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Acronyms

BAT	Best available technology
BAU	Business as usual
BC	Base Case
BNAT	Best not yet available technology
BoM	Bill of Material
DW	Dishwasher
EoL	End-of-life
GWP	Global Warming Potential
LLCC	Least life-cycle costs
MEPS	Minimum Energy Performance Standard
p.a.	Per Annum (per year)
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
POP	Persistent Organic Pollutants
ps	place setting
VOC	Volatile Organic Compounds

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 is revising the Ecodesign and Energy-/Resource label implementing measures for the product group 'household dishwashers (DW)'. 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 2011b) and consists 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) 1059/2010 (European Commission 2010a) and the Ecodesign Regulation (EC) 1016/2010 on household dishwashers (European Commission 2010b).

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

This report provides input to Task 5-7 while Task 1-4 have been discussed in the 1st Technical Working Group meeting on 23 June in Seville. Task 5-7 will be discussed by the TWG on 17 November in Brussels. After this meeting, Task 1-4 will be updated together with Task 5-7. Finally, a full preparatory study consisting of Task 1-7 will be released resulting in an updated preparatory study including a comprehensive techno-economic and environmental assessment of this product group. This will provide policy makers with an evidence basis for assessing whether and how to revise the existing Regulations.

Objectives and structure of this report

The present document is prepared as input for the second TWG meeting (17 November 2015, Brussels).

This document is structured in the following chapters, following Tasks 5 to 7 of MEErP:

- Chapter 5: Definition and environmental and economic assessment of base cases
- Chapter 6: Selection of design options implementing best available technologies to improve the environmental impact for this product group, and environmental and economic assessment of these design options. Description of best not available technologies for further discussion;

- Chapter 7: Analysis of policy options

A second questionnaire to stakeholders has been sent in the summer of 2015 to collect information for the study. Feedback received has been reported in this document.

Stakeholder written feedback

Stakeholders are asked to carefully study the assumptions and results presented in the individual chapters of this report, and to point out potential modifications and additions deemed 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/Dishwashers/index.html), and takes place using the on-line platform BATIS (further information on access to BATIS is provided upon registration).

Experts not able to participate in the stakeholder meeting are also welcome to provide written comments.

5. Task 5: Environment and economics

The aim of this section is to assess environmental and economic impacts associated to different Base Cases. The assessment is based on the updated version of the EcoReport Tool, as provided with the MEErP 2011 methodology (COWI and VHK 2011b).

5.1. Product specific inputs

According to MEErP methodology, Base Cases (BC) should reflect average EU products. Different products of similar functionalities, Bill of Materials (BoM), technologies and efficiency can be compiled into a single Base Case. Therefore, it does not always represent a real product. The Base Cases are used as reference for modelling the stock of products together with their environmental and economic impact and the available improvement design options.

For the identification of the Base Cases for household dishwashers, the analyses presented in the previous Tasks 1 (Scope & definition), 2 (Markets), 3 (Users) and 4 (Technologies) have been considered.

5.1.1. Base Cases for dishwashers

The selection of the Base Case models has been done on the basis of the analysis of the latest technical data developed by CECED (2014). CECED databases for dishwashers have been developed since 1999. This technical database includes the parameters declared for the energy labelling.

5.1.1.1. Basic description of Base Cases

The following Base Cases have been identified and chosen to further assess the environmental and economic impacts over the life cycle of dishwashers:

- Base Case 1 (BC1): Household dishwashers with a nominal rated capacity of 13 place settings.
- Base Case 2 (BC2): Household dishwashers with a nominal rated capacity of 10 place settings (slim-line dishwasher).

Two base cases have been chosen to represent two types of dishwashers on the market, i.e. standard dishwashers with a width around 60 cm and slim-line dishwashers with a width around 45 cm. Such a subdivision has also been followed in the policy measures already in place. Table-top dishwashers account for less than 1% of the models on the market. This kind of dishwashers is therefore discarded as a base case and for further life cycle cost calculations.

Table 5-1 summarises the detailed performance characteristics chosen for the dishwasher Base Cases including the respective underlying sources and assumptions (a more detailed description of the assumptions can be found in the sections 5.1.1.2 to 5.1.1.5).

Table 5-1: Performance characteristics of the chosen Base Cases 1 and 2 for dishwashers

	BC1 (13 ps)	BC2 (10 ps)	Sources
Nominal rated capacity (ps)	13	10	BC1 "13ps": 31% 13ps models and 25% 12ps models in 2014; Table 2-11: overall decreasing trend of 12ps models and increasing trend to 13 ps models in the past years* BC2 "10ps": 7.7% 9ps models and 6.1% 10ps models in 2014; choice for 10ps due to Table 2-11: for small DW overall decreasing trend of 9ps models and increasing trend to 10 ps models in the past years*
Width (cm)	60	45	BC1 "13ps": most 13ps models with 60 cm width (few models with

	BC1 (13 ps)	BC2 (10 ps)	Sources
			larger widths from 63 to 68 cm)* BC2 "10ps": most 10ps models with 45 cm width (few models with larger widths from 50 to 53 cm)*
Manufacturing cost (in €)	135	133	Based on an analysis of top seller products at mediamarkt national websites (IT, BE, DE, ES, PL, SE)**: BC1 "13ps": average purchase price 526 € (13ps, A++); BC2 "10ps": average purchase price 516 € (9 or 10ps, min A+)
Maintenance and repair costs (in €/lifetime)	15	15	BC1 "13ps" / BC2 "10ps": assumption that 10% of the dishwashers are repaired once in their lifetime at 150 Euro
Energy Consumption:			
Annual Energy consumption in Eco programme (kWh/year)	268	245	BC1 "13ps" / BC2 "10ps" average energy consumption of 13 ps DW models (n=1 821) p.a*; average energy consumption of 10 ps DW models (n=362) p.a*
Annual Energy consumption including other programs (real life conditions) (kWh/year)	303	272	Based on the use and energy consumption of other programs than the Eco programme (see Table 5-4 and Table 5-6)
Energy consumption Eco programme (kWh/cycle)	0.96	0.87	BC1 "13ps" / BC2 "10ps": annual average energy consumption divided by 280 cycles per year (annual energy consumption of left-on and off-mode negligible, estimated around 4kWh/year, i.e. 0.01 kWh/cycle)
Energy consumption including other programs (real life conditions) (kWh/cycle)	1.08	0.97	Based on the use and energy consumption of other programs than the Eco programme (see Table 5-3 and Table 5-5)
Water consumption:			
Annual Water consumption in Eco programme (L/year)	2 731	2 877	BC1 "13ps" / BC2 "10ps": CECED database 2014: average water consumption of 13 ps DW models (n=1 821) p.a. average water consumption of 10 ps DW models (n=362) p.a.
Annual Water consumption including other programs (real life conditions) (L/year)	3 057	3 401	Based on the use and water consumption of other programs than the Eco programme (see Table 5-4 and Table 5-6)
Water consumption Eco programme (L/cycle)	9.8	10.3	BC1 "13ps" / BC2 "10ps": annual average water consumption divided by 280 cycles
Water consumption including other programs (real life conditions) (L/cycle)	10.9	12.1	Based on the use and water consumption of other programs than the Eco programme (see Table 5-3 and Table 5-5)
Detergent consumption:			
Detergent consumption (g per cycle)	20	20	Assumption as 20 g as mostly tabs are used with on average content of 20 g detergent.
Rinsing agent (g or ml per cycle)	3	3	Data taken from (JRC IPTS 2015)
Regeneration salt (g per cycle)	19	19	own estimation
Other parameters:			
Noise (dB(A))	45	48	BC1 "13ps" / BC2 "10ps": average noise level of 13 ps DW models (n=1 821) and 10 ps DW models (n=362)*
Cycle time (min) (eco programme /	196 124	185 123	Based on direct input of stakeholders (see tables Table 5-3 and Table 5-5

	BC1 (13 ps)	BC2 (10 ps)	Sources
real life conditions)			
Lifetime (years)	12.5	12.5	BC1 "13ps" / BC2 "10ps": Section 4.2.6.1: First useful service life of dishwashers replaced due to a defect (i.e. technical product lifetime) is 12.5 years

* CECED database 2014

** Based on an analysis of top seller products at mediamarkt national websites (IT, BE, DE, ES, PL, SE)
The manufacturing costs are derived from the purchase price following assumptions similar to Lot 14 (ENEA/ISIS 2007b): Manufacturing costs plus 28% costs for manufacturers' marketing & administration, multiplied by a factor 2.5 to account for the sales margin plus 21.6% for average EU VAT 2015.

Compared to the base cases used in the Ecodesign preparatory study of 2007 by (ENEA/ISIS 2007a) the current base cases both have a larger rated capacity. The selected base cases in the Ecodesign preparatory study of 2007 were a 12 ps and a 9 ps machine. As far as the energy consumption is concerned, the declared energy consumption for the standard Base Case (BC1) dishwasher is significantly lower while the slim-line dishwasher Base Case (BC2) accounts for a slightly higher value. Compared to the 2007 base cases, both base cases show a remarkable reduction in the water consumption and a reduction in the declared noise levels.

5.1.1.2. Raw materials use and manufacturing of the products: Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

<u>Material input</u>

The Bill of Materials (BoM) of the base case products have been selected based on input provided by stakeholders. Primary input data come from direct communication with manufacturers. Manufacturers provided information on 4 models for the 13ps DW (BC1) and 1 model for the 10ps DW (BC2). In order to define the average model for each base case the data collected have been analysed and aggregated or averaged regarding the type of material.

To compile the BoM considered for the household dishwasher base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. The following correspondences were considered:

- different ferrous metals as steel sheet galvanized
- wiring as Cu wire
- zinc die-casting as CuZn38
- ethylene propylene diene monomer (EPDM) / for process development and control (PDC) as LDPE
- Polyoxymethylene (POM) as HDPE
- electronic components as controller board
- composites of some plastics as the main plastic they are made of, for example PC+ABS was classified as PC

For certain other materials no correspondence is possible. In this case the missing materials' weight is reallocated in other material categories, e.g. wood as cardboard and fleeces as PET. Other materials are not considered when the corresponding weight is not relevant, e.g. small pieces made of crepe tape weighting in total 0.7g or adhesive tape weighting in total 0.1g.

The amount of materials that does not exactly correspond to the categories included in the ErP EcoReport data base is around 7% of the total mass.

Table 5-2: Aggregated BoM considered for the current household dishwasher base cases and the base cases used in Lot 14

Component / Material	BC 1 (13 ps) Weight (in kg)	Base Case 12 ps Lot 14 (in kg)	BC 2 (10 ps) Weight (in kg)	Base Case 9 ps Lot 14 (in kg)
Product				
Bulk Plastics	9 993	7 701	7 668	7 189
TecPlastics	881	637	777	376
Ferro	21 553	27 266	18 922	20 781
Non-ferro	5 831	1 374	5 830	1 080
Coating	0	0	0	0
Electronics	1 382	448	1 206	694
Miscellaneous	8 140	10 732	7 133	10 087
Refrigerant	--	--	--	--
Packaging				
Bulk plastics	926	896	768	780
Miscellaneous	407	1646	305	175
SUM	49 113	50 699	42 609	41 162

Compared to the base case used in the Ecodesign preparatory study of 2007 by (ENEA/ISIS 2007) (see also Table 4.7), current base cases consist of more plastics (both bulk plastics and tecno plastics). Additionally, an increase in the amount of electronics and non-ferrous metals is observed. These increases are compensated to a certain extent by a lower use of the ferrous metals. The overall weight of the base case dishwashers in this study are close to the base cases used in the Ecodesign preparatory study of 2007 (see also Table 5-7). The amount of materials that does not exactly correspond to the categories included in the ErP EcoReport data base is around 7% of the total mass.

Manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of **sheetmetal scrap**. The default value is 25%.

According to section 4.2.2., Lot 14 has used 5% as input for the sheetmetal scrap, whereas stakeholder feedback in case of washing machines ranged from negligible (0.18%) to 12.2%. For further calculation of the environmental impacts, a value of **5% sheetmetal scrap** is taken.

5.1.1.3. Distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP Methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the **volume of the final (packaged) product.**

Regarding the average volume of the final packaged product the same values as in Lot 14 (ENEA/ISIS 2007a) are assumed (see section 4.2.4 of Task 4):

- 0.400 m^3 for Base Case 1 (13 place settings)
- 0.303 m^3 for Base Case 2 (10 place settings)

It is expected that the volume of the final (packaged) product is based on the width of the machine, i.e. 60 cm (12 ps, 13 ps) or 45 cm (9 ps, 10 ps) and not on the amount of place settings.

5.1.1.4. Use phase

To calculate the environmental impacts of the use phase, the input parameters for the EcoReport tool are set as follows.

For the base cases only **direct ErP (energy) impacts** are considered.

Both for 13 ps and for 10 ps dishwashers, according to data collected in Section 4.2.6.1, the **product service lifetime** is assumed to be 12.5 years (which corresponds to the first useful service-life of dishwashers which are replaced due to a defect according to (Prakash et al. 2015)).

During their use phase, household dishwashers generally consume electricity in on-mode, left-on-mode and off-mode, as well as consumables (water, detergents, rinsing agents, regeneration salt).

For the **electricity consumption** two alternatives are regarded for each base case:

- "Eco programme" uses the aggregated annual energy consumption per year in the Eco-programme, as stated on the energy label. This includes both the electricity consumption for 280 cycles in the Eco-programme and the annual electricity consumption in left-on and off-mode. The data is taken from the CECED database on dishwashers in 2014 (cf. Table 5-1 and Table 5-3).
- "real-life" uses the annual electricity consumption under real-life conditions. Data on the real-life use of the different programs and data on the energy consumption of the various programmes are used. The real-life selection of programs is derived from the latest consumer survey (Hook et al. 2015) and the energy consumption of the different programs is defined according to direct stakeholder input. The percentage of real-life use of the different programs is taken from data of machines which are at maximum 3 years old. Consumption in low power modes (left-on mode, off mode) are not taken into account as the additional energy consumption is very small compared to the total energy consumption (around 4 kWh per year, which would increase the annual energy consumption about 1.5%).

The electricity consumption of the dishwashers in the different programmes represents consumption at full load. Only few data was available on half load consumption and the difference with full load consumption values depends on the efficiency of the machine. Differences between full load and half load range from 5% for efficient machines to 12% for inefficient machines. For a 13 ps machine, extrapolation would lead to a difference between 0.7% and 1.6% per ps. (VHK 2014) assumed that most people do not fully load there machine and a loading of 9 ps per wash is assumed for a 12 ps base case. Applying the same logic for a 13 ps machine would lead to an average loading of 10 ps in a 13 ps machine, i.e. 3 ps less. This would lead to a reduction of 2.1% to 4.8% in the real life energy consumption of the base case. The effect of 'underloading' is judged to be small and therefore excluded from further calculations.

For the **water consumption** also two alternatives are regarded for each base case:

- "Eco programme" uses the aggregated annual water consumption per year in the Eco-programme, as stated on the energy label. The data is taken from the CECED database on dishwashers in 2014 (cf. Table 5-1).
- "real-life" uses the annual water consumption under real-life conditions. The calculations are equivalent to the calculations of the electricity consumption under real-life conditions.

The effect of 'underloading' is not manifested in the water consumption. The water consumption does not, or hardly, change when washing a full load or a half load.

The following tables give an overview of the assumptions to account for real-life conditions under full load. The expected cycle time is presented as well.

Table 5-3: Real-life usage and energy and water consumption values – Base Case 1 (13 ps) – full load

	Real-life usage	Electricity consumption		Water consumption		Cycle time	
		Absolute (in kWh)	Relative to Eco-programme	Absolute (in litre)	Relative to Eco-programme	Absolute (in minutes)	Relative to Eco-programme
Ecoprogram	**20.5%**	**0.96**		**9.8**		**196**	
Normal program 45-55°C	19.9%	1.31	136%	13.1	135%	124	63%
Normal program 60-65°C	15.6%	1.42	148%	13.0	133%	136	69%
Intensive program 70-75°C	9.1%	1.53	160%	12.9	132%	148	75%
Automatic (average)	9.9%	1.18	124%	10.6	108%	133	68%
Glass/ Gentle/Light programme	5.9%	0.92	96%	11.4	117%	102	52%
Short	12.0%	0.76	80%	9.2	94%	30	15%
Rinse/ Rinse and Hold	7.1%	0.06	6%	4.0	41%	13	7%
Sum/Average 'real life usage'	**100%**	**1.08**	**113%**	**10.9**	**112%**	**124**	**63%**

Table 5-4: Annual energy and water consumption values – Base case 1 (13 ps) – full load – 280 cycles p.a.

