity
- Lower washing temperatures than the nominal ones.

Table 4.11: Overview of technologies for washing machines and washer-dryers (own elaboration)

Improvement	Technology Deployment		Expected benefits (e.g. resource savings)	Drawbacks and additional comments (e.g. costs, barriers)	Relevance (or not) as Base Case option, BAT, BNAT	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
Machine construction						
• Tub-drum geometry	Commonly implemented since 2005 (100%)	Stable implementation			Base Case	Base Case
• Increased rated capacity	Increase from 5 to 6 kg for 30% of machines in 2005 and 90% of machines nowadays		Savings if the machines is fully loaded,	Possible increase of energy consumption if partially loaded.	Base case	Base case
• Multi-drum washing machine			Impacts to be further analysed	It might be difficult to measure applying the existing test standards		
• Fiberglass drum construction	It could be implemented in less than 2% of machines		No direct impact on consumption of energy and water. Further environmental impacts to be analysed			
• Increased durability						
• Use of recycled plastic (washing machine)	Implemented in less than 1% of the products		Improvement potential in terms of resources to be evaluated		BAT	BAT
Increased motor efficiency						

Improvement	**Technology Deployment**		**Expected benefits (e.g. resource savings)**	**Drawbacks and additional comments (e.g. costs, barriers)**	**Relevance (or not) as Base Case option, BAT, BNAT**	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
• High efficiency motors	Brushless DC motor implemented in 0.5% of the products in 2005 Brushless DC direct drive motor implemented in 0.5% of the products in 2005 Three phase motor implemented in 5% of the products in 2005 Permanent magnet synchronous DC motors (PMSM) implemented in 50% of the products in 2005		Increased energy efficiency Additional noise reduction and longevity		BAT	BAT
• Optimised materials in motors	Not implemented / about 0% in 2005				BAT	BAT
Time-temperature trade off						
• Decrease of reached temperatures in the washing programmes	Commonly implemented since 2005 (100%)	Stable implementation / reversed trends to be discussed	Water and energy savings, variable and associated to longer cycle times and reduced temperatures	Cycle times may not be acceptable in extreme cases Temperature control sensors are not implemented in all products (in 80% of the products in	Base Case	Base Case

Improvement	Technology Deployment		Expected benefits (e.g. resource savings)	Drawbacks and additional comments (e.g. costs, barriers)	Relevance (or not) as Base Case option, BAT, BNAT	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
				2005)		
• Low temperature programmes: introduction of 20°C cycle	Commonly implemented nowadays (100%)	Stable implementation	Water and energy savings, variable and associated to the use of lower washing temperatures	To analyse in conjunction with the hygiene issues		
• Programmes handling hygienic aspects	Implemented in 0.5% of the products in 2005		Increased hygiene	Increase of energy demand		
Improved thermal efficiency						
• Design optimisation	Commonly implemented since 2005 (100%)	Stable implementation	No further savings foreseen		Base Case	Base Case
• Washing machines with heat pump technology					BAT	-
• Washer-dryer with heat pump technology					-	BAT
Alternative heating systems						
• Hot-fill-feature:					BAT	BNAT
• Heating by hot water circulation loop ("heat-fed machines")		0%			BNAT	BNAT
Reduction of water consumption						
• Rinsing optimisation	Implemented in about 20% of the products in				BAT	BAT

Improvement	**Technology Deployment**		**Expected benefits (e.g. resource savings)**	**Drawbacks and additional comments (e.g. costs, barriers)**	**Relevance (or not) as Base Case option, BAT, BNAT**	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
	2005					
• Use of rain/well water			Saving of fresh water		BAT	BNAT
• Water recycling	Not implemented significantly (0%)				BNAT	BNAT
Optimised mechanical action • Ecobubble™technology • Internal water circulation • Spray-technology	Implemented in about 20% of the products in 2005				BAT	BNAT
Spin speed and alternative drying systems						
• Alternative drying systems						
• Increase of spin speed	Increase from 1200 to 1600 rpm implemented in about 15% of the products in 2005		Increased energy demand but savings in case of further drying needs			
Sensors and automatic controls						
• Unbalance control	Implemented in about 5% of the products in 2005		Noise reduction		BAT	BAT
• Automatic load detection	Weight sensors implemented in 2% of products in 2005 Water sensors implemented in 5% of prod-				BAT	BAT

Improvement	**Technology Deployment**		**Expected benefits (e.g. resource savings)**	**Drawbacks and additional comments (e.g. costs, barriers)**	**Relevance (or not) as Base Case option, BAT, BNAT**	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
	ucts in 2005 Sophisticated electronic controls (fuzzy logic) implemented in 50% of products in 2005					
• Automatic detergents dosage systems			Mainly saving of detergent, also possible saving of water		BAT	BNAT
Anti-crease mechanisms						
• Steam Care/Steam finishing	Implemented in 0.5% of the products in 2005		Increased hygiene, reduced wrinkling (with reduced demand for ironing), improved odour	Increase of energy demand		
• Anti-crease systems			Reduced wrinkling (with reduced demand for ironing)	Increased energy demand	BAT	
Alternative washing systems						
• Ultrasonic cleaning technologies					BAT	BNAT
• Polymer bead technology	Not implemented significantly (0%)				BNAT	BNAT
Consumer feedback mechanisms						
• LCD with actual load indication	Implemented in 0.5-1% of the products in 2005				BAT	BNAT

Improvement	**Technology Deployment**		**Expected benefits (e.g. resource savings)**	**Drawbacks and additional comments (e.g. costs, barriers)**	**Relevance (or not) as Base Case option, BAT, BNAT**	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
• Display of consumption of resources			Indirect savings associated to the possible influence on user behaviour		BAT	BNAT
"Smart" appliances						
• Internet connectivity	Not implemented significantly (0%)		Savings associated to the potential planning of the wash when more convenient		BAT	BNAT
• Electronic update of the programmes /diagnostics:			No direct impact on consumption of energy and water. Further environmental impacts to be analysed			
• Smart grid ready (SG ready) products			No direct savings but possible gains associated in conjunction with the electricity generation process.		BAT	BNAT
Others						
• Noise reduction			Side effect of other options, no savings			
• Single stain removal system	Implementation should be higher than in 2005 but			Complex influence on water and		

Improvement	**Technology Deployment**		**Expected benefits (e.g. resource savings)**	**Drawbacks and additional comments (e.g. costs, barriers)**	**Relevance (or not) as Base Case option, BAT, BNAT**	
Areas and options	**State of the art**	**Short-term trends (e.g. 2020)**			**Washing machines**	**Washer-dryers**
	not known			energy consumption if option is chosen.		
• Delay start	Implemented in about 30% of the products in 2005; used in 8% of the washing cycles		Savings associated to the potential planning of the wash when more convenient (with possible acceptance of long time cycles)	Increase of electricity demand due to delay start mode.	BAT	BAT
• Voice controlled appliances	Not implemented significantly (0%)		No savings, benefits are from a social point of view		BNAT	BNAT
• Mixed appliances	Not implemented significantly (0%)		Unclear impact		BNAT	

4.2. Production, distribution and end-of-life

4.2.1. Production and Bills-of-Materials (BOMs)

In general, large white goods, such as washing machines and washer-dryers, are composed of the following materials/metals (UNEP 2013):

- Metals (steel, copper, aluminium, stainless steel and their alloys).
- Diverse plastics and organic materials, including their additives, fillers, stabilizers, as well as rubber, wood, textile, fibres, etc.
- Inert materials, such as glass and concrete (incl. ferrite-containing concrete in washing machines).
- Low value printed wire boards (PWB) and electronics containing precious and platinum-group metals.

Table 4.12 provides a first general average material composition of washing machines based on 2011 data, although without specifying geographical and technical representativeness (UNEP 2013).