	Electricity (kWh p.a.)	Water (litre p.a.)	Cycle time (minutes p.a.)
Eco programme	268	2 731	54 880 (= 915 hours)
Real life usage	303	3 057	34 720 (= 579 hours)

Table 5-5: Real life usage and energy and water consumption values – Base Case 2 (10 ps) – full load

	Real-life usage	Electricity consumption		Water consumption		Cycle time	
		Absolute (in kWh)	Relative to Eco-programme	Absolute (in litre)	Relative to Eco-programme	Absolute (in minutes)	Relative to Eco-programme
Ecoprogram	**20.5%**	**0.87**		**10.3**		**185**	
Normal program 45-55°C	19.9%	1.16	132%	14.5	141%	136	73%
Normal program 60-65°C	15.6%	1.23	141%	15.0	146%	139	75%
Intensive program 70-75°C	9.1%	1.30	149%	15.6	152%	142	76%
Automatic (average)	9.9%	1.05	121%	12.2	118%	111	60%
Glass/ Gentle/ Light programme	5.9%	0.81	93%	12.8	125%	98	53%
Short	12.0%	0.78	90%	9.7	95%	39	21%
Rinse/ Rinse and Hold	7.1%	0.06	7%	3.7	36%	12	7%
Sum/Average 'real life usage'	**100%**	**0.97**	**111%**	**12.1**	**118%**	**123**	**67%**

Table 5-6: Annual energy and water consumption values – Base Case 2 (10 ps) – full load – 280 cycles p.a.

	Electricity (kWh p.a.)	Water (litre p.a.)	Cycle time (minutes p.a.)
Eco programme	244.67	2 877	51 800 (= 863 hours)
Real life usage	271.55	3 401	34 440 (= 574 hours)

With regard to **dishwashing detergent, rinsing agent and regeneration salt** the following assumptions are made:

- According to the data outlined in section 3.1.7.2 a detergent consumption of 20 g per dishwashing cycle is assumed for both base cases (most users use tablets with a fixed amount of dishwasher detergent which cannot be reduced even if a smaller dishwasher is used). In case of powder usage, users tend to overdose. So even if users could reduce the amount of detergent in smaller dishwashers it is likely that they will use the same amount. Given 280 cycles per year, this results in an amount of 280 tabs per year or 5.6 kg detergent per year. (cf. Lot 14, 9 ps: 6.85 kg p.a.; 12 ps: 7.25 kg p.a.).
- Rinsing agent: 3 ml (=3 g) of rinsing agent per cycle. This assumption is supported by data provided in (JRC IPTS 2015). This report states that although the quantities used of rising agent are variable between the different machines, the standard appears to be setting 3 or 4ml as default. The majority of the devices examined in that study operated with 3ml resulting in 0.84 kg per year. (cf. Lot 14: 9 ps: 1.16 kg p.a.; 12 ps: 1.02 kg p.a.).
- Regeneration salt: 19 g per cycle (own estimation), resulting in 5.3 kg per year. (cf. Lot 14: 9 ps: 8.33 kg p.a.; 12 ps: 7.835 kg p.a.)

Regarding **refrigerants (refill)** it is assumed that no refill of refrigerant is needed during the use phase. This is only an issue for a heat pump equipped appliance which is a technology recently introduced in the market. Therefore this is not taken into account for the base cases as heat pumps are not used in average appliances. A dishwasher equipped with a heat pump is described as a possible design option in section 6.1.

In Lot 14 (ENEA/ISIS 2007a) the travelling distance of 'maintenance and repair services' over the product life of a dishwasher has been assumed to be **160 km** for a 12 ps dishwasher. For the purposes of this report the same distance is assumed for both a 13 ps and a 10 ps dishwasher. The input parameter for the weight of spare parts is automatically fixed at 1% of the total weight of the analysed product.

5.1.1.5. End-of-Life (EoL) phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the dishwasher is purchased and discarded, 12.5 years have been assumed, the same as for the product service life, i.e. the period that the product is in use and operational. This assumption is made because consumers do not keep the old dishwasher stocked after buying a new one.

As "unit sales L years ago" the assumption of (CLASP 2013) for the year 2007 is taken (6.4 million units, see also section 2.2.1.2) with a relative share of large dishwashers of 86% and of slim line dishwashers of 14% (according to the share of models on the market, see section 5.1.2). The resulting unit sales figures are

- 5.504 million units (for standard dishwashers, Base Case 1) and
- 0.896 million units (for slim-line dishwashers, Base Case 2)

The current **fraction of materials** contained in appliances on the market is calculated by the EcoReport tool based on the material shares of the current BoM (including packaging material), the calculated spare parts for maintenance and repair, and the auxiliary materials consumed during the use phase (detergent, rinse agent and regeneration salt). For comparison the material inputs from lot 14 are displayed as well in Table 5-7.

It is seen that the fractions of materials of household dishwashers about 10 years ago slightly differ to that of today's dishwashers. It has to be noted that this effect might be caused by the different data sources and the underlying assumptions.

Table 5-7: Comparison of the current share of materials in household dishwashers with former fractions (including auxiliary materials)

Materials	Base Case 1 (13 ps)	Base Case Lot 14 12 ps	Base Case 2 (10 ps)	Base Case Lot 14 9 ps
Bulk Plastics	5.6%	3.4%	4.5%	3.3%
Tecno Plastics	0.5%	0.3%	0.4%	0.2%
Ferro	11.1%	10.8%	10.1%	8.5%
Non-ferro	3.0%	0.5%	3.1%	0.4%
Coating	--	--	--	--
Electronics	0.7%	0.2%	0.6%	0.3%
Miscellaneous	4.4%	4.9%	4.0%	4.2%
Refrigerants	--	--	--	--
Extra	--	--	--	--
Auxiliaries	74.8%	80.0%	77.4%	83.1%
SUM	**100%**	**100%**	**100%**	**100%**

Further, the EcoReport tool requires input on the **destination of the EoL available mass** over 5 fractions: re-use, recycling (material), recovery (heat), incineration and landfill/missing/fugitive. In lack of more specific data on the destination of the material fractions of dishwashers the default values of the EcoReport tool have not been changed with the exception of auxiliaries. Dishwashing detergents, rinsing agent and regeneration salt are subsumed under this category. As consumables, they are not undergoing any reuse, recycling or recovery process at their end of life but go with the wastewater to the respective treatment; thus, the default values in this EcoReport "Disposal & Recycling" section have been changed to 100% fugitive accordingly.

Two important parameters for the modelling are recycled content and recyclability of materials. The recycled content is the proportion of material input to the production process that has been recycled in a previous system. The recyclability rate is the proportion of a certain material in the product that will be recycled in a subsequent system. This takes into account any inefficiency in the collection and recycling processes. (Allacker et al. 2014)

The EcoReport tool requires to define qualitatively the '**EoL recyclability'**. This relates to the potential of the new products to change the course of the material flows, e.g. due to faster pre-disassembly or other ways to bring about less contamination of the mass to be recycled. In that case, it is likely that the recycled mass at the EoL will displace more virgin material in other applications. The recyclability does not influence the mass balance but it does give a reduction or increase up to 10% on all impacts of the recycled mass. For the calculation of base cases, an **average recyclability** of the fractions is chosen.

Table 5-8 gives a summary of the assumptions.

Table 5-8: End-of-life destination of material fractions

Per fraction (post-consumer)	Bulk Plastics	TecPlastics	Ferro	Non-ferro	Coating	Electronics	Misc. , excl. refrigerant	Refrigerant	Extra	Auxiliaries
EoL mass fraction to re-use, in %	*1*		*1*			*1*	*1*	*1*	*1*	*0*
EoL mass fraction to (materials) recycling, in %	*29*		*94*			*50*	*64*	*30*	*60*	*0*

Per fraction (post-consumer)	Bulk Plastics	TecPlastics	Ferro	Non-ferro	Coating	Electronics	Misc. , excl. refrigerant	Refrigerant	Extra	Auxiliaries
EoL mass fraction to (heat) recovery, in %	*15*		*0*			*0*	*1*	*0*	*0*	*0*
EoL mass fraction to non-recov. incineration, in %	*22*		*0*			*30*	*5*	*5*	*10*	*0*
EoL mass fraction to landfill/missing/fugitive, in %	*33*		*5*			*19*	*29*	*64*	*29*	*100*
TOTAL	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
EoL recyclability	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg

5.1.2. Life Cycle Cost Inputs for dishwashers

In the EcoReport tool the Life Cycle costs are calculated according to the following formula:

LCC = PP + PWF * OE + EoL

With:

- LCC is the Life Cycle Costs to end-users in €
- PP is the purchase price (incl. installation costs) in €
- OE is the annual operating expense in €
- EoL is the end-of-life costs for end-users (i.e. costs for disposal)
- PWF (Present Worth Factor) is

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

Where

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

To calculate the PWF the discount rate d and the escalation rate e of the operating expenses has to be defined. For the discount rate (d = interest - inflation) (COWI and VHK 2011b) recommends to apply 4% (which is also the required discount rate of the impact assessment guidelines of the Commission). The 4% results from an assumed MEErP interest rate of 6.5% and an inflation rate of 2.5%. For the base case calculations the recommended discount rate of 4% has been chosen. However, over the period of 1999-2013 the interest rate was on average close to 2% and the inflation rate around 2.1%. This would result in a discount rate of 0%. Therefore a sensitivity analysis with a discount rate of 0% is calculated (for results see section 5.3).

The escalation rate (e = inflation corrected running cost price increase) shall be the weighted average of the different annual growth rates of the different elements of the operating expenses. (COWI and VHK 2011b) suggest a default value of 4% which is assumed to reflect the situation of dishwashers.

Additionally, end-users in Europe do not have separate costs for the disposal of household dishwashers, so EoL is zero.

In case d = e the PWF = N, i.e. the formula can be simplified to

LCC = PP + N * OE

For the calculation of the EU totals data on the annual sales and the stock are taken into account.

Regarding **stock** data, (VHK 2014) assumes for the year 2010 a stock of 82.8 million units of dishwashers and estimates an increase to **98.3 million units in 2015** (cf. Table 2.7 and Table 2.9). These figures coincide well with the assumptions in (CLASP 2013) (82.2 million in 2010 and 99.1 million in 2015). These figures can also be validated by taking into account around 213 million households in EU-28 in 2011 (Eurostat 2011) combined with an average EU household penetration rate of 40% of dishwashers in 2012 (cf. section 2.2.1.1), resulting in around 85 million units in 2011.

For **sales** data (VHK 2014) assumes for the year 2010 an annual sales of 6.9 million units and estimate an increase resulting in an annual sales of **8.1 million units in 2015** (cf. (CLASP 2013): 7.4 million units in 2010 and 8.8 million units in 2015).

For further calculations (VHK 2014) projections are used for 2015.

No data is available on the detailed split between standard dishwashers and slim-line dishwashers. Therefore the relative share is estimated according to the CECED database on the models offered in 2014. In 2014, 14% of the models on the market were slim-line models, 86% of the market were standard models with a width of 60 cm.

Table 5-9: Assumptions on stock and sales of slim-line and standard dishwashers

	Share of models on the market 2014	Sales (2015) (in million units)	Stock (2015) (in million units)
Slim-line	14%	1.1	13.70
Standard	86%	7.0	84.60
Total	100%	8.8	98.3

The average **market price** in 2015 for dishwashers with 13 place settings was 526 Euro, for a 10 ps dishwashers 516 Euro (based on an analysis of top seller products at mediamarkt national websites (IT, BE, DE, ES, PL, SE), cf. also Table 5-1, including VAT). These values are close to the assumption made in (VHK 2014) (541 Euro in 2010). **Installation costs** for consumers are not relevant for dishwashers.

Maintenance and repair costs are based on own estimations at 15 € of one repair per product service life of 12.5 years. This cost is taken into account for both 10 ps and 13 ps dishwashers. Assuming that 10% of the dishwashers are repaired once in their lifetime (Consumer Reports 2010) and the cost of the reparation amounts for 150 euro (own assumption), 15 euro is attributed to the repair cost for all dishwashers. These assumptions have a relative high uncertainty as no reliable data is available. For washing machines a repair rate of around 50% is assumed. The impact of a higher rate of repairs of 50%, resulting in repair costs of 75 € per dishwasher, is therefore considered in a sensitivity analysis (for results see section 5.3).

The **electricity rate** has been taken according to (Eurostat 2015). The EU-28 average electricity price for households was 0.208 € in 2014 (including taxes, levies and VAT). The electricity prices vary between the member states by a factor of three: the highest prices are found in Denmark (0.304 €/kWh) and Germany (0,297 €/kWh), whereas the lowest prices are found in Bulgaria (0.090 €/kWh) and Hungary (0.115 €/kWh). France (0.175 €/kWh) and UK (0.201 €/kWh) have a medium price level.

Regarding the **water rate**, (European Environment Agency 2003) states that there are wide variations in water charges within individual countries and between different countries in Europe. This is because of the wide range of factors that determine local water prices, and whether there is a full recovery of costs, including those for water treatment and supply, for sewage treatment and for environmental damage. (COWI and VHK 2011b) proposed 3.70 €/m³ as European average for the year 2011.

(COWI and VHK 2011b) also proposed long-term growth rates for electricity rates (5%) and water rates (2.5%). Applying the growth factor of 2.5% to derive the current water rate from the 2011 costs, in 2014 the water rate would be 3.98 €/m³.

For **detergent costs**, section 2.3.2 shows a range between 0.08 € and 0.24 € for tablets (mono-tabs with and without phosphate) across Europe (Bio by Deloitte 2014). For further calculations, a mean value of **0.16 € per tab** of 20 g is taken, which equals 8 € per kg. For the rinsing agent 3 € per liter (with a density of 1 kg/liter) is assumed and for regeneration salt 1 € per kilogram (own assumptions).

Finally the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. The average product installed approximately equals the average new product a number of years ago. This number of years equals half the product life which is 6.25 years in the case of dishwashers. The ratio therefore has been estimated from the average energy consumption (according to the CECED database) per cycle in 2014 (0.942 kWh/cycle) and the average consumption per cycle in the years 2007 (1.015 kWh/cycle) and 2008 (1.020 kWh/cycle) (see also section 2.2.2.3). The resulting ratio is 92.5%.

Table 5-10 summarizes the data input for carrying out the economic assessment of the base cases.

Table 5-10: Inputs for the LCC for dishwashers (data is considered to be representative for EU-28 in 2014)

Input parameter	BC1 (13 ps)	BC2 (10 ps)
Annual sales (million units/year)	7.0	1.1
EU stock (million units)	84.60	13.70
Purchase price (€)	526	516
Installation costs	-	-
Indicative maintenance and repair costs (€), referred to the total product service life	15* (sensitivity analysis: 75)	15*
Product service life (years)	12.5	
Electricity rate (€/kWh) $_{2014}$ / long-term growth rate per year	0.208 / 5%	
Water rate (€/m³) $_{2014}$ / long-term growth rate per year	3.98 / 2.5%	
Costs for detergents: • Detergent costs • Rinsing agent • Regeneration salt	0.16 €/mono-tablet (= 8 €/kg; 44.8 € p.a.) 3 €/liter (2.52 € p.a.) 1 €/kg (5.32 € p.a.)	
Discount rate d Escalation rate e	4.0% (sensitivity analysis: 0%) 4.0%	
Ratio (energy consumption) average new vs. average product installed ('stock')	0.925	

*assumption that 10% of the dishwashers are repaired once in their lifetime at 150 euro

5.2. Environmental Impact Assessment of Base-Cases

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

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

5.2.1. Base Case 1: Standard dishwasher, 13 place settings

Table 5-11 shows the material consumption of a household dishwasher with 13 place settings over the whole life cycle of 12.5 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair that account for 1% of the bill of materials, and the sum of detergents (=auxiliaries) used over the life cycle. The material consumption during the End-of-Life phase is split in disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

Table 5-11: Life cycle material consumption of a standard household dishwasher with 13 place settings

Life Cycle phases -->		Production	Distribu-tion	Use phase	End-of-Life		
Material	Unit				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	10 919	-	109	2 890	2 364	5 774
TecPlastics	g	881	-	9	214	175	500
Ferro	g	21 553	-	216	833	15 831	5 105
Non-ferro	g	5 831	-	58	42	798	5 050
Coating	g	0	-	0	0	0	0
Electronics	g	1 382	-	14	134	139	1 122
Misc.	g	8 547	-	85	2 572	4 993	1 067
Extra	g	0	-	0	0	0	0
Auxiliaries	g	0	-	147 000	123 600	0	23 400
Refrigerant	g	0	-	0	0	0	0
Total weight	g	49 113	-	147 491	130 286	24 301	42 017

Table 5-12 shows the environmental impacts of a household dishwasher with 13 place settings over the whole lifecycle of 12.5 years under **real-life conditions**, i.e. assuming that all programmes are used according to real-life consumer behaviour.

The results are also shown in Figure 5-1 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

An important aspect to consider is that the default values for calculating the impact of the dishwashing detergent in the EcoReport tool are based on a phosphate containing detergent (cf. (COWI and VHK 2011a) p. 116: "Dishwasher detergent, rinsing agent and salt based on EU Ecolabel studies (avg. EU phosphate) and CECED data (energy). Phosphate emissions are considered after Urban Waste Water Treatment (80% removal efficiency)".