Table 4.12: Average composition of washing machines; source: (UNEP 2013)

Material (%)	Washing machine
Iron/Steel	52.1
Copper	1.2
Aluminium	3.1
Stainless steel	1.9
Brass	0.1
Plastics	6.8
Rubber	2.8
Wood	2.6
Other organic	0.1
Concrete	23.8
Other inert material	1.9
PWB	0.4
Cables (internal / external)	1.1
Other materials	2.2
Total	100

The Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) used following average production input data for a washing machine model in 2007:

Table 4.13: Average production input data for a 5 kg washing machine model used by Lot 14 in 2007; source: (ENEA/ISIS 2007c)

PRODUCTION		
Materials type	**Material**	**WM 5 kg (g)**
Ferrous metals	cast iron	6,214

PRODUCTION		
Materials type	**Material**	**WM 5 kg (g)**
	Iron	4,978
	Stainless Steel	1,939
	Stainless steel sheet	564
	Steel	12,521
	Steel strip	6,145
	Sum Ferrous metals	***32,361***
Non ferrous metals	Al	1,503
	Aluminium sheet	1
	Aluminium casting (recycled 80%)	729
	Brass	14
	Copper sheet	0
	Copper wire	348
	Cr	1,761
	Cu	869
	Ni	1
	zinc die-casting	85
	Sum Non ferrous metals	***5,311***
Plastics	ABS	1,145
	EPDM - rubber	1,675
	PA	6
	PA 66-GF(Glass Fibre Reinforced)	0
	PA66	88
	PC	188
	PC-G (Glass Reinforced)	2
	PE	10
	Plastics, others	1,037
	POM	41
	PP	5,402
	PP-K40	2,533
	PPO (=PPE)	2
	PPS-GF	76
	PVC	221
	PBT	8
	Sum Plastics	***12,434***
Various	Bitumen	38
	Concrete	18,180
	Electronic, boards, switches, lamp, etc	165
	Filter	28
	Glass	1,773
	Gravel	25
	Oil - Feet	28
	Others	204
	Paper (booklets etc)	106
	Wiring	88
	Wood	1,573
	Sum Various	***22,206***
	Sum TOTAL	**74,225**

In case of washer-dryers additional components compared the BOM of washing machines are required to provide the hot air venting system: air ducts (plastic materials), heating elements (consisting of metals for resistance wire and copper wires), ventilator including electric motor, heat exchanger, electronic components for control), including moisture sensor.

The following variations compared to the BOM as provided in Table 4.13 might be observed at individual washing machine and washer-dryer models:

- Higher content of ferrous metals in devices with balance weights from steel (and correspondingly the absence of concrete)
- If the machine is equipped with a permanent-magnet synchronous motor (PMSM, the motor weight is reduced from around 6.5 kg to 3.5 kg; further there is presence of rare-earths in the permanent magnets, most likely the NdFeB-type. Rare earths like Neodymium (used as NdFeB) or Samarium (used as SmCo) enhance the magnet field. Neodymium further stabilises magnets against demagnetisation due to mechanical shocks or other magnet fields. Dysprosium, for example, is added to get permanent magnets more heat resistant.
- Comparable to dishwashers in cases where heat pumps are being used some additional components are required: copper pipes for the cycle of refrigerant, a compressor system consisting of an electric motor and the compressor itself (mainly made of steel), heat-exchanger (commonly made of aluminium and copper) and electronics for the control unit.
- Some machines are available with automatic dosage systems. Those machines additionally require dosage pumps (electric motors, pump housings [plastics], and pump wheels), possibly magnetic valves (brass, copper, resin) reservoirs for detergents (plastics) as well as electronics for the control units.
- Further variations based on other implemented improvement options with regard to energy and material efficiency (cf. section 4.1.3).

According to (UNEP 2013), the composition of white goods strongly varies from product to product, and as they become 'greener' their resource efficiency increases. For example, “critical” materials are mainly found on Printed Wiring Boards PWBs. According to a study by UNU 2007 cited in (UNEP 2013), large white goods contain on average

- 20 ppm palladium (Pd),
- 160 ppm silver (Ag) and
- 38 ppm gold (Au).

4.2.2. Assessment of the primary scrap production during sheet metal manufacturing

According to the EcoReport tool, the primary scrap production during sheet metal manufacturing is calculated as a percentage of the total sheet metal manufacturing value.

Primary scrap is considered in MEErP as "*the material that is lost during the fabrication of semi-finished products (rolled sheets, extrusions, castings, etc) and finished products (e.g. metalwork products). It is brought to the internal furnace (fabricator scrap) or to an external smelter (traded scrap) and recycled within a matter of minutes/hours (when inside the same factory: the so-called 'run-around-scrap') or at the most weeks (when collected and transported to the smelting plant). It is relatively uncontaminated and pure material that can be re-used with little or no pre-treatment*”

Deviating from the default value of 25% given in the EcoReport tool, the Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) has chosen 5% as input for the sheet metal scrap during the manufacturing of washing machine models in 2007 which leads to following values:

Table 4.14: Average input data for sheet metal scrap of washing machine manufacturing used by Lot 14 in 2007; source: (ENEA/ISIS 2007c)

	Washing machine 5 kg
Sheet metal manufacturing	23,717 g
Sheet metal scrap (5% of the sheet metal manufacturing)	1,186 g

Indications from stakeholders suggest that for the production of a complete washing machine housing (made out of steel), this value could be increased up to 12.2%.

4.2.3. Packaging materials and volume and weight of the packaged products

According to (WRAP [n.d.]b), different product packaging is possible: typically used across the industry is a mixture of cardboard and expanded polystyrene (EPS). The use of PE foams in place of the EPS should be considered as it will help with recyclability. If practical, the use of all corrugated carton board for packaging needs should also be considered. The corrugated carton board used for the caps could be changed to use newer flute designs (such a P Flute) which provide the same strength but use less material and are therefore lighter.

The Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) used following average production input data for the packaging of a washing machine model in 2007:

Table 4.15: Average production input data for packaging of a washing machine model used by Lot 14 in 2007; source: (ENEA/ISIS 2007c)

PRODUCTION		
Materials type	**Material**	**WM 5 kg (g)**
Packaging	Cardboard	107
	EPS	678
	Paper (booklets etc)	10
	PE - foil	175
	Plastics, others	56
	PP	8
	Wood	879
	Sum Packaging	***1,912***

In reply to a questionnaire circulated to stakeholders on March 2015 (JRC IPTS 2015a), it has been reported that the packaging of a product serves to protect the product throughout its journey from the manufacturing plant till the end consumer. A high level of protection is needed as products have to withstand conditions of mechanical stress in warehouses, loading and transportation, fall tests. The following indicative examples were provided, for both washing machines and washer-dryers. The example for washer dryers represents an imported product from a China factory for which extra protection was needed.

Table 4.16: Average data for packaging of a washing machine and a washer dryer; source: stakeholder information

Material (g)	Washing machine	Washer dryer
Carton box	200	3,000

Material (g)	Washing machine	Washer dryer
EPS	700	1,000
PE	300	---

In terms of final volume and weight of the packaged product, the following indications were reported by the above sources.

Table 4.17: Input data for volume and weight of packaged washing machines and washer-dryers used by Lot 14 in 2007 (ENEA/ISIS 2007c) and by stakeholders (JRC IPTS 2015a)

Model	Volume of final packaged product (m^3)	Weight of final packaged product (kg)
Washing machine, 5 kg capacity (Lot 14)	0.360	74.22
Washing machine (stakeholder information)	0.447 (product only: 0.319)	62 (product only: 61)
Washer dryer (stakeholder information)	0.450 (product only: 0,320)	88 (product only: 84)

4.2.4. Transport of components, sub-assemblies and finished products

The EcoReport 2011 software tool uses average mix of transport modes by type of product. If for the appliances in scope the real transport mix deviates substantially from the average transport mix, this can be corrected ex-post giving the industry sectors with an environmentally-friendly transport policy (local suppliers, ship instead of airplane) an option to take their effort into account.