At present, consumer dishwasher detergents are allowed to contain phosphates. However, from 2017 onwards phosphates will be banned from consumer dishwashing detergents as stated in the Detergent Regulation (EC) No 648/2004 and corroborated by the Commission Communication COM(2015) 229. Thus the impact on eutrophication through the dishwashing detergent discharge will be significantly lower in the future.

A sensitivity analysis has been conducted for the Base Case 1 (standard, 13 ps). For this analysis the specific eutrophication potential of the dishwashing detergent included in the EcoReport tool has been reduced by 90%. The results are shown in the last row of Table 5-12.

The whole eutrophication potential is reduced by approximately 90% which means that the main contributor to the eutrophication potential is the discharge of dishwashing detergent. This aspect has to be kept in mind when interpreting the results.

Table 5-12: Life cycle environmental impacts of a standard household dishwasher with 13 place settings (real life usage)

Life Cycle phases -->		Production			Distri-bution	Use phase	End-of-Life			Total (of absolute values of impacts)
	Unit	**Mate-rial**	**Manufac-turing**	**Total**			**Disposal**	**Recycl.**	Total	
Resources & Waste										
Total Energy (GER)	MJ	5 641	829	6 470	590	36 968	207	-554	-347	44 375
of which, electricity (in primary MJ)	MJ	2 740	497	3 236	1	34 389	0	-144	-144	37 770
Water (process)	ltr	1 442	7	1 449	0	53 114	0	-251	-251	54 814
Water (cooling)	ltr	971	232	1 202	0	1 537	0	-64	-64	2 803
Waste, non-haz./ landfill	g	34 005	2 750	36 755	346	21 004	905	-9 003	-8 097	66 203
Waste, hazardous/ incinerated	g	204	0	204	7	603	0	-9	-9	823
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	314	46	360	39	1 581	1	-38	-37	2 017
Acidification, emissions	g SO2 eq.	2 543	199	2 743	118	7 173	8	-273	-265	10 299
Volatile Organic Compounds (VOC)	g	54	0	55	8	769	0	-11	-11	843
Persistent Organic Pollutants (POP)	ng i-Teq	531	11	542	2	102	0	-120	-120	766
Heavy Metals	mg Ni eq.	2 445	27	2 472	18	372	3	-486	-483	3 345
PAHs	mg Ni eq.	156	0	156	20	87	0	-7	-7	270
Particulate Matter (PM, dust)	g	2 674	31	2 704	1 368	178	48	-406	-358	4 608
Emissions (Water)										
Heavy Metals	mg Hg/20	1 166	1	1 166	1	176	0	-275	-275	1 618
Eutrophication	g PO4	36	0	36	0	3 759	1 025	-8	1 017	4 812
Sensitivity analysis: reduction of 90% in the eutrophication input data for dishwashing detergent										
Eutrophication	g PO4	36	0	36	0	382	104	-8	95	514
Reduction of eutrophication by		*0%*	--	*0%*	--	*90%*	*90%*	*0%*	*91%*	*89 %*

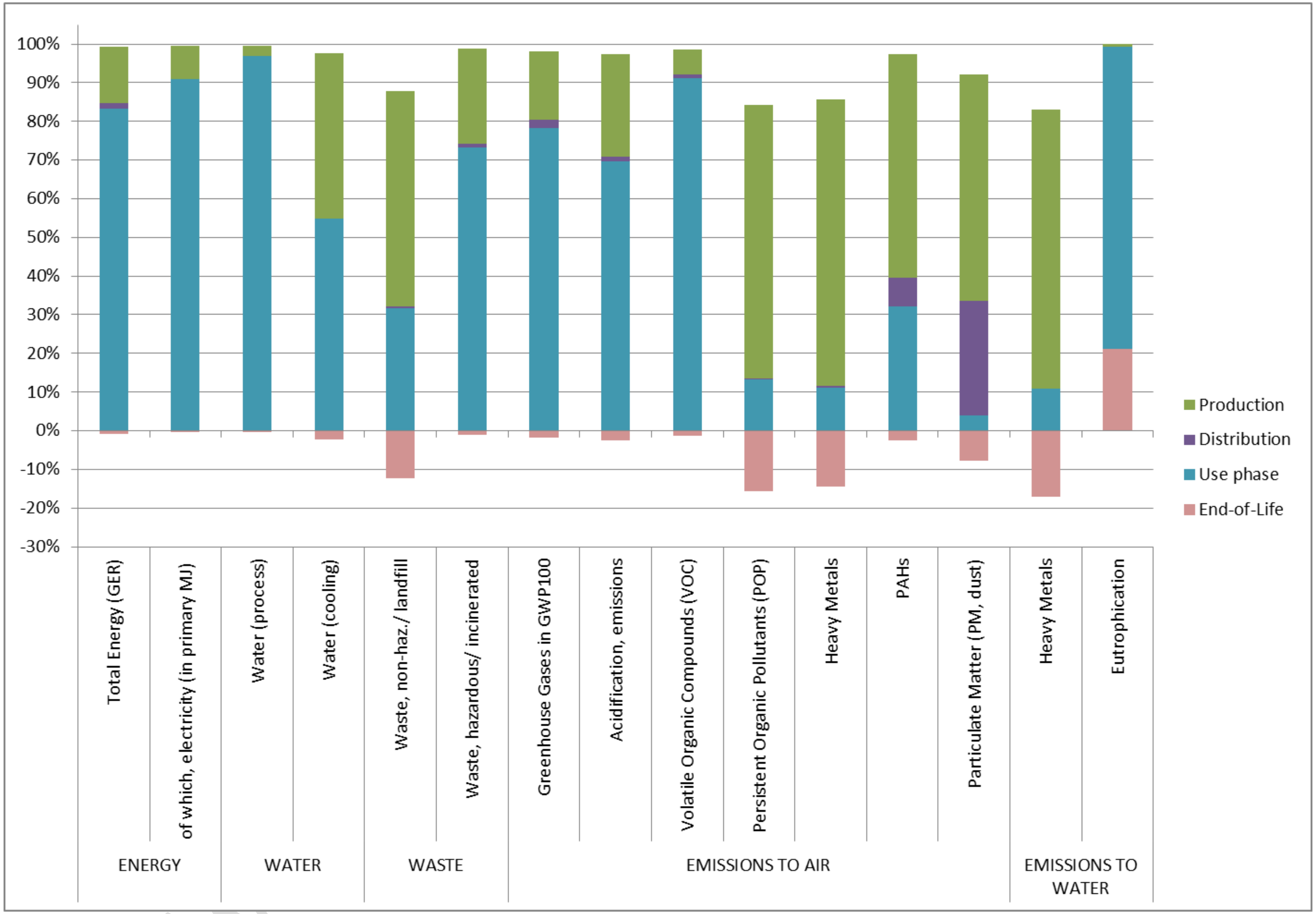

Figure 5-1: **Contribution of different life cycle phases to the environmental impacts of a standard household dishwasher with 13 place settings (real life usage)**

Figure 5-1 shows that the use phase clearly dominates the consumption of energy (>80%) and water (>95% of water process and > 50% of water cooling) and the generation of waste (especially hazardous/incinerated waste) along the life cycle. Besides process water, which is essentially related to the consumption of water by the cleaning and drying cycle, consumption of electricity is the main contribution to all the other indicators of these three macro categories (see also Table 5-12).

Regarding the emissions to air and water, the use phase also dominates four impacts categories, namely global warming potential (GWP100) (≈ 80%), acidification potential (AP) (≈ 70%), volatile organic compounds (VOC) (≈ 90%) and eutrophication potential (EP) (≈ 80%). For persistent organic pollutants (POP), heavy metals to air (HM air), polycyclic aromatic hydrocarbons (PAHs), particulate materials (PM, dust) and heavy metals to water (HM water) the use phase has a contribution ranging from 5% to close to 35% from the total of each category. This is mainly caused by the consumption of electricity (see also Table 5-12).

The contribution of the production phase scores significantly in the following impacts categories: non-hazardous waste (≈. 55%), POP (≈ 60%), HM air (≈ 75%), and PAHs and PM, dust scoring both approximately 55% and finally HM water getting approximately. 60% of the total of this category. This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation of PAHs (<10 %) and PM (>20%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL for non-hazardous waste, POP, HM air and HM water is close to -15%.

5.2.2. Base Case 2: slim-line dishwasher, 10 place settings

Table 5-13 shows the material consumption of a household dishwasher with 10 place settings over the whole life cycle of 12.5 years.

Table 5-13: Material consumption of a household dishwasher with 10 place settings

Life Cycle phases ->		**Production**	**Distribution**	**Use phase**	**End-of-Life**		
Material	**Unit**				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	8 436	-	84	2 787	2 281	3 452
TecPlastics	g	777	-	8	132	108	546
Ferro	g	18 922	-	189	661	12 556	5 894
Non-ferro	g	5 830	-	58	34	653	5 201
Coating	g	0	-	0	0	0	0
Electronics	g	1 206	-	12	216	225	776
Misc.	g	7 439	-	74	2 219	4 307	987
Extra	g	0	-	0	0	0	0
Auxiliaries	g	0	-	147 000	128 614	0	18 386
Refrigerant	g	0	-	0	0	0	0
Total weight	g	42 609	-	147 426	134 664	20 129	35 243

Table 5-14 shows the environmental impacts of a household dishwasher with 10 place settings over the whole lifecycle of 12.5 years under real-life conditions.

Please take into account the considerations made with regard to the Eutrophication Potential in section 5.2.1. It can be assumed that the Eutrophication Potential can be reduced by 90% through use of phosphate free dishwashing detergent.

Table 5-14: Life cycle environmental impacts of a standard household dishwasher with 10 place settings (real life usage)

Life Cycle phases -->		Production			Distri-bution	Use phase	End-of-Life			Total (of absolute values of impacts)
	Unit	Mate-rial	Manufac fac-turing	Total			Disposal	Re-cycl.	Total	
Resources & Waste										
Total Energy (GER)	MJ	4 873	681	5 555	474	33 416	224	-551	-326	39 772
of which, electricity (in primary MJ)	MJ	2 379	409	2 787	1	30 841	0	-197	-197	33 826
Water (process)	ltr	1 221	6	1 227	0	59 080	0	-210	-210	60 517
Water (cooling)	ltr	782	191	973	0	1 377	0	-53	-53	2 403
Waste, non-haz./ landfill	g	30 091	2271	32 362	288	19 138	888	-7 316	-6 428	58 216
Waste, hazardous/ incinerated	g	173	0	173	6	547	0	-12	-12	738
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	272	38	310	32	1 429	1	-35	-35	1 805
Acidification, emissions	g SO2 eq.	2 235	164	2 398	96	6 500	9	-258	-249	9 248
Volatile Organic Compounds (VOC)	g	49	0	49	6	690	0	-10	-10	755
Persistent Organic Pollutants (POP)	ng i-Teq	491	10	501	2	94	0	-98	-98	695
Heavy Metals	mg Ni eq.	2 119	23	2 143	15	333	3	-389	-386	2 877
PAHs	mg Ni eq.	136	0	136	16	78	0	-8	-8	238
Particulate Matter (PM, dust)	g	2 393	25	2 418	1036	161	51	-398	-347	3 962
Emissions (Water)										
Heavy Metals	mg Hg/20	999	1	1 000	0	159	0	-214	-214	1 373
Eutrophication	g PO4	30	0	31	0	3 758	1 067	-7	1 060	4 849

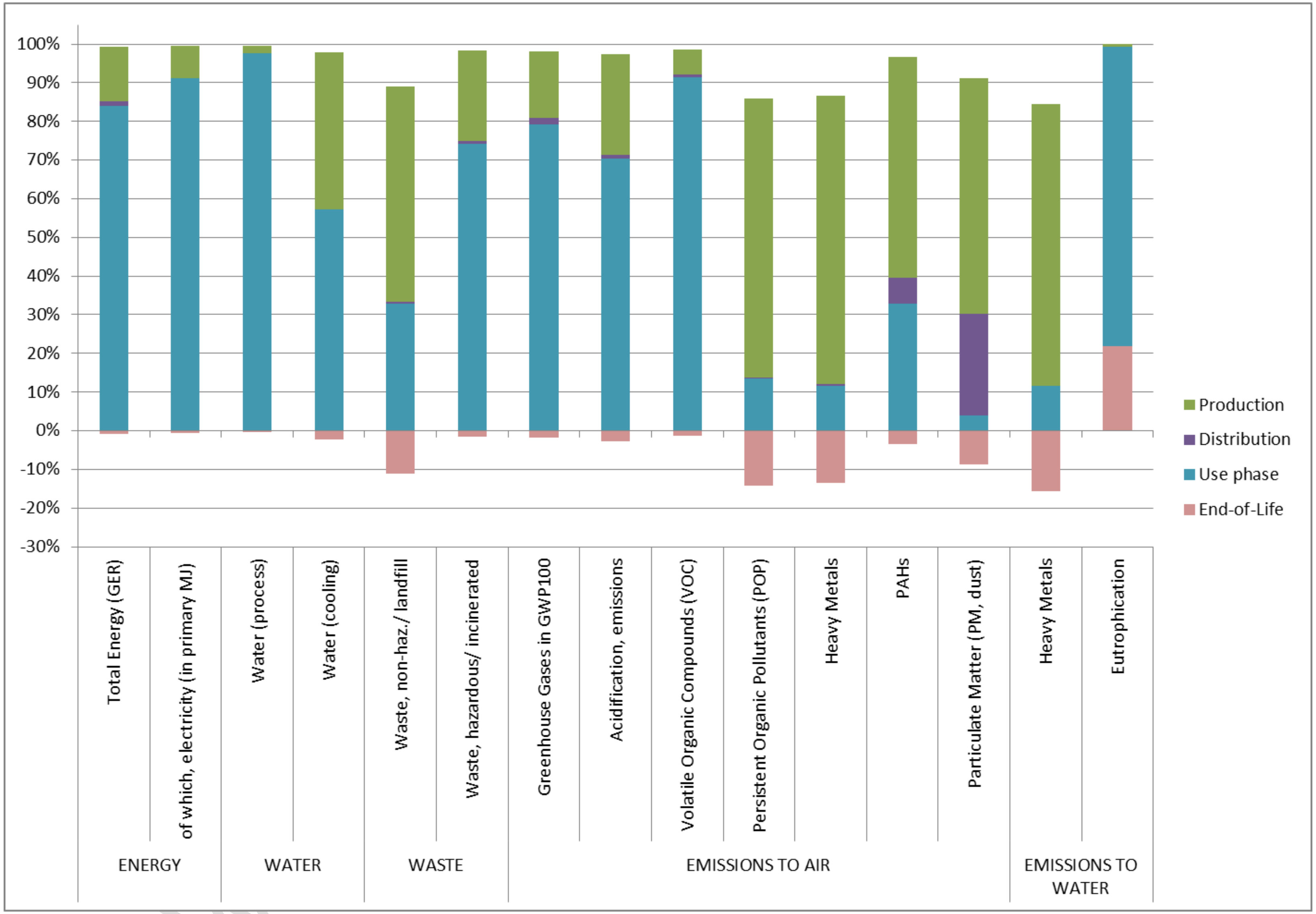

Figure 5-2: **Contribution of different life cycle phases to the environmental impacts of a slim-line household dishwasher with 10 place settings (real-life usage)**

Figure 5-2 (BC2) shows very similar results to Figure 5-1 (BC1). The use phase clearly dominates the consumption of energy (>80%) and water (>95% of water process and close to 60% of water cooling) and the generation of waste (especially hazardous/incinerated waste with a value close to 75%) along the life cycle of the base case. Once again, besides process water, which is essentially related to the consumption of water of the dishwashing cycles, consumption of electricity is the main contribution to all the other indicators of these three macro categories.

Regarding the emissions to air and water, the use phase also dominates the same four impacts categories, namely GWP100, AP, VOC and EP. For POP, HM air, PAHs, PM and HM water the use phase has a contribution ranging from 5% to close to 35% from the total of each category. This is mainly caused by the consumption of electricity, as commented previously.

The contribution of the production phase scores significantly in the same impacts categories as in the Base Case 1 (13ps) and with similar relative values: POP, HM air, PAHs, PM and HM.

The distribution phase is relevant only for the generation of PAHs (<10 %) and PM (>20%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL for POP, for HM air and for HM water is close to -15%, being in line with Base Case 1 (13 ps).

The differences observed between both base cases are not significant. For example the exact percentages of each impact category for each lifecycle phase may vary among 1 and 5 percentage points in most of the cases.

5.2.3. Comparison of the environmental impacts using the Eco-programme vs. real-life programme choice

Table 8-11 and Table 8-12 in the Annex show the environmental impacts of both base cases when using only the eco programme.

Compared to the environmental impacts under real-life programme choice it can be seen that the changes in the environmental impacts mainly occur during the use phase. The end-of-life phase only is affected through a slightly higher amount of waste water in the case of the real-life conditions.

The following table therefore directly compares the environmental impact in the use phase of Base Case 1 (using only the real-life programme choice vs. only use of eco programme). The environmental impacts in most impact categories when only using the eco programme are about 9 to 12% lower compared to real life programme choice. This corresponds well to the higher electricity consumption under real-life programme choice (see section 5.1.1.4). Only the eutrophication potential does not change significantly as this mainly comes from the use of dishwashing detergents and there is no difference between the two scenarios.