As an illustration, Bosch and Siemens Hausgeräte GmbH informs in their Group Sustainability Report 2013 about the share of transport means of exported appliances from Germany. In 2013, 33% of the total export transport volume was per rail, 40% per truck, 14% per short sea shipping (Europe) and 13% per general sea shipping. (BSH Bosch und Siemens Hausgeräte GmbH 2013)

The Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) used following input data for the transport distance of washing machines:

- Washing machine, 5 kg model: average transport = 648 km

However, since the main environmental impacts for these types of appliances are in the use phase, the approximation made with the EcoReport tool should be satisfactory for the purposes of the study.

4.2.5. Technical product life (time-to-failure of critical parts)

4.2.5.1. Data on technical product lifetime of washing machines

The Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) used following input data for the product life of washing machines:

- Washing machine model with 5 kg load capacity: 15 years

(VHK 2014), has been commissioned by the European Commission to systematically monitor and report on the impact of Ecodesign, Energy Labelling, Energy Star and Tyre Labelling measures. Their study with regard to the application of a newly developed accounting method to the existing Ecodesign preparatory studies and impact assessment reports available on 1 November 2013 inter alia calculated sales and stock data as well as impacts of household washing machines (cf. also section 2.2). These data were also based on a product lifetime of 15 years for washing machines.

(Prakash et al. 2015) analysed various international literature with regard to the lifetime of washing machines. The retrieved product life data vary between 9 and 20 years for washing machines. The large variations are explained with different countries (Netherlands, Greece, UK, Canada, China) and years (2005-2014) of the analysed studies, as well as very different survey and calculation methods used (e.g. official statistics, consumer surveys, calculations based on sales data, surveys in households and electrical stores).

Further, (Prakash et al. 2015) analysed data of the Society for Consumer Research (GfK) for large household appliances in Germany with regard to the developments of the average "first useful service-life". This indicator is the timespan in which the product is *used* only by the *first* consumer; it is – however – not to be confused with the technical product life-time which might be longer if the appliance is still functioning and is for example passed on within family members and/or to friends or resold to third persons. Whereas the user related service-life is already described in section 3.3.1, in the following information shall be given about the overall technical lifetime which was derived for those products that were replaced due to a defect.

The results of (Prakash et al. 2015) based on GfK data show that the average life-span of large household appliances at all (covering washing machines, dryers, dishwashers, ovens, refrigerators and freezers) in Germany which had to be replaced due to a defect (i.e. technical product lifetime) decreased from 2004 to 2012/2013 by one year and now lies at 12.5 years. On an average, the product replacement of large household appliances due to a defect slightly decreased from 57.6% in 2004 to 55.6% in 2012. This means that a defect still is the main cause of the replacement; on the other hand, it is important to realise that almost one third of the replaced large household appliance was still functional.

Extracting the data specific only for washing machines, the results show that for appliances which were replaced due to a defect (i.e. technical product lifetime), the first useful service-life was 12.5 years in 2004 and 11.9 years in 2012/2013.

Table 4.18: "First useful service life" of washing machines in Germany in 2012/2013 compared to 2004; source: (Prakash et al. 2015) based on GfK data

	2004	2012/2013
"First useful service life" of washing machines (including those still functional)	12.7 years	11.9 years
"First useful service life" of washing machines replaced due to a defect (i.e. technical product lifetime)	13.5 years	12.5 years

According to (Prakash et al. 2015), the need for replacing devices being less than 5 years old due to a defect has increased. The proportion of washing machines which had to be replaced within less than 5 years due to a defect rose from around 6% to 15% of all defective washing machine replacements between 2004 and 2012.

According to some stakeholders the number of cycles might be a better indicator for assessing the durability of a product. Indicative correlations between expected number of cycles a product is designed to last and equivalent years of use of the appliance have been also provided by stakeholders. A more durable product might last for 5000 washing cycles, against 1800-3000 cycles of typical appliances. This might for instance lead to lifetime extension up to 20 years.

In reply to a questionnaire circulated in March 2015 (JRC IPTS 2015a), one stakeholder from industry reported that the products are not designed to fail. Consumers are provided with a wide range of products responding to their different, individual needs such as convenience, performances, energy efficiency, design, robustness, after-sales service, and affordability.

Extended warranty options vary across EU countries. For washing machines, stakeholders informed that the warranty provided by manufacturers is typically 2 years but it can also be between 2 and 5 years, depending on the model. One stakeholder reports a free 5 years parts guarantee in many EU countries for consumers who register their appliance and the parts being fitted by one of the authorised engineers. Certain motors moreover can have 10 year part warranties. Another stakeholder informed that they offer extended warranty of up to 10 years, but without specifying if for certain components or the whole product. Extended guarantee plans are also offered for purchase which cover full risks of breaks downs. Finally, some retailers may offer extended warranties at the point of purchase, either free of charge – mostly proposed by a commercial action – or against a fee.

4.2.5.2. Common causes of breakdowns and product design with regard to durability and reparability

In the following, relevant studies and test reports specific with regard to typical defects and failures of household washing machines and washer-dryers have been analysed, also with regard to recommendations for proposed design improvements. More general studies on integrating resource / material efficiency aspects as possible Ecodesign measures can be found in section 1.3.4.

RReuse study

The Reuse and Recycling EU Social Enterprises network (RREUSE) is a European umbrella organisation for national and regional networks of social enterprises with re-use, repair and recycling activities. They cover 42,000 Full Time Equivalent (FTE) employees and over 200,000 volunteers working throughout 22 member organisations across 12 EU Member States.

In 2013, RReuse has conducted an investigation into some of the main obstacles its members encounter when repairing products, inter alia for washing machines and dishwashers, to provide part of the basis for setting requirements within implementing measures to improve the reparability of products, and thus their material and resource efficiency. Based on a questionnaire sent out through their network, the findings are answers from 9 individual reuse and repair centres from four national networks of social enterprises namely AERESS (Spain), Repanet (Austria), Réseau Envie (France) and the Furniture Reuse Network (UK).

The study revealed the following examples of common causes of break downs for household washing machines (RReuse 2013):

- Concerning the durability of components, many washing machine shock absorbers cannot withstand 1600 rpm for a long period of time and wear out quickly. Ball bearings which were designed for washing machines which centrifuge at 300 rpm are also often used in today's washing machines which operate at 1000 or 1200 RPM, which also leads to quick degradation. In addition, it can happen that the bearings can get pressed into the plastic outer casing of the washing machine drum and stops the drum from rotating, which can also deform or even break the drum spider.
- The seals of the pumps which are made out of rubber degrade quite often and this can easily block the pump. Finally, the membrane of pressure switches (pressostat) can degrade over time which leads to the washing machine to take on more water than it is originally designed for.
- The heaters can stop working prematurely, especially in regions with hard water (high lime content), often due to a lack of yearly maintenance of the machine
- The electronic steering components linked to the timer can fail, which is a problem as it is increasingly difficult to identify the problem. These problems were not encountered in the past when the steering mechanisms were primarily mechanical.
- Faults relating to the interlock

With regard to product design, (RReuse 2013) suggests following measures to help improve the reparability of washing machines:

<u>Design for disassembly for repair</u>:

The product should be able to be disassembled non-destructively into individual components and parts without the need for special proprietary tools to do this. If special tools are required however, these must be readily and freely available to every repair shop (not just to the after sales service providers of the manufacturers). Design for better disassembly could include for example:

- Seals on electronic boards should be easily removable for repair of the electronic board.
- The casing of the drum must be able to be opened.

<u>Potential standardisation of components</u>:

- Simplification of specific components as well as the potential standardisation of key components across different brands would significantly increase the efficiency of repair. This could include, for example, the rubber tubes or sealants, especially for the drum shaft.

<u>Improved durability of components</u>:

Increasing the durability of parts that are known to wear out or get damaged easily can significantly prolong the lifetime of a product. Examples are:

- Bearings and shock absorbers.
- Drum shaft seals
- Door hinges.
- Motors: Choosing a motor known to not degrade too quickly as for example brushless motors or single-phase motors would also help prolong the lifetime of a washing machine, although it is recognized that these are more expensive and less commonly used motors nowadays than AC motors with carbon brushes.