Table 5-15: Comparison of environmental impacts during the use phase (use of eco programme vs. real life programme choice) (BC1)

		Use phase		Difference
	Unit	Real life programme choice	Use of eco programme	
Resources & Waste				
Total Energy (GER)	MJ	36 968	32 943	-11%
of which, electricity (in primary MJ)	MJ	34 389	30 364	-12%

		Use phase		Difference
Water (process)	ltr	53 114	47 458	-11%
Water (cooling)	ltr	1 537	1358	-12%
Waste, non-haz./ landfill	g	21 004	18 930	-10%
Waste, hazardous/ incinerated	g	603	539	-11%
Emissions (Air)				
Greenhouse Gases in GWP100	kg CO_2 eq	1 581	1 409	-11%
Acidification, emissions	g SO_2 eq	7 173	6 412	-11%
Volatile Organic Compounds (VOC)	g	769	679	-12%
Persistent Organic Pollutants (POP)	ng i-Teq	102	93	-9%
Heavy Metals	mg Ni eq.	372	331	-11%
PAHs	mg Ni eq.	87	77	-11%
Particulate Matter (PM, dust)	g	178	162	-9%
Emissions (Water)				
Heavy Metals	mg Hg/20	176	159	-10%
Eutrophication	g PO4	3 759	3 758	0%

5.3. Life Cycle Costs for consumers of Base-Cases

The life cycle costs have been calculated with the EcoReport tool. The methodology and the assumptions (regarding product price, energy and water costs, repair and maintenance costs as well as costs for detergents) are described in section 5.1.2 (see also Table 5-10).

The life cycle costs per appliance over a lifetime of 12.5 years are summarised for both base cases in Table 5-16.

Table 5-16: Life Cycle Costs for the base cases under real life conditions over the whole product life cycle (in Euro)

	Unit	**Base Case 1 (13 ps)**	**Base Case 2 (10 ps)**
		Real life usage	**Real life usage**
Product price	€	526	516
Electricity	€	789	706
Water	€	152	169
Dishwashing detergent	€	560	560
Rinsing agent	€	32	32
Regeneration salt	€	67	67
Repair & maintenance costs	€	15	15
Total	€	**2 140**	**2 064**

5.3.1. Life cycle cost of Base case 1 (13 place settings)

The contribution of the different cost elements are shown in Figure 5-3 for Base Case 1 (13 ps). The largest contributions to the overall costs are coming from the purchase price and the expenditures in electricity and dishwashing detergents. The latter one even overtakes the investment costs.

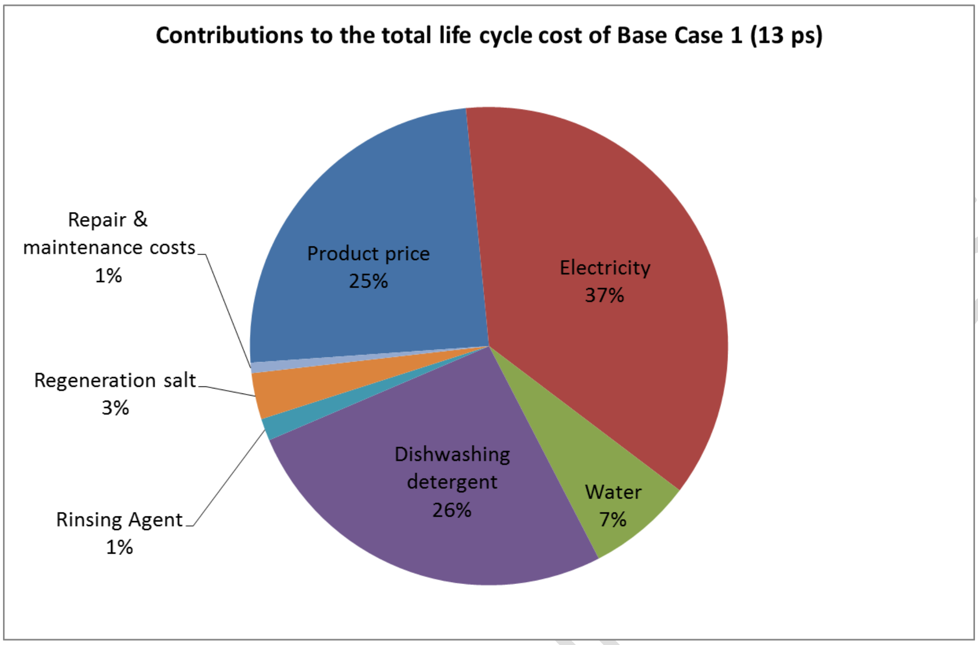

Figure 5-3: Relative contributions of costs to the total life cycle cost of Base Case 1 (13 ps)

5.3.2. Sensitivity Analysis

5.3.2.1. Higher repair frequency

Table 5-17 shows the results of the sensitivity analysis in comparison to Base Case 1.

When considering higher costs for maintenance and repair, i.e. a repair rate of 50 % resulting in repair costs of 75 € per appliance (instead of a repair rate of 10 % resulting in repair costs of 15 € per appliance) the share of the costs for maintenance and repair increases from 0.7 % to 3.4 %.

Table 5-17: Life Cycle Costs – sensitivity analysis "higher repair rate/cost" (over the whole product life cycle, in euro)

	Base Case 1 (13 ps)		Sensitivity: higher repair rate	
	Absolute LCC	Relative contribution	Absolute LCC	Relative contribution
Product price	526 €	24.6%	526 €	23.9%
Electricity	789 €	36.9%	789 €	35.8%
Water	152 €	7.1%	152 €	6.9%
Dishwashing detergent	560 €	26.2%	560 €	25.5%
Rinsing agent	32 €	1.5%	32 €	1.4%

	Base Case 1 (13 ps)		**Sensitivity: higher repair rate**	
Regeneration salt	67 €	3.1%	67 €	3.0%
Repair & maintenance costs	15 €	0.7%	75 €	3.4%
Total	**2 140** €	**100%**	**2200** €	**100%**

5.3.2.2. Discount rate = 0 %

Table 5-18 shows the results of the sensitivity analysis in comparison to Base Case 1.

It can be seen that the life cycle costs when applying a discount rate of 0 % are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4 %), thus both effects compensate each other. By setting the discount rate to 0 % only the escalation rate is effective, i.e. the operating expenses are increased over the time (resulting present worth factor is 16.45 years).

Two main effects can be seen:

- the overall LCC are higher compared to the base case and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 25 % to 20 %).

As a result from the latter effect, the additional costs of design options payoff quicker if a discount rate of 0 % is applied.

Table 5-18: Life Cycle Costs – sensitivity analysis "discount rate = 0 %" (over the whole product life cycle, in Euro)

	Base Case 1 (13 ps) discount rate = 4 %		**Sensitivity: discount rate = 0 %**	
	Absolute LCC	**Relative contribution**	**Absolute LCC**	**Relative contribution**
Product price	526 €	24.6 %	526 €	19.9 %
Electricity	789 €	36.9 %	1 038 €	39.2 %
Water	152 €	7.1 %	200 €	7.6 %
Dishwashing detergent	560 €	26.2 %	737 €	27.8 %
Rinsing agent	32 €	1.5 %	41 €	1.6 %
Regeneration salt	67 €	3.1 %	88 €	3.3 %
Repair & maintenance costs	15 €	0.7 %	20 €	0.7 %
Total	**2 140 €**	**100 %**	**2 650 €**	**100 %**

5.3.3. Life cycle cost of Base Case 2 (10 place settings)

The contribution of the different cost elements are shown in Figure 5-4 for the Base Case 2 (10ps). The largest contributions to the overall costs are again the purchase price and the expenditures in electricity and dishwashing detergents. As for Base Case 1 the costs for electricity consumption and dishwashing detergent exceed the investment costs. Compared to Base Case 1 the share of electricity costs is slightly higher and the shares of dishwashing detergent and water consumption are slightly higher as well. These differences are negligible.

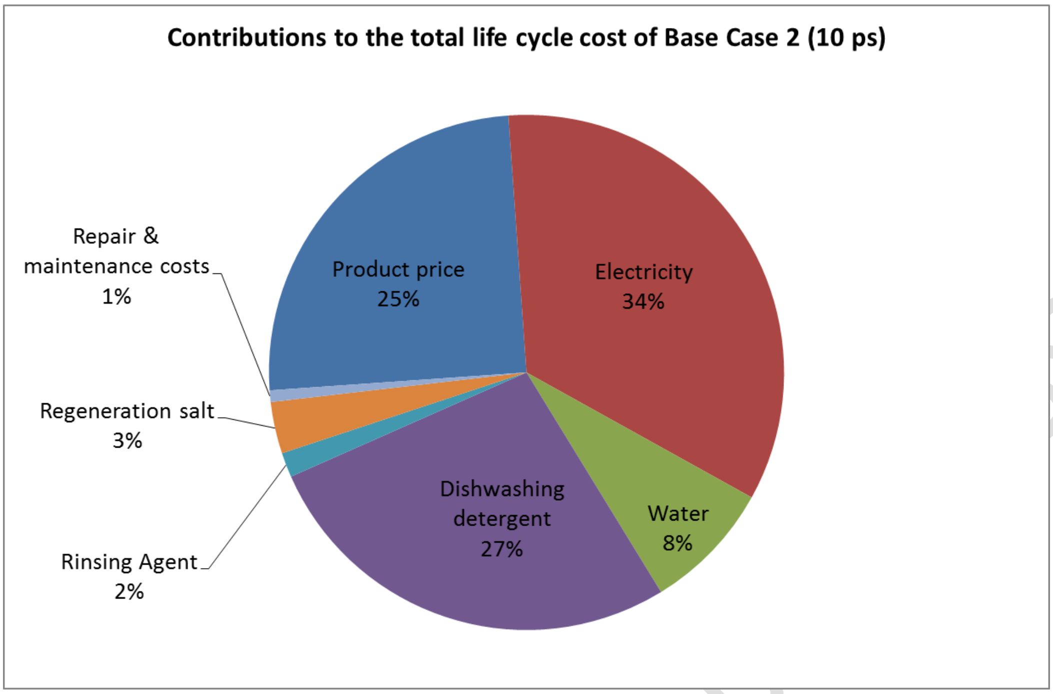

Figure 5-4: Relative contributions of costs to the total life cycle cost of Base Case 2 (10 ps)

5.3.4. Comparison of the LCC using the eco programme vs. real-life programme choice

Table 8-13 in the annex shows the LCC per product both when using only the eco programme and under real life programme choice.

The electricity and water costs when using only the eco programme are lower compared to the real life programme choice. The electricity costs are 12% (BC1) and 10% (BC2) lower than under real life programme choice, the water costs are 11% (BC1) and 15% (BC2) lower. This difference is due to the slightly higher electricity and water consumption under real life conditions (see section 5.1.1.4).

The differences between the total LCC are rather small however (around 5% for both base cases).

5.4. EU totals

The environmental impacts and the LCC under real life conditions are aggregated using stock and market data indicating

- the life cycle environmental impact of all new products designed in 2014 (reference year),
- the annual environmental impacts of the stock of dishwashers in 2014 (including production, use and end-of-life),
- the annual monetary costs for consumers (also for 2014) (including acquisition, use and maintenance and repair).

The following table shows the environmental impacts of all new dishwashers produced in 2014 over their lifetime under real life conditions (Table 5-19).

Table 5-19: Life cycle environmental impacts of all new dishwashers reflected for both base cases (real life usage) produced in 2014 (over their lifetime)

	Unit	Base Case 1 (13 ps, real life)	Base Case 2 (10 ps, real life)	Total
Resources & Waste				
Total Energy (GER)	PJ	305.8	43.0	348.8
of which, electricity (in primary MJ)	PJ	262.4	36.8	299.2
Water (process)	mln. m^3	380.2	66.1	446.3
Water (cooling)	mln. m^3	18.7	2.5	21.3
Waste, non-haz./ landfill	Kt	350.1	49.9	400.0
Waste, hazardous/ incinerated	Kt	5.6	0.8	6.4
Emissions (Air)				
Greenhouse Gases in GWP100	mt CO_2 eq.	13.6	1.9	15.5
Acidification, emissions	kt SO_2 eq.	68.4	9.6	78.0
Volatile Organic Compounds (VOC)	Kt	5.7	0.8	6.6
Persistent Organic Pollutants (POP)	g i-Teq	3.7	0.5	4.2
Heavy Metals	ton Ni eq.	16.6	2.3	19.0
PAHs	ton Ni eq.	1.8	0.2	2.0
Particulate Matter (PM, dust)	Kt	27.2	3.6	30.8
Emissions (Water)				
Heavy Metals	ton Hg/20	7.5	1.0	8.5
Eutrophication	kt PO_4	33.7	5.3	39.0

Table 5-20 shows the annual environmental impact of the stock of dishwashers in the reference year (2014). The stock refers to

- the environmental impact through the production of the annual sales of DW in the reference year
- the environmental impact of 1 year use of the whole stock
- the end-of-life treatment of the amount of dishwashers discarded in that year (according to the EcoReport tool: "simplified model assuming produced = EoL")

Table 5-20: EU Total Impact of STOCK of Dishwasher in reference year 2014 (produced, in use, discarded) (real life usage)

	Unit	Base Case 1 (13 ps, real life)	Base Case 2 (10 ps, real life)	Total
Resources & Waste				
Total Energy (GER)	PJ	317.5	45.9	363.3
of which, electricity (in primary MJ)	PJ	273.3	39.4	312.7
Water (process)	mln. m3	397.0	71.1	468.1
Water (cooling)	mln. m3	19.2	2.6	21.9
Waste, non-haz./ landfill	Kt	356.7	51.5	408.2
Waste, hazardous/ incinerated	Kt	5.8	0.8	6.7

	Unit	Base Case 1 (13 ps, real life)	Base Case 2 (10 ps, real life)	Total
Emissions (Air)				
Greenhouse Gases in GWP100	mt CO2 eq.	14.1	2.0	16.1
Acidification, emissions	kt SO2 eq.	70.7	10.2	80.8
Volatile Organic Compounds (VOC)	Kt	6.0	0.9	6.9
Persistent Organic Pollutants (POP)	g i-Teq	3.7	0.6	4.3
Heavy Metals	ton Ni eq.	16.8	2.3	19.1
PAHs	ton Ni eq.	1.8	0.3	2.1
Particulate Matter (PM, dust)	Kt	27.3	3.6	30.9
Emissions (Water)				
Heavy Metals	ton Hg/20	7.5	1.1	8.6
Eutrophication	kt PO_4	34.9	5.7	40.5

Table 5-21 shows the total annual consumer expenditure of all EU consumers for 2014.

Table 5-21: Annual consumer expenditure of all EU consumers for 2014 under real life conditions (in Euro) (including annual sales of 2014 (product price) and annual usage of stock (electricity, water, detergents, repair + maintenance))

	Unit	Base Case 1 (13 ps)	Base Case 2 (10 ps)	Total	Total %
Product price	Million €	3 682	568	4 250	25.2
Electricity	Million €	5 337	774	6 111	36.2
Water	Million €	1 029	185	1 215	7.2
Dishwashing detergent	Million €	3 790	614	4 404	26.2
Rinsing agent	Million €	213	35	248	1.5
Regeneration salt	Million €	450	73	523	3.1
Repair & maintenance costs	Million €	102	16	118	0.7
Total	**Million €**	**14 603**	**2 264**	**16 868**	**100**

6. Task 6: Design options

6.1. Options

6.1.1. Single design options

In Task 4, several design options for household dishwashers have been described in detail. Table 6-1 summarizes and clusters these initial design options and provides rationales for the project team's decision which of the options are to be further analysed in the following tasks.

Table 6-1: Overview of design options for household dishwashers

Improvement options	Description	Rationales for the selection of design options for further follow-up
Option 1: Reduction of thermal losses	During a dishwashing cycle a part of the energy used for heating up the water and the dishes is lost. Examples to reduce those thermal losses are: 1a) Improved insulation of the appliance 1b) Heat exchanger (water buffering tank) 1c) Cross flow heat exchanger (with storage tank)	1a) Not chosen as considered to be fully optimised. 1b) not chosen as integrated in option 2a 1c) considered as BNAT, not clear if this will be implemented in the future.
Option 2: Improved drying systems	Usually, for drying the dishes they are heated in the final hot rinse phase. For reducing the energy demand in that phase, alternative drying technologies have been developed. Examples are: 2a) (Water tank) condenser fostering the condensing of the hot vapour at the tub walls and thus the drying of the dishes 2b) Automatic door opening systems facilitating the hot air escaping from the dishwasher 2c) Adsorption drying technologies (like Zeolith®, or others); 2d) Fan for better air circulation 2e) Direct heating of load, thus avoiding last hot rinse, i.e. avoiding rinse water to be heated up additionally	1b) + 2a) chosen as "heat exchanger" 2b) chosen 2c) chosen 2d) chosen 2e) not chosen. The last rinse takes place with warm water to remove remaining soil from the dishes. Thus, apart from difficulties in heat transfer to the dishes without water the cleaning performance would be worse if the last rinse would be with cold water only.
Option 3: Temperature - time trade off	Using lower temperatures in dishwashers, e.g. in the final hot rinse phase, combined with increasing cycle times to ensure the same cleaning and drying performance with lower energy consumption for heating. Examples are: 3a) Extension of programme duration and lowering of final hot rinse temperature - moderate scenario (e.g. 4 hours) 3b) Extension of programme duration and lowering of final hot rinse temperature - extreme scenario (e.g. 6 hours)	3a) chosen 3b) according to industry information in case of dishwashers it is not possible to reduce the temperature in the main wash phase under a certain level as otherwise it could be difficult to meet the Ecodesign requirements on cleaning performance. Also, longer duration of the main wash phase makes it more difficult to remove the soil from the water as it will become too small to be filtered out keeping the filter grid large enough for hydraulic reasons. The temperature of the final rinse cannot be reduced that much either

Improvement options	Description	Rationales for the selection of design options for further follow-up
		as a certain temperature level is usually kept to remove remaining soil. Currently the average duration of the Eco-programme is 196 min (see Table 5-3), which has not changed during the past 2 years (see section 2.2.3.1). Therefore it seems that for dishwashers, with the current soiling in the standard, it is not an option to increase the time up to 6 hours.
Option 4: Alternative heating systems	Alternative heating systems to reduce the electricity demand of the dishwasher for heating the water by external heating sources. Examples are 4a) Heat pump technology: the electric energy usually used to heat the machine/dishes/water is replaced by using the heat of the ambient air and/or the waste water/heat of the drying phase 4a1) either with common refrigerant R134a 4a2) or with alternative refrigerant with lower GWP (e.g. propane, isobutane) 4b) Heat-fed machines: the electric heating elements of the appliance are replaced by a hot water circulation loop using a heat exchanger to transfer the heat from the hot water circulation to the machines. The appliance itself is connected to the cold water tap; the cleaning water is not heated by an electric resistance heater but by a hot water heat exchanger which is fed by the hot water delivery of the dwelling generated e.g. by central or district heating. 4c) Hot fill (connection of the appliance to a hot water supply), i.e. the wash water for the machine is directly fed with external hot water and less water has to be heated internally by the machine itself.	4a1) chosen 4a2) considered as BNAT 4b) not chosen as dishwashers are located in the kitchen with a large distance to a possible hot water storage. 4c) discussed separately: almost all dishwashers on the market can be connected to hot water. Therefore the technology can be considered as standard. However, in real life it does not take place very often and it is advantageous only under certain conditions, e.g. if the hot water is generated by sustainable energy sources such as photovoltaics or a solar thermal boiler. Moreover, this option cannot be combined with other options, e.g. heat exchanger for better drying (with cold water) or the adsorption drying technologies. For comparative reasons the potential will be discussed based on existing detailed research (see section 6.1.3).
Option 5: Increased motor efficiency	Compared to universal commutator motors with brushes, more energy efficient motors become common in household dishwashers. Advantages are also claimed in terms of lower noise, partly less volume and weight, and longer lifetime due to absence of brushes which are more prone to wear. Examples are 5a) Brushless, inverter driven asynchronous DC motors 5b) Brushless, permanent magnet synchronous DC motors (PMSM)	5) and 5b) not chosen as assumed that most appliances on the market already have a brushless DC motor (BLDC)

Improvement options	Description	Rationales for the selection of design options for further follow-up
Option 6: Sensors and automatic controls	Certain electronic controls might support the adaptation of energy, water and detergent consumption to specific loads and soiling. Examples are: 6a) Soil sensor 6b) Load sensor 6c) Automatic detergent dosage systems which is supposed to lead to reduced mis-dosing (under- or overdosing)	6a) and 6b) chosen: advanced sensor technology (turbidity sensor, water level measurement, temperature measurement) to adapt programme to work with different loads and soiling. 6c) considered as BNAT, currently no systems on the market. Beko has shown a prototype on IFA 2015, but not yet available on the market and performance not yet verified.
Option 7: Alternative spraying / water systems	Examples are 7a) "Water wall" (a line of spray jets that move back and forth along the bottom of the tub) instead of rotating spray arms 7b) Steam technology (i.e. treating the dishes with steam instead of water to some extent e.g. for pre-cleaning or delicate dishes)	7a) not chosen, so far no effect on energy efficiency has been detected. Explicitly developed to improve cleaning performance (e.g. in the edges of the lower basket) not the energy efficiency. 7b) not chosen as no effect on energy efficiency detected.
Option 8: Machine geometry	Dishwashers can be equipped with a so-called tall tub. Outer dimensions are the same as for a standard dishwasher, but more space is created in the inner tub. The water uptake and spraying is usually adapted compared to a standard dishwasher.	Not chosen, as so far no effect on energy efficiency has been detected.
Option 9: Consumer feedback mechanisms	Feedback to consumers via LCD display on certain parameters might lead to optimized consumer behaviour in terms of e.g. loading and dosage. Examples are: 9a) Displaying a detergent dosage recommendation 9b) Indication of the energy and water demand of the chosen programme	9a) not chosen as most people use tabs and therefore this has no influence on detergent consumption. Moreover, in the Eco-programme standard testing protocol the amount of detergent is fixed. 9b) chosen. Should influence consumer behaviour to some extent.
Option 10: Smart appliances	Examples are 10a) Internet connectivity 10b) Electronic update of the programmes / diagnostics in case of failures 10c) Smart grid ready products	10a), 10b) and 10c) not chosen as no direct improvement potential on energy efficiency
Option 11: Material selection	The choice of materials might not have direct impacts on the energy or water consumption of dishwashers but might improve the overall resource efficiency or durability of the appliances. Examples are: 11a) Use of postconsumer recycled plastic 11b) Increased overall durability of the machine (e.g. increasing the durability of the materials and components used)	11a) not chosen, currently no possibility to systematically use recycled plastic 11b) chosen and discussed in section 6.1.4.2

6.1.2. Selection of single design options

Based on a questionnaire, manufacturers have been asked to provide specific technical and cost data of the above listed design options and combinations thereof. To assess the design options, stakeholders were also asked to estimate the current and future market penetration of certain improvement options as well as to give an indication of which of the single options are compatible with other options.

Comparisons are made to the base cases (BC) which are defined in section 5.1.1. Stakeholders were asked to provide information about changes induced by the design options compared to the base cases with regard to:

- Performance parameters (energy and water consumption, noise, cycle time)
- Variation of material resources (compared to the BoM of the base cases)
- Manufacturing costs, maintenance and repair costs
- Product lifetime

Only little information has been provided by stakeholders on the single design options and combinations. Based on this limited input and additional expert knowledge, the project team has assumed the input for further calculations as described in Table 6-4.

The saving potentials have been derived as follows:

1. Where applicable the absolute saving potential (energy and water) was determined for the eco programme of Base Case 1 (13 ps) and the corresponding relative saving in this programme was calculated.
2. This relative saving was applied to the other programmes (sometimes with exceptions: e.g. it is assumed that in the short and the rinse/rinse & hold programme some of the technologies are not applied. The moderate increase of programme duration only affects the eco programme).
3. For savings through consumer feedback mechanisms no saving in the eco programme is established. Savings result from a shift in programme usage under real life conditions (10% more use of eco programme, 5% less use of normal 45-55°C and of normal 60-65°C each).
4. The changes in material composition and the additional material costs are an estimation based on the additional components necessary.
5. In case of Base Case 2 (10 ps)
    a. Where no specific data was available it is assumed that the relative saving potential derived for Base Case 1 can be applied to Base Case 2.
    b. Other assumptions are the same for Base Case 2 (e.g. for which programme the savings are valid, shift in real life programme usage, etc.).
    c. The changes in material composition are slightly adapted (reduction by 20%).
    d. The manufacturing costs of the design options are assumed to be the same as for Base Case 1.

All percentage values are rounded values – the calculations are made with the exact figures.

From the estimated manufacturing costs the increase of the purchase price is calculated with the same assumptions as outlined in section 5.1.1.1 and Table 5-1 (assumptions according to Lot 14):

Manufacturing costs

- plus 28% costs for manufacturers' marketing & administration,
- multiplied by a factor 2.5 to account for the sales margin
- plus 21.6% for average EU VAT 2015

Note that this estimation only takes into account the estimated increase of manufacturing cost related to the design options. Other features that can raise the purchase price and which usually go together with premium models, e.g. better aesthetics, are not taken into account. Therefore the shown purchase price could be lower than the real market price of machines equipped with certain improvement options.

6.1.3. Hot fill

"Hot fill" was not included as regular design option, on the one hand because it is in principle possible to connect all dishwashers on the market to a hot water tap (i.e. to use the dishwasher with hot water, which is heated by another water heating systems, also called "hot fill"). In contrast to washing machines, it is not necessary to have two inlet valves therefore the existing valve can be used either for the cold or for the hot water tap. On the other hand the question how beneficial the hot water connection is cannot be answered by a simplified calculation with the EcoReport tool. The project team therefore decided to discuss the pros and cons of the hot water connection of dishwashers based on existing research.

If the dishwasher is connected to hot water, it needs less electricity than if it was connected to cold water. The water has to be heated by another system however (e.g. usually district heating or central hot water generation systems) which also need energy. The energy source usually is not electricity, therefore the energy consumption cannot be summed up easily but other indicators (like the primary energy consumption or the global warming potential) have to be used for comparison.

The hot water has to be led through the building to the dishwasher, thus usually conduction losses occur e.g. in the water storage tank, in the circulation pipe and in the water stub line. Usually only the losses in the water stub line are attributed to the dishwasher use if it is connected to hot water.

According to (Bush & Nipkow 2005; Gensch et al. 2009) the environmental and cost savings through hot water connection of a dishwasher depend on various framework parameters. (Gensch et al. 2009) therefore conducted a detailed study to analyse the saving potential with regard to these parameters. They therefore took into account

- different electricity and hot water generation systems of four different European countries (Germany, France, Spain and Sweden),
- differences in pipe lengths and insulation,
- five dishwasher types (models) with different technology.

The main results are:

- It is not possible to draw general conclusions with regard to possible environmental advantages of hot water connection of dishwashers – the conclusions are only valid under certain framework conditions.
- The savings in electricity consumption vary according to the technology used in the dishwashers. The relative savings lie between -18% and -44% (corresponding 0.14 to 0.52 kWh/cycle)
- The environmental benefit differences between the type of electricity and warm water generation (e.g. green electricity or not, country specific differences) are bigger than the environmental benefit differences between cold or hot water connection of the dishwasher.
- The saving potential for GWP and primary energy consumption depends on
    - The type of electricity generation: For example, if the electricity generation has a low GWP (as in France and Sweden as they have a high share of nuclear power), the hot water connection only leads to savings in GWP if
        - 1) the dishwashers are not otherwise optimised, e.g. by design options like heat exchanger or adsorption drying technology
        - 2) with a water stub line of at most 5 m and
        - 3) with solar thermic warm water generation.

- The type of warm water generation: in Germany the hot water connection results in savings in GWP in all scenarios if the warm water is generated by solar thermic or biomass generation.
- Dishwasher technology: if the dishwasher already includes other energy saving technologies (e.g. heat exchanger, adsorption technology), further savings are smaller compared to less optimised dishwashers.
- Length and insulation of the water stub line: the difference in the saving potential (GWP, primary energy consumption) between stub lines of zero and of 10 meter lies between 5 and 13% (depending on indicator and dishwasher technology).

The following examples illustrate the differences between the electricity and warm water generation and the dishwasher type (green: decrease of GWP of more than 10%, red: increase of GWP of more than 10%).

Example 1 (high GWP savings): Germany, conventional electricity generation, medium pipe length (5 m)

Table 6-2: Relative GWP through hot water connection (example 1)

Type of warm water generation	District heating	Natural gas	Oil	Biomass	Solar thermic (combined with natural gas)
Dishwasher Type "M1 (GV640)"	88%	92%	97%	76%	80%
Dishwasher Type "EuP reference (GV 600)"	77%	82%	89%	62%	67%
Dishwasher "M3" (with zeolite technology)	96%	101%	107%	82%	88%

Source: (Gensch et al. 2009)

Example 2 (low GWP savings): Sweden, conventional electricity generation, medium pipe length (5 m)

Table 6-3: Relative GWP through hot water connection (example 2)

Type of warm water generation	District heating	Oil	Biomass	Solar thermic (combined with biomass)
Dishwasher Type "M1 (GV640)"	209%	240%	99%	90%
Dishwasher Type "EuP reference (GV 600)"	235%	276%	92%	80%
Dishwasher "M3" (with zeolite technology)	239%	276%	110%	99%

Source: (Gensch et al. 2009)

It is therefore questionable to encourage consumers in general to use hot fill for dishwasher use.

6.1.4. Durability

6.1.4.1. Cycle time and life time of dishwashers

It is assumed that longer program cycle times do not lead to shorter life time of a dishwasher. Longer operating hours of motors do not lead to more wear and tear in case of brushless motors which are currently the most used motor technology. In addition, the motor usually does not work in full power mode for most of the time, in eco programmes the spray arms are used alternatingly and the reached temperatures are lower. All these aspects lead to lower strain on the parts of a dishwasher. Moreover, a longer cycle time is usually related to a longer drying phase where the machine is basically waiting for the dishes to dry and not in operating mode.

6.1.4.2. More durable materials/products

Durability is not included as a design option as the necessary calculations would be too complex to be performed by the EcoReport tool, taking into account not only alterations at current dishwashers but also forecasting future efficiency gains. Environmental impacts of life time extension strongly depend on the energy consumption of future dishwashers. Therefore this aspect is discussed based on existing research.

(Ardente & Talens Peirò 2015) recently published a report on the benefits and costs/impacts of options for different potential material efficiency requirements for dishwashers.

(Ardente & Talens Peirò 2015) first conduct a literature review on the environmental analysis of dishwashers. The main conclusion drawn are that design for disassembly and recycling is very important in case of dishwashers as the possibility of the extraction of valuable materials (mainly copper and PCBs containing other precious metals) differs significantly depending on the design of the dishwasher.

Secondly, they conduct an LCA and analyse the environmental impacts of four life cycle stages with respect to 13 impact categories. For the use phase the electricity and water consumption are taken into account, but not the detergent, rinsing agent and regeneration salt. The use phase has the highest impact in 10 out of the impact categories. The production of materials dominates the categories “abiotic depletion”, “freshwater eutrophication” and “ecotoxicity”. The disposal mainly contributes only to freshwater eutrophication due to the impact of landfilling plastic parts. The manufacturing process has only very low environmental impacts (below 1% in all categories).

Finally, they apply the REAPro method to dishwashers (Resource Efficiency Assessment of Products, see (Ardente & Mathieux 2012). Two end-of-life scenarios are distinguished: scenario 1 is a shredding based scenario with little manual treatment, scenario 2 consists of a preliminary manual disassembly followed by one or two shredding phases (combined treatment). The two scenarios are compared with regard to several indicators:

- Reusability/Recyclability/Recoverability index (in mass): No relevant differences between the scenarios with regard to these indicators were found. In both cases the majority of material losses results from landfill of bitumen and wood parts and to the partial recovery of ferrous metals.
- Reusability/Recyclability/Energy Recoverability benefit rate indexes: only with regard to the recyclability benefit rate relevant differences between the scenarios were found. Due to the higher recycling rates of some precious metals and copper in scenario 2 the impacts on abiotic resource depletion and ecotoxicity are significantly lower.
- Recycled content rate / recycled content benefit index: The main conclusion is that the use of recycled plastics parts for the manufacturing of a dishwasher has low relevance in its environmental impact from a life cycle perspective.

With regard to the use of hazardous substances PCBs and LCD screens are seen as relevant components.

(Ardente & Talens Peirò 2015) also calculate a durability index: the savings through a life time extension of certain dishwasher by 1 to 4 years is calculated, taking into account differences in energy efficiency of the new appliance (the use of a new possibly more energy efficient appliance is postponed by the life time extension). The most important findings are:

- With regard to the impact categories that are mostly influenced by the material production (abiotic resource depletion, freshwater eutrophication and ecotoxicity) the extension of the life time saves to 30% of the impacts. The improvement is only slightly influenced by the change in efficiency of the new dishwasher.
- The possible savings with regard to the other impact categories strongly depend on the efficiency of the new appliance. With regard to the GWP, the impact of life cycle extension is ambivalent. If the new dishwasher is more than 10% more efficient than the old one the GWP increases through life time extension. If the new dishwasher has the same energy efficiency than the old one, the GWP can be reduced by 3%.

- This means, with regard to the environmental impacts dominated by the use phase it depends on the future development of the energy efficiency if it is beneficial to extend the life time of a dishwasher. For the other three impact categories assessed the life time extension is beneficial in any case.
- The components most frequently subject to failures are identified to be the motor (circulation and drain pump), the piping equipment, electric and electronics and structural and interior parts.