<u>Protection of electronic and mechanical components</u>:

- Construct electronic boards to be protected by fuses. In addition a fuse should be included at the input of the device to protect the electronics from power surges.

WRAP study

In the UK, WRAP has been working between September 2013 and March 2014 with a consortium of specialists to develop outputs through targeted research and engagement with industry and other bodies with regard to evidence around perceived failure rates and opportunities for life extension for the product group washing machines. (WRAP 2013c) There are no standards on washing machine durability, thus the WRAP study requires specifications for durability of: Motor, control electronics, bearings and seals; paddles, latches and hinges, the heating element as well as for facia switches and dials.

For motors, bearings and seals, the specifications required by (WRAP 2013c) are for example 3,000 hours (i.e. around 8-9 years) with no maintenance.

Table 4.19: Examples for failures of washing machines (Source: (WRAP 2013c))

Failure mode	Cause	Time of failure usually arising (early/late)
Motor	Worn brushes; overload / burn out	Late
Bearing	Leaking seal or gradual wear	Late

Failure mode	Cause	Time of failure usually arising (early/late)
Electronics	Poor design; poor connectors; no surge protection; no humidity or vibration protection	Both early and late
Drum paddles	Poor attachment to drum	Both early and late
Heating element	Corrosion / poor connectors	Both early and late
Facia dials and switches	Poor design / manufacture / wear	Can be both
Door latches, hinges and interlocks	Poor design / manufacture / corrosion / wear / user error	Can be both
Blocked filters / pump	User error or poor filter design	Can be both
Water inlet valve or level sensor failure	Poor design / manufacture / wear	Can be both
Dampers – resulting in noise and vibration	Poor design / manufacture / wear	Late most likely

WRAP research on design for durability and reparability of washing machines

WRAP has conducted a case study analysing and presenting measures that extend the product’s life of washing machines (WRAP 2011b). The specifications were developed by assessing a range of washing machine price-points, through research with manufacturers, retailers and repairers, and also by carrying out machine ‘teardown’ to identify design features that facilitate durability and repair. Two models have been used to demonstrate the practical application of many of these good practice features.

According to (WRAP 2011b), washing machines are mainly constructed with the same basic components; with regard to durability, products either vary in the positioning of these parts, but more fundamental differentiations between washing machines arise by the quality of their build and components.

The study found that parts that are more prone to wear and that are more likely to need replacing are:

- door seals and hinges (items becoming caught in the seals, or deterioration of the rubber);
- inlet and outlet hoses;
- water heating elements;
- drum bearings (failure due to water leaks);
- motors (particularly from wear on brushes);
- soap drawer (misuse, or detergent solidifying causing blockages); and
- motor and drum bearings (due to overloading).

Besides of these parts, the study reports that Bosch has found that electrical failure is currently the leading fault, particularly of the PCB (printed circuit board) caused by fluctuations in mains voltage supply, although surge protection is provided with these machines. Electrical faults can also occur as a result of water leaks from poor installation of the machine in the household and blockages in the soap drawer or inlet and outlet pipes. Further, Bosch has found that failures of other electrical components such as motors and pumps are becoming less common. (WRAP 2011b)

Table 4.20: Examples for durable design of washing machines (Source: own adaptation based on (WRAP 2011b), (WRAP [n.d.]c), (WRAP [n.d.]d))

Part / component of the washing machine	Design to facilitate durability	Effect

Part / component of the washing machine	Design to facilitate durability	Effect
Chassis	Steel, coated	Prevents rusting
Rear panel	Stainless steel	Provides greater corrosion protection
	Solid enclosed base	Provides resistance to vibration and rigidity to the machine
Front control panel casing and dials	ABS (acrylonitrile butadiene styrene) or PCABS (a poly-carbonate ABS blend)	Robust engineering polymers being ideal for this type of application where the surface is subject to wear and tear
	Sufficient wall thickness of the panels	Provides rigidity, limits flexing during use and offers protection to the internal parts
Motor	Entirely enclosed brushless motor; some brushless motors have been certified to last for at least 20 years / 4,400 cycles (220 p.a.)	Improved energy efficiency and speed, increased stability, reduced damage; decreases noise and vibration (eliminates the need for a belt drive)
	Longer brushes	Prevents brushes to be worn to early
	Improve quality of windings, improve surge suppression, fit re-setting thermal overload switch	Prevents motor from overload / burn out
Bearing	Overload and unbalanced load sensor; use better or shielded seal; better quality bearings (e.g. case hardened roller bearings)	Prevents leaking seal or gradual wear
Heating element	Ceramic element	Prevents corrosion
Detergent drawer, inside	Polypropylene	Provides good water and chemical resistance
Drum housing (outer tub)	Plastic, supported by springs and dampers	Prevents the drum vibration being transferred to the chassis where it can cause electrical failure
	Four steel transit bolts	Secures and protects the drum during transportation and can easily be removed and reused for further transportation
Drum paddles	Make them an integral part of the steel drum (screw or bolt on instead of clip fit or rivet)	Prevents loosening
Internal hoses	Securely fixed to the chassis with pipe clips	Prevents movement during use, provides damping and reduces vibration noise
Component and cable fixing	PCBs secured with clips	Enables quick and easy replacement over numerous access cycles Dampens and resist vibrations more effectively compared to screws
	Electrical connectors secured firmly with snap-fits	Resists vibrations
	Use of plastic connectors rather than soldered joints	Allows easier access for parts
	Internal cables are routed around the inside of the chassis and secured by cable ties or clips; length of the wiring is kept to a minimum	Prevents movement which could cause failure from flexing
Facia dials and switch-	Individual micro-switches per position	

Part / component of the washing machine	Design to facilitate durability	Effect
es	rather than potentiometer type / brush connector	
Leak protection	Most electronics located at the top of the machines; electronic components below the tub are covered	Prevents water damage
	Positioning of wiring looms and connectors	Minimises electrical failures
	Motor cabling with plastic shroud	Protects from potential leaks
Sensors		Detect and prevent major causes of damage and failure in washing machines: • load weighting (recommending appropriate wash programmes and/or improving load distribution to prevent uneven wear on the bearings), • leaks (resulting in shut down) • foam / detergent sensor (to control rinse cycles)

Table 4.21: Examples for repairable design of washing machines (Source: own adaptation based on (WRAP 2011b), (WRAP [n.d.]c), (WRAP [n.d.]d))

Part / component of the washing machine	Design to facilitate repairs	Effect
Casing of the machine	Minimal amount of screws and fixings (snap-fits and lugs); Screws standardized in size and head type Brass threads	Allows quick and easy access for repair cycles Avoids tool changes during repair Allows simple and numerous access cycles
Top cover	Reduce number of fixings to assemble the top cover within the frame; or Design the frame with a ledge so that the top cover can be pushed in and secured with an adhesive strip	Enables these parts to be separated for ease of repair or replacement
Back panel	Single cover plate with one screw; large profile of the back panel	Good access to key components like rear of the drum, drive belt, internal water hoses and motor
Front panel	Using locator lugs at the bottom, and screws at the top of the machine; or Increasing the lip of the front panel edge so that it tucks under the base and can be held in place with screws located vertically	Avoids weaken the joint in case of repeated removal of the front panel
Motor and drive belts	Few bolts and locator lugs Easy access to drive belts	Easy to unhook Removing by hand possible without tools needed
PCBs	PCBs should be coated and dried before inserting into the cover	Avoids that conformal coated PCBs cannot be removed from their housing as the coating has been applied after they were inserted into the housing

Part / component of the washing machine	Design to facilitate repairs	Effect
	Using screws, lugs and easy snap-fits with release catches in the same direction; or Integrating a slot in the chassis	Snap-fits partly don't need tools to open Allows the main PCB and housing to pull out and separate for part repair or replacement
Drum Tubs	Bolted together instead of being ultrasonically welded	The non-permanent joint provides easy access
Internal hoses	Simple metal spring clips	Easy removal and replacement
Rubber door seals	Secured with two metal tension rings on the inside and outside of the drum	Simple removal of tension rings by unclipping
Doors	Using bolts	Easy removal and replacement

Additional information from stakeholders

According to feedback from stakeholders, in March 2015 the Spanish consumer organisation OCU (OCU 2015) published the results of a survey of more than 23.638 users (4.821 of which amongst its Spanish subscribers) aiming to discover what was their level of satisfaction with regards to domestic appliances such as washing machines, dishwashers and fridges. Aside from Spain, the survey also covered geographically Italy, Portugal and Belgium.

With regards to washing machines the most frequent failures reported concerned

- the door (12%),
- the filter (11%),
- the spinning function (10%),
- the drain pump (9%), and
- water leakage (9%).

According to stakeholders, also environmental parameters can influence the product lifetime negatively, such as exceptional humid environment, power supply outside the tolerance value for stability of supply and, exceptionally, hard water for scale build up on the heating element.

One stakeholder from industry informed that as part of their continuous improvement efforts, some broken components are sent to the design laboratory to investigate the causes for breakdown and use information to improve reliability and durability. Further, if during the warranty period it is necessary to exchange a defective product rather than repair it, whenever this is cost effective, the appliance could be shipped to service warehouse and repaired, so that it can be placed on the market again as second or third choice. The most frequent failures in the first years of life are regularly monitored to take early actions and improve design and production quality in order to constantly reduce the failure rate. For critical components as electronics, motor etc. there are specific reliability tests to ensure a robust design and rigorous suppliers quality control.

According to stakeholders, examples of actions taken by manufacturers to facilitate the repair operations are:

- A quick and reliable technical assistance service.
- Fault code indicated in the user interface through LEDs indicating the suspected cause of the failure.

- PC diagnostic tool which allows, once the machine is connected to a PC, performing a complete check-up of the product, detecting any faults, and even updating the software to the latest version available.
- Some broken components are sent to the design laboratory to investigate the causes for breakdown and use information to improve reliability and durability.
- If, during the warranty period, it is necessary to exchange a defective product rather than repair it, whenever this is cost effective, the appliance could be shipped to service warehouse and repaired, so that it can be placed on the market again.

A focus on components that are crucial for the correct functioning of appliances is fundamental, i.e. if that component breaks down, the appliance cannot be longer used for the main functions of use for which it was intended. There should therefore be a clear differentiation of a component that is critical to the main functions versus the auxiliary functions of the product.

However, it was reported by another stakeholder from industry that any list of components developed for regulatory purposes should be justified and supported by robust quantitative and qualitative data, in a clear and transparent way. Assessments should be empirically and scientifically based.

4.2.6. Materials flow and collection efforts at the end-of-life and waste management (landfill/ incineration/ recycling/ re-use)

The following sections provide an overview of European end-of-life management paths of household washing machines and washer-dryers. In this context, the Waste Framework Directive 2008/98/EC (European Parliament 2008) provides following definitions for possible end-of-life operations:

- 'Re-use' means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived. In this context, 'preparing for re-use' means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.
- 'Recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.
- 'Recovery' means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II of Directive 2008/98/EC sets out a non-exhaustive list of recovery operations.
- 'Disposal' means any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I of Directive 2008/98/EC sets out a non-exhaustive list of disposal operations, such as for example landfill.

4.2.6.1. Collection rates

Washing machines are classified under category 1 "Large household appliances" of the WEEE-Directive 2012/19/EU (cf. section 1.3.1.2). From 15th August 2018 on, new WEEE categories will be imposed in the EU. Within this categorisation, most washing machines will fall under the new category 4 (large equipment – any external dimension more than 50 cm). Devices using refrigerants or any other fluids other than water for heat exchange will fall under category 1 (temperature exchange equipment).

In any case, this means that special collection and management systems for end-of-life washing machines are in place within the EU.

Generally, the current category 1 equipment (large household appliances) is, on a weight base, the most significant WEEE-category and makes up 49 % of the EEE put onto the EU-market and 43 % of the WEEE collected in the EU in 2010 (Eurostat 2013).

High collection rates of category 1 equipment are crucial in order to achieve the collection targets laid out in Article 7 of the WEEE-Directive. From 2016 on, the minimum collection target over all categories will be 45% on a Member State level and will further increase to a minimum of 65% from 2019 on (calculated on the basis of the total weight of WEEE collected as a percentage of the average weight of EEE placed on the market in the three preceding years on a Member State level).

A 2008 review of the WEEE-Directive 2002/96/EC revealed that only 16.3% of the arising waste of this product-category was collected within the formal system in the EU in 2005 (Huisman et al. 2007). Data from Eurostat suggests that this situation has somehow improved until 2010, when 4,693,199 t of category 1 equipment was put onto the EU-market (EU27 + Iceland + Norway) and 1,512,920 t (i.e. 32%) of the same category were collected (Eurostat 2013).

Feedback from one stakeholder indicates that for washing machines and washer-dryers the collection rate (waste units collected from the market) is at an average of 33-40% of the appliances sold on the market. These quantities are collected and recycled through official channels managed by producers. The percentage is low due to the fact that these devices have a high metal content and are actively sought and recycled also by commercial channels, effectively bringing the collection rate probably up to 87-100% (for general illustration, cf. Figure 4-1).

The fate of devices not collected cannot be exactly quantified. Nevertheless, the following pathways can be considered for the majority of the items not collected:

- Prolonged storage in households and offices (including for reuse);
- Recycling within the EU but without collection being covered by official member state statistics;
- Export as used EEE or end-of-life equipment to non-European destinations.