Finally (Ardente & Talens Peirò 2015) identify and address potential measures for resource efficiency of dishwashers. With regard to durability these are measures to facilitate reparability, extended product warranties or better information for after sales service providers.

It has to be noted that (Ardente & Talens Peirò 2015) have based their investigation partly on input from the previous study in Lot 14. The BoM has changed as can be seen in Table 5-2 and the energy consumption and lifetime of the dishwasher 'to be replaced' is also different.

- Operating time: 12 years (currently assumed to be 12.5 years)
- Energy consumption during use: 233 kWh/year (currently assumed to be 272 kWh/year)

Especially the difference in BoM and the energy consumption could alter the conclusions. This has to be taken into account when interpreting the results.

6.1.5. Selection of combinations of design options

The choice of combinations of single design options is explained in detail in section 6.4.1. Basically an analysis of the single design options based on the simplified payback period and the environmental impacts is done before the combinations are chosen. The combination of the design options is considered as a second degree of interaction between the single design options. When implementing multiple design options in the same dishwasher, the resulting environmental improvement is expected to be smaller than the sum of the environmental improvements per individual option. In other words, if a dishwasher has been already improved with one design option, every consequent design option will only realize a part of its individual potential. This is the reason why the energy savings and the costs are not the direct sum of the single design options that the combination consists of.

For a better overview in the document, the single design options are discussed together with their combinations in the tables from Table 6-4 to Table 6-7

The following combinations were identified as not possible:

- heat pump technology with adsorption drying
- heat pump technology with moderate increase of programme duration (as the cycle time with heat pump is already quite long it is not seen beneficial to further increase the programme duration)
  Water tank condenser or automatic door opening with adsorption drying: all three options are alternative systems to improve the drying efficiency and partly recuperate the heat contained in the steam. The DW can either condense the water at the cold surface of the water tank and drain or it can open the door to let the steam escape from the appliance or it can use the adsorption drying to efficiently use the hot and humid air. In case of the adsorption drying system the steam is led through the adsorption material and the saving results from the adsorption energy. If there were a water tank condenser or automatic door opening, there would be no steam available to go through the adsorption system anymore
- hot fill in combination with adsorption drying might only bring benefits for high temperature programmes
- hot fill in combination with a water tank for better drying does not bring benefits as the water in the tank should be cold to enhance condensation.

The changes of the combinations compared to the single design options have been derived as follows:

- The saving potential of the combos is estimated to be lower than the sum of the saving potentials of the single design options,
- The changes in material composition, the additional manufacturing costs and changes in maintenance and repair are assumed to be the sum of the changes of the single design options.
  It is assumed that the combinations of options do not result in changes in detergent consumption and life time.

The assumptions regarding the saving potential, the material composition, the manufacturing and the maintenance and repair costs of both single and combined design options are outlined in Table 6-4 and Table 6-6 (for BC 1 and BC2 respectively).

The resulting purchase prices and absolute values of the energy and water consumption are then outlined in Table 6-5 and Table 6-7 (for BC 1 and BC2 respectively).

Table 6-4: Selected design options (BAT) and estimation of alterations compared to the Base Case 1 (13 ps)

Improvement options BAT (NOTE: new numbering)	Alterations compared to BC 1 (%)						
	Energy consumption (Eco programme/ Real-life)	Water consumption (Eco programme/ Real-life)	Deter-gent con-sumption	Lifetime	Main changes in material composition	Manufacturing costs	Mainte-nance and repair costs
Base Case 1 (standard, 13 ps)	**0.96 kWh/cycle** (Eco) **1.08 kWh/cycle** (Re-al-life)	**9.8 liter/cycle** (Eco) **10.9 liter/cycle** (Real-life)	**20 g**	**12.5 years**	**n.a.**	**135 €**	**15 €**
Single design options							
D1: Heat exchanger for pre-warming incoming water and fostering the condensation in the drying phase	- 0.12 kWh (=-13%) - 13%*	n.a.	n.a.	n.a.	+ 0.5 kg PP	+8 € (water tank)	n.a.
D2: improved drying through automatic door opening system	- 0.1 kWh (=-10%) - 10%*	n.a.	n.a.	n.a.	Negligible	+5 € (special door lock with spacing actor)	n.a.
D3: improved drying through adsorption technology	- 0.12 kWh (=-13%) -13%*	n.a.	n.a.	n.a.	+ 1.3 kg zeolite + 1.5 kg steel + 0.25 kg plastics (PP)	+25 € (zeolite + tank + fan+ heating element)	n.a.
D4: Fan for better air circulation	- 0.14 (=-15%) -15%*	n.a.	n.a.	n.a.	Negligible	+5 €	n.a.
D5: moderate increase of programme duration	- 0.19 kWh (=-20%) -20% (only in eco programme)	n.a.	n.a.	n.a.***	n.a.	0 €	n.a.
D6: Heat pump with common refrigerant (R134a)****	- 0.4 kWh (=-42%) -42%*	+ 2.2 L/cycle (= +23%) +23%*	n.a.	n.a.	+ 200 g R134a + 3.5 kg plastics + 3,0 kg copper + 9.5 kg steel	+100 € (compressor, 2 heat exchanger, phase change material, fan, control)	+5 €

Improvement options BAT (NOTE: new numbering)	Alterations compared to BC 1 (%)						
	Energy consumption (Eco programme/ Real-life)	Water consumption (Eco programme/ Real-life)	Deter-gent con-sumption	Lifetime	Main changes in material composition	Manufacturing costs	Mainte-nance and repair costs
D7: advanced sensor technology	0% -11%**	0% - 10%**	n.a.	n.a.	Negligible	+5 € (digital pressure sensor, digital tempera-ture sensor)	n.a.
D8: consumer feedback mechanisms	n.a. shift in programme choice: +10% eco programme -5% normal 45-55°C -5% normal 60-65°C	n.a. like for energy con-sumption	n.a.	n.a.	Negligible	+5 € (sensors + display ele-ments)	n.a.
Combinations of single design options							
C1= D4 + D2 (fan + door opener)	-21%*	n.a.	n.a.	n.a.	Negligible	+10 €	n.a.
C2 = D5 + D4 + D7 + D2 (in-creased programme duration + fan+ + advanced sensor technology + door opener)	-25% eco / -22%*	n.a.	n.a.	n.a.	Negligible	+ 15 €	n.a.
C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)	-26%*	n.a.	n.a.	n.a.	+ 0.5 kg PP	+ 18 €	n.a.
C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)	-30% eco / -28%*	n.a.	n.a.	n.a.	+ 0.5 kg PP	+ 23 €	n.a.
C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technolo-gy + door opener + heat exchanger + consumer feedback mechanisms)	-30% eco / -28%* + shift in programme choice	n.a.	n.a.	n.a.	+ 0.5 kg PP	+ 28 €	n.a.
C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration +	- 35% eco / - 30%*	n.a.	n.a.	n.a.	+ 1.3 kg zeolite +1.5 kg steel	+ 40 €	n.a.

Improvement options BAT (NOTE: new numbering)	Alterations compared to BC 1 (%)						
	Energy consumption (Eco programme/ Real-life)	Water consumption (Eco programme/ Real-life)	Deter-gent con-sumption	Lifetime	Main changes in material composition	Manufacturing costs	Mainte-nance and repair costs
fan + advanced sensor technology + consumer information mechanisms + adsorption drying technology)	+ shift in programme choice				+0.25 kg plastics (PP)		
C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor tech-nology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)	- 60%* + shift in programme choice	+23%	n.a.	n.a.	+ 0.5 kg PP + 200 g refrigerant + 3.5 kg plastics (PP) + 3.0 kg copper + 9.5 kg steel	+ 128 €	+ 5 €

n.a. not affected;

* in all programmes except 'short' and 'rinse&hold': 0%

** all programmes except Eco-programme (usually sensors not active not increase reproducibility)

*** see paragraph on cycle time and life time of dishwashers (section 6.1.4.1)

**** heat pump dishwashers: a) the data on material composition is based on direct input by stakeholders, b) costs for maintenance and repair: following the same reasoning of 10% of dishwashers to be repaired, but now at 200 euro instead of 150 euro, thus +5 euro for every dishwasher.

Table 6-5 shows the absolute values of the energy and water consumption for the base case and the selected design options. Both the values for the Eco-programme and the real-life conditions are shown. The variation in purchase price is also shown.

Table 6-5: Overview of the purchase prices and absolute values of the energy and water consumption for Base Case 1 (13 ps) and the selected design options

	Purchase Price	Eco programme		Real-life usage	
		Energy consumption	Water consumption	Energy consumption	Water Consumption
Unit	Euro	kWh/cycle	L/cycle	kWh/cycle	L/cycle
Base Case 1 (13 ps)	**526**	**0.96**	**9.8**	**1.08**	**10.9**
Single design options					
D1: heat exchanger	557	0.84	9.8	0.96	10.9
D2: improved drying through automatic door opening system	545	0.86	9.8	0.98	10.9
D3: improved drying through adsorption technology	623	0.84	9.8	0.96	10.9
D4: Fan for better air circulation	545	0.82	9.8	0.94	10.9
D5: moderate increase of programme duration	526	0.77	9.8	1.04	10.9
D6: Heat pump with common refrigerant (R134a)	915	0.56	12.0	0.67	13.1
D7: advanced sensor technology	545	0.96	9.8	0.99	10.0
D8: consumer feedback mechanisms	545	0.96	9.8	1.04	10.6
Combinations of single design options					
C1= D4 + D2 (fan + door opener)	565	0.76	9.8	0.88	10.9
C2 = D5 + D4 + D7 + D2 (increased programme duration + fan + advanced sensor technology + door opener)	584	0.72	9.8	0.86	10.9
C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)	596	0.71	9.8	0.83	10.9
C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)	615	0.67	9.8	0.80	10.9
C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door	635	0.67	9.8	0.77	10.6

	Purchase Price	Eco programme		Real-life usage	
		Energy consumption	Water consumption	Energy consumption	Water Consumption
Unit	Euro	kWh/cycle	L/cycle	kWh/cycle	L/cycle
opener + heat exchanger + consumer feedback mechanisms)					
C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan + advanced sensor technology + consumer information mechanisms + adsorption drying technology)	682	0.62	9.8	0.74	10.6
C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)	1024	0.38	12.0	0.47	12.7

Table 6-6: Selected design options (BAT) and estimation of alterations compared to the Base Case 2 (10 ps)

Improvement options BAT (NOTE: new numbering)	Alterations compared to BC 2 (%)						
	Energy consumption (Eco programme/ Real-life)	Water consumption (Eco programme/ Real-life)	Deter-gent con-sumption	Lifetime	Main changes in material composition	Manufacturing costs	Maintenance and repair costs
Base Case 2 (10 ps)	**0.87 kWh/cycle** (Eco) **0.97 kWh/cycle** (Real-life)	**10.3 liter /cycle** (Eco) **12.1 liter/cycle** (real-life)	**20 g**	**12.5 years**	**n.a.**	**133 €**	**15 €**
Single design options							
D1: Heat exchanger for pre-warming incoming water and fostering the condensation in the drying phase	-13% -13%*	n.a.	n.a.	n.a.	0.4 kg PP	+8 €uro	n.a.
D2: improved drying through automatic door opening system	-10% - 10%*	n.a.	n.a.	n.a.	Negligible	+5 €	n.a.
D3: improved drying through adsorption technology	- 0,1 kWh (=-11%) -11%*	n.a.	n.a.	n.a.	+ 1.0 kg zeolite + 1.2 kg steel + 0.2 kg plastics (PP)	+25 €	n.a.
D4: Fan for better air circulation	-15% -15%*	n.a.	n.a.	n.a.	Negligible	+5 €	n.a.
D5: moderate increase of programme duration	-20% -20% (only in eco programme)	n.a.	n.a.	n.a.***	n.a.	0 €	n.a.
D6: Heat pump with common refriger-ant (R134a)****	- 42% -42%*	+23% +23%	n.a.	n.a.	+ 160 g R134a + 2.8 kg plastics + 2.4 kg copper + 7.6 kg steel	+100 €	+5 €
D7: advanced sensor technology	0% -11%**	0% -10%**	n.a.	n.a.	negligible	+5 €	n.a.
D8: consumer feedback mechanisms	n.a. shift in programme	n.a. like for energy	n.a.	n.a.	negligible	+5 €	n.a.

Improvement options BAT (NOTE: new numbering)	Alterations compared to BC 2 (%)						
	Energy consumption (Eco programme/ Real-life)	Water consumption (Eco programme/ Real-life)	Deter-gent con-sumption	Lifetime	Main changes in material composition	Manufacturing costs	Maintenance and repair costs
	choice: +10% eco programme -5% normal 45-55°C -5% normal 60-65°C	consumption					
Combinations of single design options							
C1= D4 + D2 (fan + door opener)	-21%*	n.a.	n.a.	n.a.	Negligible	+ 10 €	n.a.
C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)	-25% eco / -22%*	n.a.	n.a.	n.a.	Negligible	+ 15 €	n.a.
C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)	-26%*	n.a.	n.a.	n.a.	+ 0.4 kg PP	+ 18 €	n.a.
C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)	-30% eco / -28%*	n.a.	n.a.	n.a.	+ 0.4 kg PP	+ 23 €	n.a.
C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)	-30% eco / -28%* + shift in pro-gramme choice	n.a.	n.a.	n.a.	+ 0.4 kg PP	+ 28 €	n.a.
C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + consumer information mechanisms + adsorption drying technology)	- 35% eco / - 30 %* + shift in pro-gramme choice	n.a.	n.a.	n.a.	+ 1.0 kg zeolite +1.2 kg steel +0.2 kg plastics	+ 40 €	n.a.
C6b = D4 + D7 + D2 + D1 + D8 + D6	-60%* + shift in program-	+23%	n.a.	n.a.	+ 0.4 kg PP + 160 g refrigerant	+ 128 €	+ 5 €

Improvement options BAT (NOTE: new numbering)	Alterations compared to BC 2 (%)						
	Energy consumption (Eco programme/ Real-life)	Water consumption (Eco programme/ Real-life)	Deter-gent con-sumption	Lifetime	Main changes in material composition	Manufacturing costs	Maintenance and repair costs
(fan+ advanced sensor technology + door opener + heat exchanger + con-sumer feedback mechanisms +heat pump)	me choice				+ 2.8 kg plastics + 2.4 kg copper + 7.6 kg steel		

n.a. not affected;

* in all programmes except ‘short’ and ‘rinse & hold’: 0%

** all programmes except Eco-programme (usually sensors not active not increase reproducibility)

*** see paragraph on cycle time and life time of dishwashers (section 6.1.4.1)

**** heat pump dishwashers: a) the data on material composition is based on direct input by stakeholders (reduced by 20%), b) costs for maintenance and repair: following the same reasoning of 10% of dishwashers to be repaired, but now at 200 euro instead of 150 euro, thus +5 euro for every dishwasher.

Table 6-7: Overview of the purchase prices and absolute values of the energy and water consumption for Base Case 2 (10 ps) and the selected design options

	Purchase Price	Eco programme		Real-life usage	
		Energy consumption	Water consump-tion	Energy consumption	Water Consump-tion
Unit	Euro	kWh/cycle	L/cycle	kWh/cycle	L/cycle
Base Case 2 (10 ps)	**516**	**0.87**	**10.3**	**0.97**	**12.1**
Single design options					
D1: heat exchanger	547	0.76	10.3	0.86	12.1
D2: improved drying through automatic door opening system	535	0.78	10.3	0.88	12.1
D3: improved drying through adsorption technology	613	0.77	10.3	0.87	12.1
D4: Fan for better air circulation	535	0.75	10.3	0.84	12.1
D5: moderate increase of programme duration	516	0.70	10.3	0.93	12.1
D6: Heat pump with common refrigerant (R134a)	905	0.51	12.6	0.61	14.6
D7: advanced sensor technology	535	0.87	10.3	0.88	11.1
D8: consumer feedback mechanisms	535	0.87	10.3	0.94	11.7
Combinations of single design options					
C1= D4 + D2 (fan + door opener)	555	0.69	10.3	0.79	12.1
C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)	574	0.66	10.3	0.77	12.1
C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)	586	0.65	10.3	0.74	12.1
C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)	605	0.61	10.3	0.72	12.1
C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)	625	0.61	10.3	0.70	11.7
C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + consumer information mechanisms + adsorption drying technology)	672	0.57	10.3	0.67	11.7

	Purchase Price	Eco programme		Real-life usage	
		Energy consumption	Water consump-tion	Energy consumption	Water Consump-tion
Unit	Euro	kWh/cycle	L/cycle	kWh/cycle	L/cycle
C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)	1014	0.35	12.6	0.43	14.1

6.1.6. Best Not Yet Available (BNAT) design options

Best Not yet Available Technologies (BNAT) have to be identified and their potential to reduce environmental impacts has to be estimated. So far the following technological options have been identified as possible in principle but so far not yet installed in any dishwasher on the market.