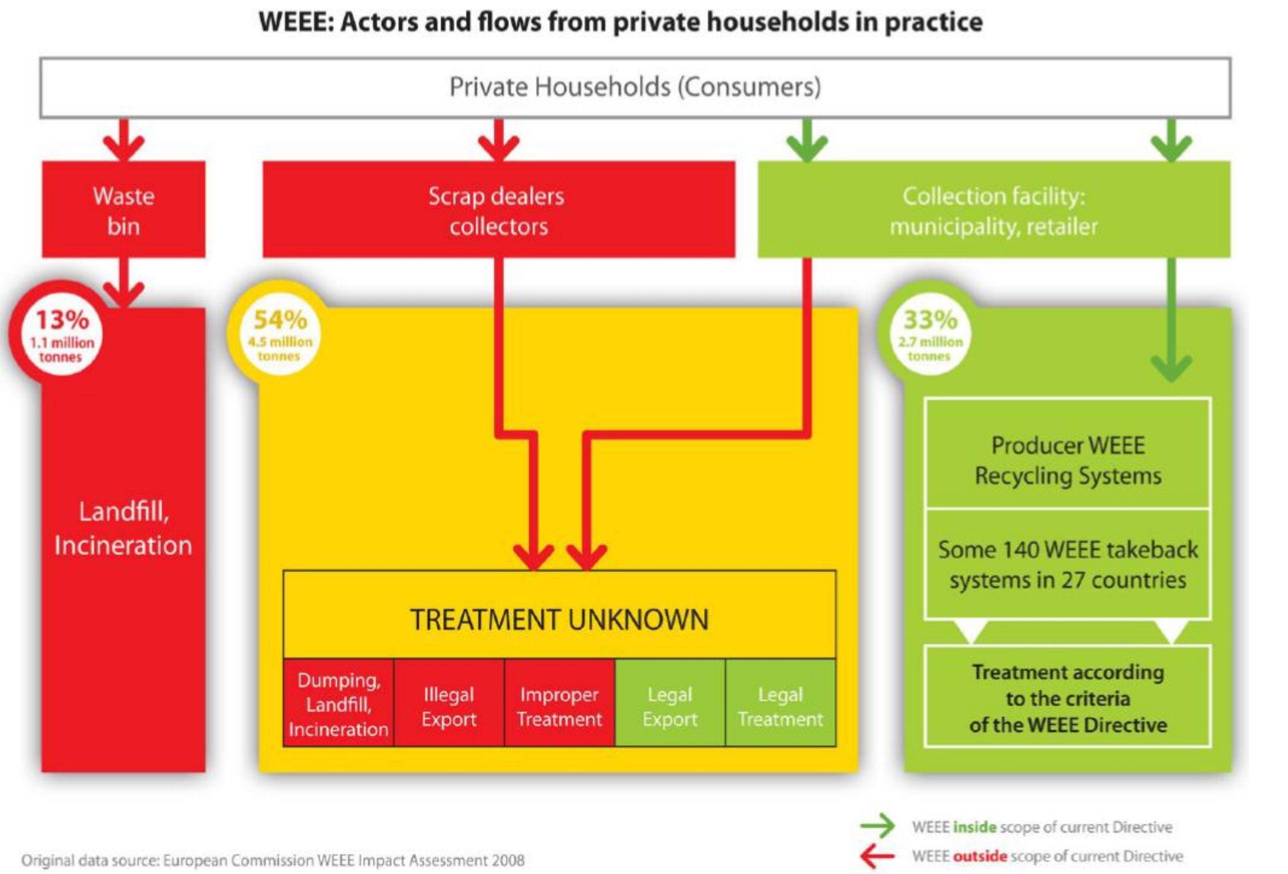

Figure 4-1 **WEEE actors and flows from private households in practice; source: stakeholder information**

Regarding exports to non-European destinations, no product group specific figures are available. Regarding second-hand markets outside the EU, visual impressions from EEE-trading hubs in Nigeria and Ghana suggest that second-hand washing machines meet a comparatively low demand in the West-African region (Manhart, personal communication 2009-2014). Information from other potential second-hand markets such as Eastern Europe is not available.

Generally, washing machines have a stable positive net-value in the European recycling markets (Henkes 2012). This net-value applies to equipment that has already been collected. In case collection costs are also taken into account, the net-value is mostly negative (Huisman et al. 2007). This is largely based on the high metal content and the comparably low content of materials requiring separate and costly treatment and disposal. Therefore, there is no obvious economic motivation for illegal exports into non-EU countries as this is observed for other types of WEEE. There might be cases when washing machines are not fully functional when exported or where used devices are not properly packed and certified. Although in such cases, the devices are classified as WEEE according to Annex VI of the WEEE-Directive, it can still be assumed that the primary motivation for export is reuse and not recycling and disposal (which would probably handled not in full compliance with the WEEE Directive.

According to (Digital Europe et al. 2013), recycling within the EU – but without collection being registered officially – is quite significant in some member states and might – if these volumes would be accounted for in official figures – lead to a collection rate of around two thirds of the volumes placed onto the market.

Due to the large size of devices, disposal via the municipal household waste is theoretically possible but considered to be not relevant in terms of quantities.

4.2.6.2. Recycling process

Different materials are recycled into raw materials and used to make new products. Some of the equipment is not collected separately, but as part of waste fractions where WEEE waste is mixed with other waste. Some of this is sorted and then becomes available for further processing and recycling. The rest ends up in the waste incinerators or at a landfill.

The devices collected within the formal WEEE-System in the EU undergo recycling treatments, which can be classified into the following steps:

- Preparation for reuse;
- Pre-processing / dismantling (including depollution);
- End-processing and final disposal.

Preparation for reuse, i.e. checking, cleaning or repairing, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing. This is mostly conducted with devices deemed suitable in terms of age, product model, appearance and spare part availability.

Pre-processing / depollution: The majority of end-of-life washing machines are passed-on to the pre-processing stage, which starts with a depollution step which requires a selective treatment during which certain substances, mixtures and components are removed from the WEEE stream. Specific parts to be removed must be perfectly accessible. In this step, the following components are removed from the devices for separate treatment:

- Power-cables,
- Large accessible printed circuit boards > 10 cm^2. According to (Ardente & Talens Peirò 2015), printed circuit boards can be removed preventively, by specific dismantling, hand-picking or mechanical sorting after preliminary and fine shredding.
- Capacitors with a height >25mm and a diameter >25mm might contain substances of concern. In particular old capacitors might contain polychlorinated biphenyls (PCB). Capacitors, generally included in printed circuit boards, are generally manually separated after the removal of the printed circuit boards.
- Some modern devices might contain LCD displays > 100cm^2, which have to be removed for separate treatment to comply with the WEEE Directive. However, (Ardente & Mathieux 2012) state that new washing machines introduced in the market embody some LCD screens. All the recyclers interviewed within the study of (Ardente & Mathieux 2012) agreed that LCDs in WMs have to be preventively extracted because potentially contaminating other fractions (for example PCBs without LCD) causing a potential downcycling of recyclable resources.
- Devices containing volatile hydrofluorocarbons (HFC) or hydrocarbons (HC) – which might be the case for modern devices with integrated heat pump – have to undergo degassing to prevent emissions to the atmosphere. Devices containing volatile hydrocarbons need to be handled with care (also during collection, transport and storage) as uncontrolled leakages might cause fires and explosions (CENELEC 2012). According to feedback of one stakeholder via questionnaire, for example washer-dryers add an additional element to the recycling operations, considered that they contain gases which must be treated in controlled environments, in a similar way to refrigerators.
- For very old devices, depollution might also have to consider mercury-containing parts and components containing asbestos.

In the subsequent pre-processing step, the remaining devices are treated in order to liberate the various materials such as steel, aluminium and plastics. This is either done by manual disassembly, or by mechanical means (shredding and automated sorting). Pre-processing (manual and mechanical) typically yields the following output fractions:

- Steel
- Stainless-steel
- Aluminium
- Copper (insulated or liberated)
- Plastics (including thermoplastics, thermosets and rubber)
- Glass
- Concrete (from balance-weight of washing machines)

Some of the above listed fractions undergo further pre-treatment and/or sorting (examples: liberation of insulated copper-cables, sorting of aluminium in different grades, further sorting of plastics according to colour and polymer-types).

End-processing: The outputs are generally fed into end-processing units, which can be described as follows:

- Steel and stainless-steel is fed into secondary steel plants;
- Aluminium is fed into secondary aluminium smelters;
- Copper is fed into copper-refineries;
- Printed circuit boards are fed into integrated smelters to recover copper, precious metals and other metals as by-products (e.g. lead, tin, indium);
- Plastics are either recycled (material recovery of thermoplastics) or incinerated (energy recovery);
- Glass is fed into glass recycling;
- Concrete is disposed together with inert construction/demolition waste. According to feedback of one stakeholder via questionnaire the concrete might create dust formations if not extracted before the shredding process, however this rarely occurs.

According to feedback from stakeholders, in general washing machines have a high metal content with some plastic and concrete where this is present. Metals and plastics have good recycling values. The concrete might create dust formations if not extracted before the shredding process, however this rarely occurs. Washer-dryers add an additional element to the recycling operations, considered that they contain gases which must be treated in controlled environments, in a similar way to refrigerators.

For both washing machines and washer-dryers, according to stakeholders there are currently well established processes in place.

4.2.6.3. Recycling and recovery rates

The Ecodesign Preparatory Study Lot 14 (ENEA/ISIS 2007c) used following input data for end-of-life parameter:

Table 4.22: Input data for end-of-life handling of household washing machines used by Lot 14 in 2007; source: (ENEA/ISIS 2007c)

End-of-life handling	Share for household washing machines, 5 kg model (%)
Dismantling	26,70

End-of-life handling	Share for household washing machines, 5 kg model (%)
Recycling	70,00
Energy recovery	3,30
Total	100%

In their study, (ENEA/ISIS 2007c) assumed that the share of re-use and closed-loop recycling of the plastics in washing machines is 0%.

In general, recyclers of large household appliances are obliged to achieve a minimum re-use and recycling rate of 75% and a recovery target of 80%. In contrast to recycling, the term recovery additionally includes the use of waste for other useful purposes, including energy recovery. These targets will be raised to 80% and 85% after 14 August 2015 (see Table 4.23).

Table 4.23: Re-use and recycling targets specified in Directive 2012/19/EU (European Parliament 2012)

Quantitative targets for WEEE category 1	Until 14 August 2015	After 14 August 2015
Re-use and recycling target	75%	80%
Recovery target	80%	85%

Feedback from stakeholders indicates that recycling rates of household washing machines and washer-dryers can be up to 80.8-95% depending on the recycling technologies. Up to 5% (foams and non-recyclable parts) are incinerated with recovery of energy.

However, according to (UNEP 2013), legal recycling-rate targets have two implicit weaknesses: They do not differ between individual substances, but are calculated solely by weight based on an entire fraction. Hence, to achieve the targets, recovery of mass substances such as plastics, glass or steel becomes much more important than recovery of precious and special metals, which are usually only present in small amounts. And, as the targets do not consider metallurgical steps, the high legal recycling targets pretend a recycling quality that in reality is not obtained. If smelting and refining are included, real recycling rates will be much lower, especially for precious and special metals.

For large white goods, usually the recycling focuses on the recovery of bulk commodity materials according to WEEE recycling guidelines. For PWBs, containing palladium, silver and gold, the following holds true according to (UNEP 2013): PWBs form a very small part of this recycling stream and are mostly lost. If recovered, physics limit the production of clean recyclates from PWBs, which makes subsequent processing in metallurgical plants difficult. PWBs will, because of the nature of mechanical separation plants, be spread throughout the recyclates of commodity materials (steel, aluminium, etc.). After that, they get lost during the metallurgical processes for these commodity metals, which do not cater for the thermodynamics that maximize recovery of "critical" elements.

End-of-life treatment of permanent magnet (PM) motors

According to (Ardente & Mathieux 2012) motors represent one of the key parts of washing machines. Motors are economically one of the most valuable parts for recycling. Motors are sometimes preventively manually disassembled when time for its separation is reasonably low (assumed lower than 50 sec in the EoL scenario assessed by (Ardente & Mathieux 2012)). Otherwise, washing machines are shredded and motors are afterwards separated (by hand-picking or further mechanical separation) which is a process that yield lower recycling rates.

Indeed, studies in the literature analysed by (Ardente & Mathieux 2012) evidenced that shredded motors imply more difficulties during the next treatments for separation of metals, with larger losses. Furthermore, avoiding pre-shredding could reduce the contamination among metals, reducing the risk that some copper fractions could contaminate steel batch. However, detailed figures about such losses are not available.

Furthermore, although copper and steels can be partially separated from pre-shredded motors, other elements, including rare earths, could not. For the recovery of such elements, a selective dismantling of motor and further extraction of magnets would be necessary. For example, neodymium and other rare earth contained in some motors (magnets for high efficiency devices) could be only recovered after a selective disassembly. Neodymium represents, among rare earths, one of the most used in terms of overall flows, and particularly relevant for some emerging technologies including permanent magnets (with high energy efficiency)

(Dalhammar et al. 2014) conducted a case study in 2012 on the potential inclusion of permanent magnet (PM) motors in the Ecodesign Regulation for electric motors. The objective was to see how the Ecodesign Directive could promote eco-innovation for resource use in PM motors (cf. also section 0). Within their study they researched that to-date methods for post-consumer rare earth element (REE) recycling are inexistent. However, one technological niche is constituted by a Siemens led motor recycling project which investigates options for the extraction of REE from electric motors. Also the Danish REEgain project (cf. http://www.reegain.dk) represents a technological niche, as various representatives from industry and academia collaborate to investigate both different processing options for rare earth ores and the recycling of REE.

According to (Dalhammar et al. 2014), to date only about 10 to 15% of machines with REE (typical hard disc magnets) can be recycled, the remainder ends up as dust in scrap yards or as pollutant in steel melts. There are currently many uncertainties. These include for example, if – and how – the magnetic properties of REEs and combinations of materials will last if the material is crushed into a material mix, or if the material must be separated into pure streams. The latter option would require much more energy at the recycling stage.

(Buchert et al. 2014) describe in their study on permanent magnets motors that the production of these motor types has only reached in the past 10 to 15 years a significant increase; due to their long life, however, so far only few magnets containing valuable rare earths arrive at the potential recycling streams. A general recycling process of permanent magnet motors is not yet established, although some manufacturers of industrial permanent magnet motors already disassemble magnets at their end-of-life and store them for potential future recycling purposes. To establish a future recycling process on an industrial-scale basis in the near future, some hundreds of tons magnet materials would have to be available, which requires a collection and disassembly system to separate the permanent magnets from the motors ideally at European level.

(Buchert et al. 2014) point out that rare earths containing magnets are mostly installed in their appliances in such a way that specific expert knowledge is necessary to detect them. Further, todays established pre-processing technologies cannot separate magnets to pure fractions but rather sort them together with the steel fraction where the rare earths get dissipative lost. Also according to assessment of one stakeholder, although in a manual recycling process brushless motors can be simply identified at first sight, a further differentiation for example between asynchronous inverter driven motors and permanent magnet motors (cf. section 4.1.3.2) is difficult.

This is why (Buchert et al. 2014) request for a marking obligation for industrial appliances containing a minimum weight of permanent magnets (for example > 10 grams) which shall inform about the following aspects:

- Are permanent magnets included in the appliance?
- If yes, which type of permanent magnet is included?

Such a marking obligation, which is proposed to take place for example in the current revision of the Ecodesign Regulation on motors (cf. section 1.2.1.1), would facilitate recycling companies localising valuable magnets.

4.3. Summary and discussion: technologies

4.3.1. Technology characterisation

Section 4.1 presents the information gathered for washing machine and washer-dryer technologies, and examples of products on the market of interest. In particular, section 4.1.6 summarises the technical options collected.

Further analysis is needed to characterise the identified technologies, as indicated in the summary in section 4.1.6 feedback from stakeholders is kindly asked to refine the classification proposed, and to complement, revise and update the information presented.

This information shall be taken as basis for defining revised Base Cases for household washing machines and washer-dryers, improvement Design Options, and define scenarios for an environmental and economic assessment.

Discussion point 4.4

Based on the information presented in Section 4.1, and in particular with reference to Table 4.11 provided in the summary section 4.1.6:

a) Is the list of technologies presented for washing machines and washer-dryers comprehensive and the classification used coherent? Please complement, update or revised the information provided.

b) Information from stakeholders is welcome for characterising:

- Environmental benefits (e.g. savings of energy, water or materials) and drawbacks (e.g. costs / cost increase, other impacts at material level) of the technologies

- State of implementation and expected trends for such technologies (both qualitative description and quantification)

- Relevance and selection of such technologies for Base Cases or as BAT/BNAT in the assessment of different design options.

- Practical examples of products implementing such technologies, also with indications of the effects in terms of Bill of Materials, energy performance, water consumption, costs, impact on end of life, etc..

c) Some sources indicate that front load machines are more efficient than top load machines. Do you have supporting evidence of this?

d) Could you provide any additional information or detailed examples about the influence of materials and product construction (e.g. use of metal parts, use of recycled plastics) on durability and other environmental and economic aspects?

e) Could you provide any concise information on the status of uptake of efficient motors in washing machines and washer-dryers, and their implications in terms of costs, use of materials (detailed BoM) and energy performance (efficiency)?

f) According to the information gathered so far, no washer-dryer on the market equipped with a heat pump uses the pump for the washing process, i.e. it is used only for drying. Is there to your knowledge a clear reason for that? Should you know, please explain why and which could be the implications in terms of economic and environmental impacts

g) According to Topten, the highest Energy Efficiency Indexes are currently obtained through a limited list of technology options, including:

- inverter driven motors and permanent magnet motors
- hat pump technology
- high load capacity
- lower washing temperatures than the nominal ones
- extension of programme duration.
- load sensors that enable to adjusting the water and energy consumption.