6.1.6.1. Heat pump with alternative refrigerant

Currently the heat pump installed in a dishwasher works with R134a (tetrafluroroethane) as refrigerant. R134a has a high specific global warming potential (see Table 6-8). The choice of this refrigerant is because of its excellent technical performance. However, in principle it is possible to construct heat pumps with other refrigerants with lower environmental damage potential (lower GWP) but most likely lower technical performance This development already takes place in case of tumble dryers, where first appliances with R290 (propane) as refrigerant are on the market. A challenge that has to be considered is that R290 is flammable. Therefore due to safety issues the amount of R290 is limited to 150 g per appliance. Table 6-8 compares the global warming potential of currently used refrigerant (R134a) with the possible substitute (R290).

Table 6-8: Global Warming Potential (GWP) of refrigerants used in heat pumps

	Used amount per dish-washer	Specific GWP (IPCC 2007; UNEP 2014)	Total GWP in case of 100% loss per dish-washer
	g	kg CO_2e/kg	kg CO_2e
R134a (tetrafluroroethane)	150 – 200	1 430	215 – 286
R290 (propane)	150	3.3	0.5

6.1.6.2. Automatic detergent dosage system

Beko presented on the trade fair “IFA” in September 2015 a prototype of a dishwasher with automatic detergent dosage system. One advantage could be a reduction in detergent consumption, if under real life conditions people tend to use too much detergent per dishwashing cycle. However, there could also be a saving potential in electricity consumption which results from the fact that most people (60%, see section 3.1.7.1) use multifunctional tabs (instead of mono-tabs or powder and separate dosing of rinsing agent and regeneration salt).

Besides detergent these tabs also include rinsing agent, which is used in the end of the programme to enable proper drying of the crockery without stains. When using a multifunctional tab instead of separate dosing of rinsing agent, less rinsing agent is available for the drying process at the end of the programme. Dishwashers therefore detect an empty rinsing agent container and subsequently modify the programme to ensure proper drying with less rinsing agent. Usually this is connected to higher temperatures during the drying phase which leads to higher electricity consumption compared to the standard electricity consumption measured under standard conditions (which include separate dosing of detergent, rinsing agent and regeneration salt).

If automatic detergent dosage is installed, also the rinsing agent is dosed separately and the necessity to ensure a proper drying through higher temperatures is not given and this additional electricity consumption under real life conditions could be saved.

6.1.6.3. Cross flow heat exchanger (with storage tank)

This option is another way to recover heat from the waste water stream and can be seen as improvement to the heat exchanger which is implemented in current dishwashers as BAT (see Table 6-1). It was already mentioned in the GEA study (GEA 1995) and Lot 14 (ENEA/ISIS 2007b), however still not applied to any machine on the market (see also section 4.1.4).

The waste water and the fresh water are passed through a cross flow heat exchanger. The fresh water flows to a buffer tank to prevent mixing of fresh and waste water in the machine. It is essential that the waste and fresh water flow in opposite directions thus theoretically most energy from the waste water can be recovered. This option is supposed to be not applicable to machines of 9 - 10 ps due to the lack of space. (Paepe et al. 2003) measured and calculated the possible heat recovery under various conditions. Depending on the temperature of the water leaving the dishwasher and the flow rate of the cold water the heat recovery lies between 75 kJ and 365 kJ (corresponding to 0.02 and 0.1 kWh). Regarding the costs (Paepe et al. 2003) assume installation costs of 40 €, which mainly depends on the costs for a 15 m copper tube (25 €). This figure would need to be updated with current cost data.

6.1.7. Modelling aspects

The additional materials of the design options outlined in Table 6-4 and Table 6-6 have been included in the EcoReport tool. The materials were assigned to the following materials of the tool:

- Plastics and PP (polypropylene): Bulk plastics – PP
- Steel: ferrous metals – Stainless 18/8 coil
- R134a: miscellaneous – refrigerant (R134a; HFC; 1430)
- Copper: non-ferrous materials – Cu tube/sheet

For the adsorption material for option D3 no suitable material is available in the EcoReport tool. Therefore the data set "zeolite, powder" of the EcoInvent database (version 3) has been included. The following calculation methods for the indicators were chosen

- Primary energy: total cumulative energy demand (renewable, non-renewable, geothermal, nuclear etc.)
- Electric energy, waste: these indicators accounted for in the EcoReport tool are no input or output parameters of LCA datasets but are corresponding processes are modelled themselves. The resulting inputs and emissions are accounted for in the other impact categories.
- Feedstock energy: no feedstock energy contained in the material.
- GWP: GWP 100 in CO_2-equivalents (using ReCiPe Midpoint)*,
- PM: in PM10-equivalents (using ReCiPe Midpoint)**
- AP: terrestrial acidification in SO_2-equivalents (using ReCiPe Midpoint)**
- VOC: as NMVOC according to (COWI and VHK 2011b)
- Eutrophication: eutrophication potential in PO_4-equivalents (using CML 2001)**
- Water (process, cooling), POP, HMa, PAH and HMw: modelled from the inventory data with the characterisation factors as outlined in (COWI and VHK 2011b).

* equivalent to the characterisation factors as outlined in (COWI and VHK 2011b).
** slightly deviating from MEErP characterisation, but not impacting the results.

6.2. Impacts

6.2.1. Impacts of single design options Base Case 1 (13 place settings)

Figure 6-1 depicts the relative environmental impacts of the single design options compared to Base Case 1 (13 ps). Table 6-9 shows the respective absolute figures of the total environmental impacts of the base case and the single design options. For better comparison, also the decrease (or increase) per option and impact category is given in percentage.

The biggest differences to the base case can be observed in design option 6 (heat pump with R134a). The savings in total energy consumption, hazardous waste, GWP, acidification and VOC emissions are between 17 and 35 %. However the impact in the categories process water, POPs, heavy metals (both to air and to water) increase significantly by 18 to 72 %.

Option 3 (adsorption technology) is connected with some significant increase in the impact categories cooling water (+6 %) and heavy metal (both to air and to water: +7 % and +19 % respectively), which can be mainly attributed to the zeolite necessary for this option. Further calculations show, that the increase in cooling water and about half of the increase of Heavy Metal emissions to water can be attributed to the inclusion of zeolite. Nevertheless the option leads to savings or only insignificant changes in all other impact categories.

For all other single design options, only savings or insignificant changes in the impacts occur. The variation in impacts stays below 15%. The design options mainly affect the total energy consumption, the electricity consumption, the GWP, the acidification potential and the emissions to air of VOCs.

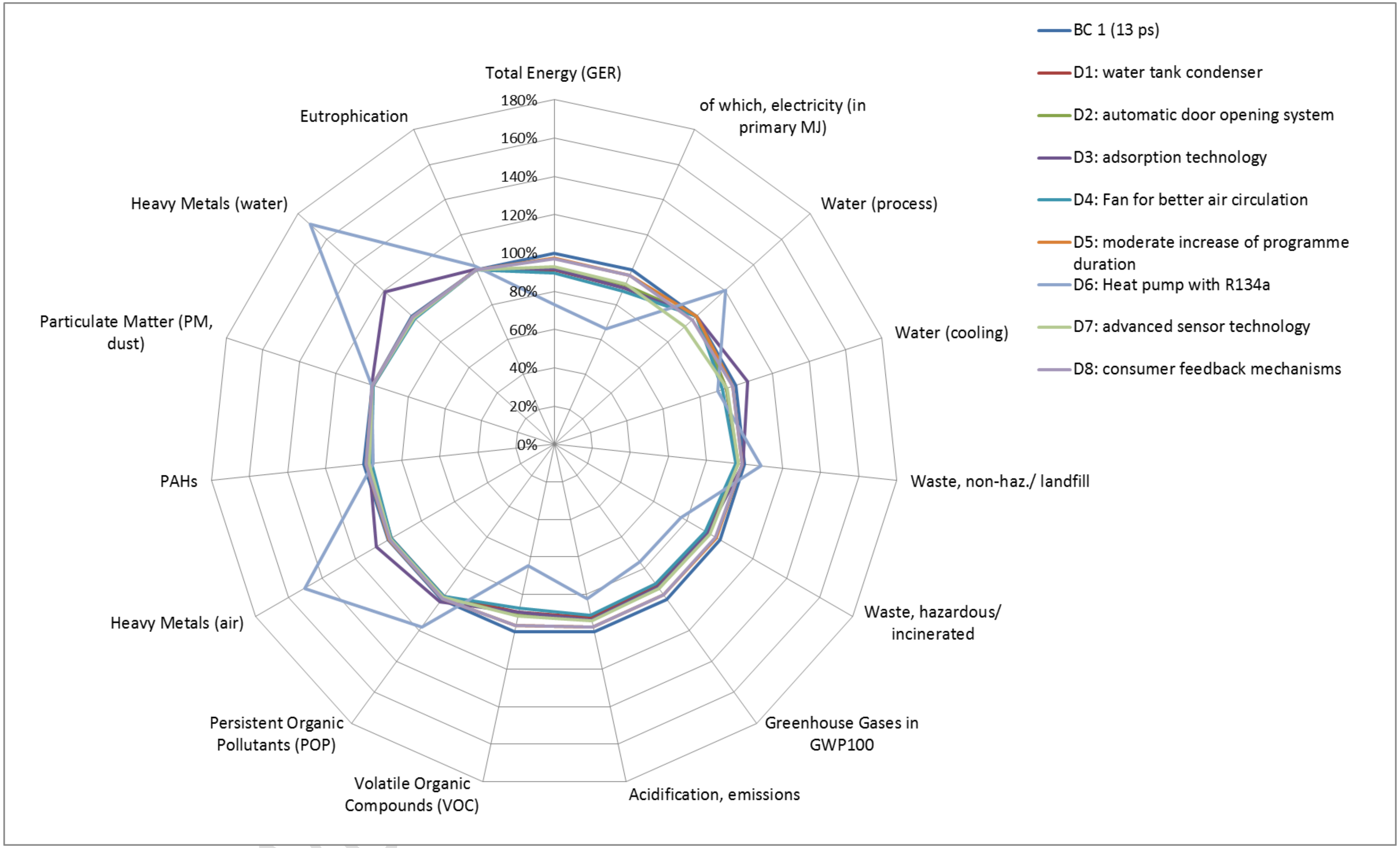

Figure 6-1: Relative environmental impacts of the single design options compared to the standard Base Case 1 (13 ps)

Table 6-9: Environmental impacts of a standard household dishwasher with 13 place settings (Base Case 1) and its single design options

		BC 1 (13 ps)	D1: water tank condenser	D2: automat-ic door opening system	D3: adsorp-tion tech-nology	D4: fan for better air circula-tion	D5: moderate increase of pro-gramme duration	D6: heat pump (R134a)	D7: advanced sensor technolo-gy	D8: consumer feedback mecha-nisms
Resources & waste										
Total Energy (GER)	MJ	43 681	39 833	40 427	39 988	39 126	42 454	32 003	40 587	42 396
			-9%	-7%	-8%	-10%	-3%	-27%	-7%	-3%
of which, electricity (in primary MJ)	MJ	37 483	33 595	34 229	33 612	32 928	36 256	24 819	34 390	36 199
			-10%	-9%	-10%	-12%	-3%	-34%	-8%	-3%
Water (process)	ltr	54 313	54 315	54 313	54 465	54 313	54 313	65 407	49 984	52 706
			0%	0%	0%	0%	0%	20%	-8%	-3%
Water (cooling)	ltr	2 675	2 528	2 531	2 847	2 473	2 621	2 403	2 538	2 618
			-6%	-5%	6%	-8%	-2%	-10%	-5%	-2%
Waste, non-haz./ landfill	g	50 008	48 054	48 331	49 666	47 661	49 375	54 343	48 412	49 345
			-4%	-3%	-1%	-5%	-1%	9%	-3%	-1%
Waste, hazardous/ incinerated	g	805	745	753	744	733	785	615	756	784
			-7%	-6%	-8%	-9%	-2%	-24%	-6%	-3%
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	1 944	1 779	1 805	1 792	1 749	1 891	1 477	1 812	1 889
			-8%	-7%	-8%	-10%	-3%	-24%	-7%	-3%
Acidification, emissions	g SO2 eq.	9 769	9 038	9 154	9 145	8 908	9 537	8 071	9 184	9 526
			-7%	-6%	-6%	-9%	-2%	-17%	-6%	-2%
Volatile Organic Compounds (VOC)	g	821	733	748	736	719	793	532	752	792
			-11%	-9%	-10%	-12%	-3%	-35%	-8%	-3%
Persistent Organic Pollutants (POP)	ng i-Teq	527	518	519	535	516	524	621	520	524
			-2%	-1%	1%	-2%	-1%	18%	-1%	-1%
Heavy Metals	mg Ni eq.	2 378	2 337	2 345	2 554	2 332	2 366	3 581	2 347	2 365

		BC 1 (13 ps)	D1: water tank condenser	D2: automat-ic door opening system	D3: adsorp-tion tech-nology	D4: fan for better air circula-tion	D5: moderate increase of pro-gramme duration	D6: heat pump (R134a)	D7: advanced sensor technolo-gy	D8: consumer feedback mecha-nisms
			-2%	-1%	7%	-2%	-1%	51%	-1%	-1%
PAHs	mg Ni eq.	256	247	249	249	246	253	244	249	253
			-3%	-3%	-3%	-4%	-1%	-5%	-3%	-1%
Particulate Matter (PM, dust)	g	3 893	3 877	3 880	3 896	3 874	3 888	3 901	3 880	3 887
			0%	0%	0%	0%	0%	0%	0%	0%
Emissions (Water)										
Heavy Metals	mg Hg/20	1 068	1 051	1 054	1 269	1 049	1 063	1 835	1 055	1 063
			-2%	-1%	19%	-2%	0%	72%	-1%	-1%
Eutrophication	g PO4	4 812	4 814	4 811	4 834	4 811	4 812	4 915	4 812	4 812
			0%	0%	0%	0%	0%	2%	0%	0%

6.2.2. Impacts of combinations of design Options Base Case 1 (13 place settings)

Figure 6-2 depicts the relative environmental impacts of the combinations of design options compared to Base Case 1 (13 ps). Table 6-8 shows the respective absolute figures of the total environmental impacts of the base case and the combinations of design options. For better comparison, also the decrease (or increase) per combination and impact category is given in percentage.

All combinations lead to savings in the total primary energy demand of 15% and more. The highest saving comes from combination C6b, which includes the heat pump (-41%).

Combinations C6a and C6b are the only combinations where, besides relevant savings in many impact categories (total energy, hazardous waste, GWP, Acidification, VOC, PAHs) also a relevant increase of impacts in some impact categories occurs.

In case of C6a which includes the design option “adsorption technology” a significant increase takes place in Heavy Metal emissions (to air: +4%, to water + 16%). Compared to the other combinations the decrease in cooling water consumption is much lower (only -5% instead of -11% to -19%). As was already described in the previous section on the single design options, this can partly be attributed to the use of zeolite material in the dishwasher.

In case of C6b, which includes the design option “heat pump” a significant increase takes place in process Water consumption (+17%), POP (+15%) and Heavy Metals (to air: +48%, to water: +69%). As the analysis of the single design options show this can be attributed to the inclusion of extra material for the heat pump in the dishwasher.

For all other combinations (C1 to C5) only savings or non-significant changes of the impacts in all impact categories occur. The impact categories with the highest savings are: total energy consumption (-15% to -22%) and the corresponding electricity consumption, cooling water consumption (-11% to -15%), hazardous waste generation (-13% to -19%), GWP (-14% to -21%), acidification (-13% to -19%) and VOC (-18% to -27%).

Comparing the environmental impacts of the different combinations it can be seen that (with the exception of those impact categories that show an increase in C6a and C6b) the savings increase from C1 to C6b (e.g. total energy from -15% (C1) to – 41% (C6b), similar for electricity, hazardous waste, GWP, acidification, VOC and PAHs). For the impact categories water (cooling), non-hazardous waste, POPs and Heavy Metals (both to air and to water) the increase in savings only takes place from combination C1 to combination C5. In the impact categories PM and eutrophication no significant saving or increase occurs.