- Would you agree with such analysis? Are there other technologies playing a key role?

- Which of such options should be prioritised in your view? Please indicate in your answer the approximate cost implications (e.g. on the final price tag) associated to the inclusion of the technologies listed. Do any of these technologies have a substantial impact on the use of critical materials (e.g. in motor magnets), or hazardous substances (e.g. refrigerants in heat pumps)?

4.3.2. Packaging

The tables below summarise the information provided by stakeholders in the course of the study:

Table 4.24 Average data for packaging of a washing machine and a washer dryer; source: stakeholder information

Material (g)	Washing machine	Washer dryer
Carton box	200	3 000
EPS	700	1 000
PE	300	---

Table 4.25 Volume and weight of the packaged product

Model	Volume of final packaged product (m^3)	Weight of final packaged product (kg)
Washing machine, 5 kg capacity (Lot 14)	0.360	74.22
Washing machine (stakeholder information)	0.447 (product only: 0.319)	62 (product only: 61)
Washer dryer (stakeholder information)	0.450 (product only: 0,320)	88 (product only: 84)

Discussion point 4.2
Do you agree with the ranges of packaging volume, weight and composition outlined above?

4.3.3. Definition of Base Cases, Design Options and Scenario definition

In the initial preparatory study "Lot 14: Domestic Dishwashers & Washing Machines – Task 5: Definition of Base Case" from July 2007, two base cases were defined for washing machines, as reproduced below:

Base cases defined for washing machines in Lot 14

Characteristic	Base case 1	Base case 2
Type of machine	5 kg load machine, front loading	6 kg load machine, front loading
Energy consumption	0.956 kWh/cycle (energy efficiency class A)	1.057 kWh/cycle (energy efficiency class A+/A)
Water consumption	50.4 litres/cycle	49.2 litres/cycle
Spinning speed	1073 rpm	1262 rpm
Washing performance	class A	class A
Drying performance	class B or C	class B or A
Noise	53dB(A) in washing / 70 dB(A) in spinning	53dB(A) in washing / 70 dB(A) in spinning

In response to the technical questionnaire sent on March 2015, stakeholders have provided some preliminary proposals for revising the base cases:

- Increase the capacity of the machine, since 5-6 kg seems to be outdated (too low);
- Increase the spin drying performance to A or B, but not C.

In section 2.4.2, it is proposed to discuss two different strategies for washing machines base cases:

- Taking the most common capacity as most representative base case for the spread of capacities, i.e. only one washing machine base case:
  - 7 kg front-loading machine, energy efficiency class A++/A+++
- Representing the market spread also within the Base Cases to analyse differences and impacts of smaller and larger appliances, i.e. two washing machine base cases:
  - 5 kg front-loading machine, energy efficiency class A+
  - 7 or 8 kg front-loading machine, energy efficiency class A+++

For washer-dryers (see 2.4.3), it is proposed to define as base case a washer-dryer with a washing capacity of 7 or 8 kg, and a drying capacity of 4 to 5 kg, and energy efficiency class A.

Depending on the final selection of Base Cases, improvement Design Options and other Scenarios of Analysis, refined input might be needed for the following analysis to carry out through the MEErP Ecoreport tool: Bills of Materials (BOMs), primary scrap production during sheet metal manufacturing, packaging volume, weight and composition, transport data, durability of the product and information on its performance, use and disposal.

Discussion point 4.2

a) Do you agree with the base case proposal outlined above for washing machines? Do you have any suggestion and/or preference?

b) How should the base cases for washer-dryers defined?

c) Which additional improvement Design Options and other Scenarios of Analysis (e.g. sensitivity analysis on durability or capacity) should be assessed for washing machines and for washer-dryers?

d) In order to assess (with the Ecoreport tool) the base cases, the following specific updated input will be needed:

- Bills of Materials (examples of representative products),

- Primary scrap production during sheet metal manufacturing (e.g. 5% as in the Ecodesign Preparatory Study Lot 14 , 12.2% as suggested by a stakeholder, 25% as default value in the Ecoreport tool? please provide supporting information to your answer)

- Packaging volume, weight and composition (see section above)

- Transport data,

- Durability of the product and information on its performance, use and disposal.

4.3.4. Product lifetime and durability

Research indicates that the initial product lifetime of 15 years of household washing machines has decreased in recent years (2012/2013) (cf. section 4.2.5.1):

- The “First useful service life” of a washing machines (including those still functional) is about 12 years
- The “First useful service life” of a washing machines replaced due to a defect (i.e. technical product lifetime) is about 12.5 years

Moreover, according to some stakeholders, the number of cycles might be a better indicator for assessing the durability of a product. Indicative correlations between expected number of cycles a product is designed to last and equivalent years of use of the appliance have been also provided by stakeholders. According to stakeholders, 5000 washing cycles are equivalent to a lifetime in an average household of 20 years. many models on the market have an expected lifetime of 1800-3500 cycles (7-14 years).

Research also indicates that the proportion of washing machines which have to be replaced earlier than the expected average lifetime due to a defect has increased (cf. section 4.2.5.1). Common causes of breakdowns are for example the electrical failures, particularly if the PCB (printed circuit board) is exposed to fluctuations in mains voltage supply. Electrical faults can also occur as a result of water leaks from poor installation of the machine in the household and blockages in the soap drawer or inlet and outlet pipes. Regarding failures under normal operation, the wearing of the door rubber ring has been reported, and to a lesser degree, mechanical failure of the pumps, drum bearings, or the interlock. The water heater is also a sensitive part, especially in areas of high water hardness.

Further analysis will be undertaken to discuss if there are any simple and inexpensive design options that could enhance durability of appliances, and could be proposed as mandatory ecodesign requirements.

Discussion point 4.3

a) Is the presented average product lifetime correct? Is it also representative of washer-dryers?

b) Are there any specific appliance parts not mentioned above that are particularly critical, and result in breakdown/failure of the machine? Are these costly parts? Could you identify any simple and inexpensive design option that could enhance durability of appliances?

c) Are there any ecodesign requirements related to resource efficiency from other product groups which could be interesting to look at for washing machines and washer-dryers? Please explain which ones and why.

4.3.5. End of Life management

Regarding end-of-life management of household washing machines and washer-dryers, research indicates that in general, the collection rates as well as recycling and recovery rates are rather high for this product group, but to a very large extent, this does not take place through official channels. More than 1/3 of the large appliances collected (including washing machines, dishwashers and washer dryers) are scrapped not following the prescriptions of WEEE in Member States, and this percentage is closer to 2/3 of the total flow of EoL appliances in some of the EU Member States. The EoL management of these appliances is largely driven by the value of the metal content, which pulls considerable amounts of them for shredding together with other metal scrap.

For washing machines and washer –dryers, special treatment according to WEEE is essentially needed for the treatment of the displays and large printed circuit boards (PCB), and – when applicable – for the refrigerants of heat pumps.

Specific EoL treatment not involving direct shredding can be interesting for other reasons too. The increasing use of permanent magnet motors in household washing machines and washer-dryers deserves attention, as these motors contain valuable rare earth elements which are more difficult to collect if the motors are not separated before shredding. This aspect will be analysed during the further course of the study.

Discussion point 4.4

a) In your view, are there any other components of concern from an End-of-Life perspective than the ones outlined above? (permanent magnet motors, PCBs, displays, refrigerants of heat pumps)?

b) The data collected indicate that the current recycling of plastics in these appliances is not extended. The use of recycled plastics in new machines is not common either. Could you characterise the main types of plastics used in washing machines and washer-dryers? Have you explored the possibility of using recycled plastics for those applications? Which are the main hurdles for using recycled plastics?

c) Do you have any concise information about the 2nd hand market of this product group, e.g. the share and characteristics of the products reused, and the estimated "first" and "second" product life times, and the percentage of collected items that is reused?

d) Could you identify any simple and inexpensive design option that could enhance the easier identification and removal of

- printed circuit boards and displays
- permanent magnets.

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