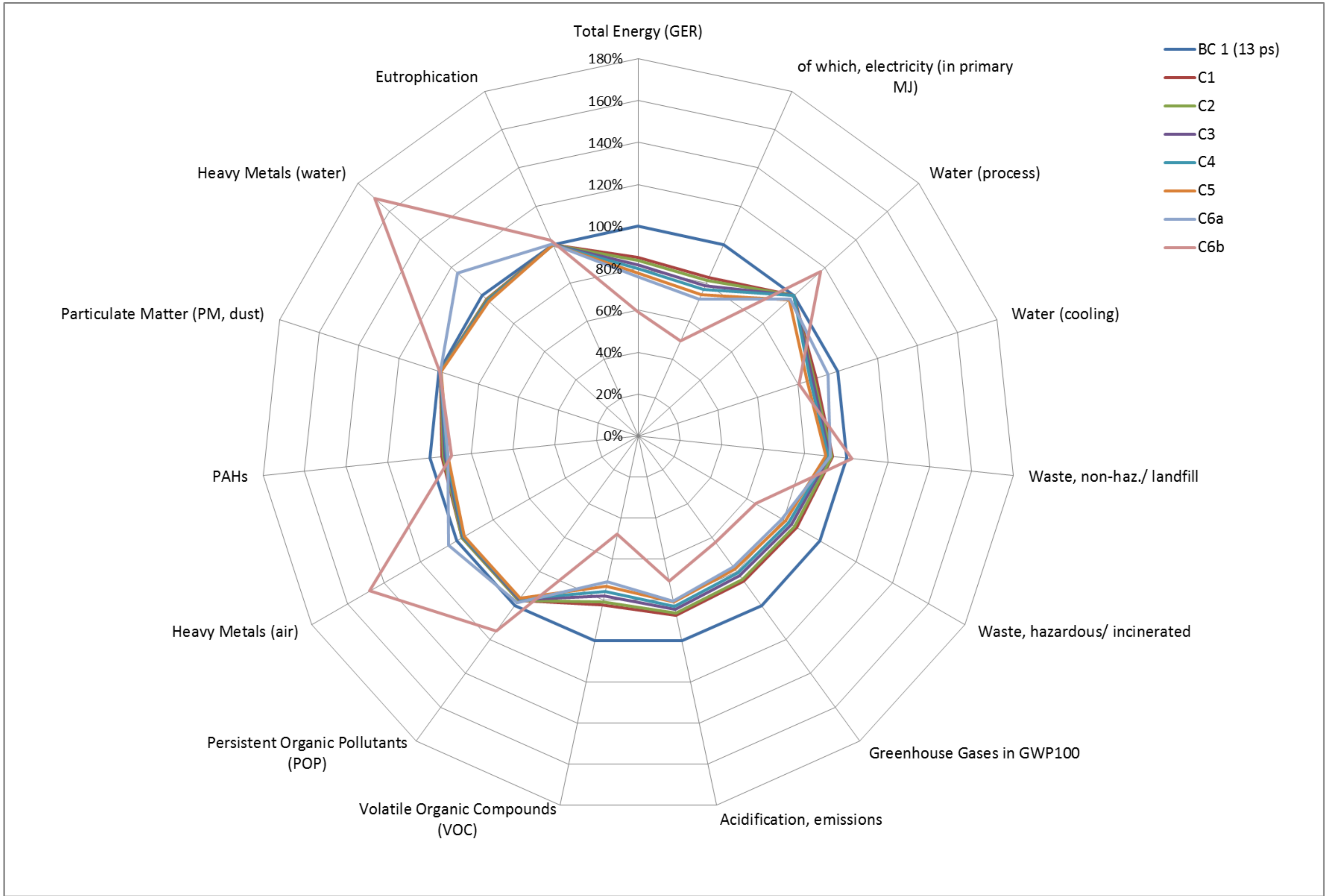

Figure 6-2: Relative environmental impacts of the combinations of design options compared to the standard Base Case 1 (13 ps)

Table 6-10: Environmental impacts of a standard household dishwasher with 13 place settings (Base Case 1) and the combinations of design options

		BC 1 (13 ps)	C1*	C2*	C3*	C4*	C5*	C6a*	C6b*
Resources & waste									
Total Energy (GER)	MJ	43 681	37 148	36 652	35.648	34.903	33.916	33 197	25 886
			-15%	-16%	-18%	-20%	-22%	-24%	-41%
of which, electricity (in primary MJ)	MJ	37 483	30 950	30 454	29.410	28.664	27.678	26 822	18 662
			-17%	-19%	-22%	-24%	-26%	-28%	-50%
Water (process)	ltr	54 313	54 313	54 313	54.315	54.315	52.708	52 858	63 633
			0%	0%	0%	0%	-3%	-3%	17%
Water (cooling)	ltr	2 675	2 385	2 363	2.342	2.309	2.265	2 545	2 154
			-11%	-12%	-12%	-14%	-15%	-5%	-19%
Waste, non-haz./ landfill	g	50 008	46 641	46 386	45.897	45.513	45.004	46 166	51 221
			-7%	-7%	-8%	-9%	-10%	-8%	2%
Waste, hazardous/ incinerated	g	805	702	694	679	668	652	637	520
			-13%	-14%	-16%	-17%	-19%	-21%	-35%
Emissions (Air)									
Greenhouse Gases in GWP100	kg CO2 eq.	1 944	1 665	1 644	1.600	1.568	1.526	1 503	1 215
			-14%	-15%	-18%	-19%	-21%	-23%	-37%
Acidification, emissions	g SO2 eq.	9 769	8 535	8 441	8.248	8.107	7.921	7 863	6 912
			-13%	-14%	-16%	-17%	-19%	-20%	-29%
Volatile Organic Compounds (VOC)	g	821	675	664	640	623	601	584	394
			-18%	-19%	-22%	-24%	-27%	-29%	-52%
Persistent Organic Pollutants (POP)	ng i-Teq	527	512	511	508	506	504	519	606
			-3%	-3%	-4%	-4%	-4%	-2%	15%
Heavy Metals	mg Ni eq.	2 378	2 312	2 307	2.295	2.288	2.278	2 485	3 517
			-3%	-3%	-3%	-4%	-4%	4%	48%
PAHs	mg Ni eq.	256	241	240	238	236	233	233	229
			-6%	-6%	-7%	-8%	-9%	-9%	-10%
Particulate Matter (PM, dust)	g	3 893	3 866	3 864	3.860	3.857	3.854	3 869	3 876
			-1%	-1%	-1%	-1%	-1%	-1%	0%

		BC 1 (13 ps)	C1*	C2*	C3*	C4*	C5*	C6a*	C6b*
Emissions (Water)									
Heavy Metals	mg Hg/20	1 068	1 040	1 038	1.033	1.030	1.025	1 240	1 807
			-3%	-3%	-3%	-4%	-4%	16%	69%
Eutrophication	g PO4	4 812	4 811	4 811	4.813	4.813	4.813	4 833	4 917
			0%	0%	0%	0%	0%	0%	2%

*C1= D4 + D2 (fan + door opener)

C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)

C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)

C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)

C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)

C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + adsorption drying technology + consumer information mechanisms)

C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)

6.2.3. Impacts of single design options Base Case 2 (10 place settings)

Figure 6-3 depicts the relative environmental impacts of the single design options compared to Base Case 2 (10 ps). Table 6-11shows the respective absolute figures of the total environmental impacts of the base case and the eight design options. For better comparison, also the decrease (or increase) per option and impact category is given in percentage.

The changes through the design options for Base Case 2 (10 ps) are very similar to those of Base Case 1 (13 ps): The biggest differences to the base case can be observed in design option 6 (heat pump with R134a). The savings in total energy consumption, hazardous waste, GWP, acidification and VOC emissions are between 18 and 35%. However the impact in the categories Process water, POPs, Heavy Metals (both to air and to water) increase significantly by 15 to 65%.

Option 3 (adsorption technology) is connected with some significant increase in the impact categories cooling water (+6%) and Heavy Metal (both to air and to water: +7% and +17% respectively), which can be mainly attributed to the zeolite necessary for this option. Further calculations showed that the increase in cooling water and about half of the increase of Heavy Metal emissions to water can be attributed to the inclusion of zeolite. Nevertheless the option leads to savings or only insignificant changes in all other impact categories.

For all other single design options, only savings or insignificant changes in the impacts occur. The variation in impacts stays below 15%. The design options mainly affect the total energy consumption, the electricity consumption, the GWP, the Acidification Potential and the emissions to air of VOCs.

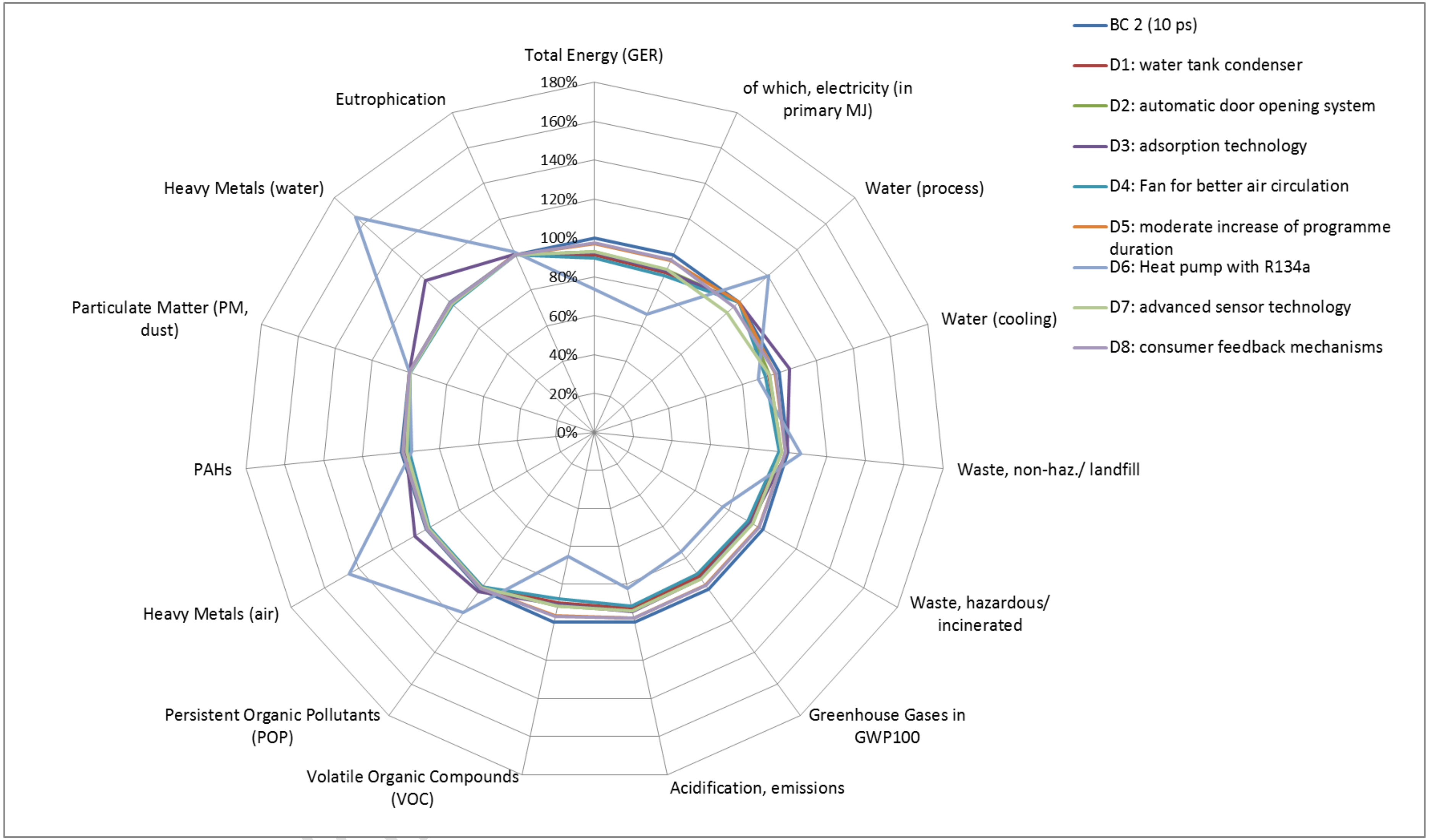

Figure 6-3: Relative environmental impacts of the single design options compared to the slim-line Base Case 2 (10 ps)

Table 6-11: Environmental impacts of a standard household dishwasher with 10 place settings (Base Case 2) and its single design options

		BC 2 (10 ps)	D1: water tank condenser	D2: automatic door opening system	D3: adsorption technology	D4: fan for better air circulation	D5: moderate increase of programme duration	D6: heat pump (R134a)	D7: advanced sensor technology	D8: consumer feedback mechanisms
Resources & waste										
Total Energy (GER)	MJ	39 118	35 719	36 247	36 144	35 100	37 997	28 722	36 356	38 107
			-9%	-7%	-8%	-10%	-3%	-27%	-7%	-3%
of which, electricity (in primary MJ)	MJ	33 432	29 999	30 561	30 316	29 413	32 310	22 241	30 670	32 421
			-10%	-9%	-9%	-12%	-3%	-33%	-8%	-3%
Water (process)	ltr	60 097	60 099	60 097	60 218	60 097	60 097	72 345	55 214	57 913
			0%	0%	0%	0%	0%	20%	-8%	-4%
Water (cooling)	ltr	2 297	2 165	2 169	2 424	2 118	2 247	2 033	2 174	2 252
			-6%	-6%	6%	-8%	-2%	-11%	-5%	-2%
Waste, non-haz./ landfill	g	45 360	43 634	43 881	45 090	43 289	44 782	48 353	43 935	44 838
			-4%	-3%	-1%	-5%	-1%	7%	-3%	-1%
Waste, hazardous/ incinerated	g	714	661	668	665	650	696	545	670	698
			-7%	-6%	-7%	-9%	-2%	-24%	-6%	-2%
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	1 737	1 591	1 614	1 615	1 565	1 689	1 318	1 619	1 694
			-8%	-7%	-7%	-10%	-3%	-24%	-7%	-2%
Acidification, emissions	g SO2 eq.	8 745	8 100	8 203	8 243	7 986	8 533	7 190	8 223	8 554
			-7%	-6%	-6%	-9%	-2%	-18%	-6%	-2%
Volatile Organic Compounds (VOC)	g	735	658	671	667	645	710	480	673	712
			-10%	-9%	-9%	-12%	-3%	-35%	-8%	-3%
Persistent Organic Pollutants (POP)	ng i-Teq	498	490	491	504	489	496	571	492	496
			-2%	-1%	1%	-2%	-1%	15%	-1%	0%
Heavy Metals	mg Ni eq.	2 104	2 068	2 075	2 246	2 063	2 092	3 067	2 076	2 094

		BC 2 (10 ps)	D1: water tank condenser	D2: automatic door opening system	D3: adsorption technology	D4: fan for better air circulation	D5: moderate increase of programme duration	D6: heat pump (R134a)	D7: advanced sensor technology	D8: consumer feedback mechanisms
			-2%	-1%	7%	-2%	-1%	46%	-1%	0%
PAHs	mg Ni eq.	222	214	215	216	212	219	209	215	219
			-4%	-3%	-3%	-4%	-1%	-6%	-3%	-1%
Particulate Matter (PM, dust)	g	3 269	3 256	3 258	3 272	3 253	3 265	3 271	3 258	3 265
			0%	0%	0%	0%	0%	0%	0%	0%
Emissions (Water)										
Heavy Metals	mg Hg/20	946	931	934	1 105	929	941	1 562	934	942
			-2%	-1%	17%	-2%	-1%	65%	-1%	0%
Eutrophication	g PO4	4 849	4 851	4 848	4 867	4 848	4 849	4 936	4 848	4 849
			0%	0%	0%	0%	0%	2%	0%	0%

6.2.4. Impacts of combinations of single design options Base Case 2 (10 place settings)

Figure 6-4 depicts the relative environmental impacts of the combinations of design options compared to Base Case 2 (10 ps). Table 6-12 shows the respective absolute figures of the total environmental impacts of the base case and the combinations of design options. For better comparison, also the decrease (or increase) per combination and impact category is given in percentage.

It can be seen that the changes through the combinations of design options for Base Case 2 (10 ps) are very similar to those of Base Case 1 (13 ps): All combinations lead to savings in the total primary energy demand of 15% and more. The highest saving comes from combination C6b, which includes the heat pump (-40%).

Combinations C6a and C6b are the only combinations where, besides relevant savings in many impact categories (total energy, hazardous waste, GWP, Acidification, VOC, PAHs) also a relevant increase of impacts in some impact categories occurs:

In case of C6a which includes the design option "adsorption technology" a significant increase takes place in Heavy Metal emissions (to air: +4%, to water + 14%). Compared to the other combinations the decrease in cooling water consumption is much lower (only -7% instead of -11% to -21%). As was already described in the previous section on the single design options, this can partly be attributed to the use of zeolite material in the dishwasher.

In case of C6b, which includes the design option "heat pump" a significant increase takes place in process water consumption (+16%), POP (+12%) and Heavy Metals (to air: +43%, to water: +63%). As the analysis of the single design options show this can be attributed to the inclusion of the heat pump in the dishwasher.

For all other combinations (C1 to C5) only savings or non-significant changes of the impacts in all impact categories occur. The impact categories with the highest savings are: total energy consumption (-15% to -22%) and the corresponding electricity consumption, cooling water consumption (-11% to -16%), hazardous waste generation (-13% to -19%), GWP (-14% to -21%), acidification (-12% to -18%) and VOC (-18% to -26%).

As for Base Case 1, it can be seen that (with the exception of those impact categories that show an increase in C6a and C6b) the savings increase from C1 to C6b (e.g. total energy from -15% (C1) to – 40% (C6b), similar for electricity, hazardous waste, GWP, Acidification, VOC and PAHs). For the impact categories water (cooling), non-hazardous waste, POPs and Heavy Metals (both to air and to water) the increase in savings only takes place from combination C1 to combination C5. In the impact categories PM and eutrophication no significant saving or increase occurs.

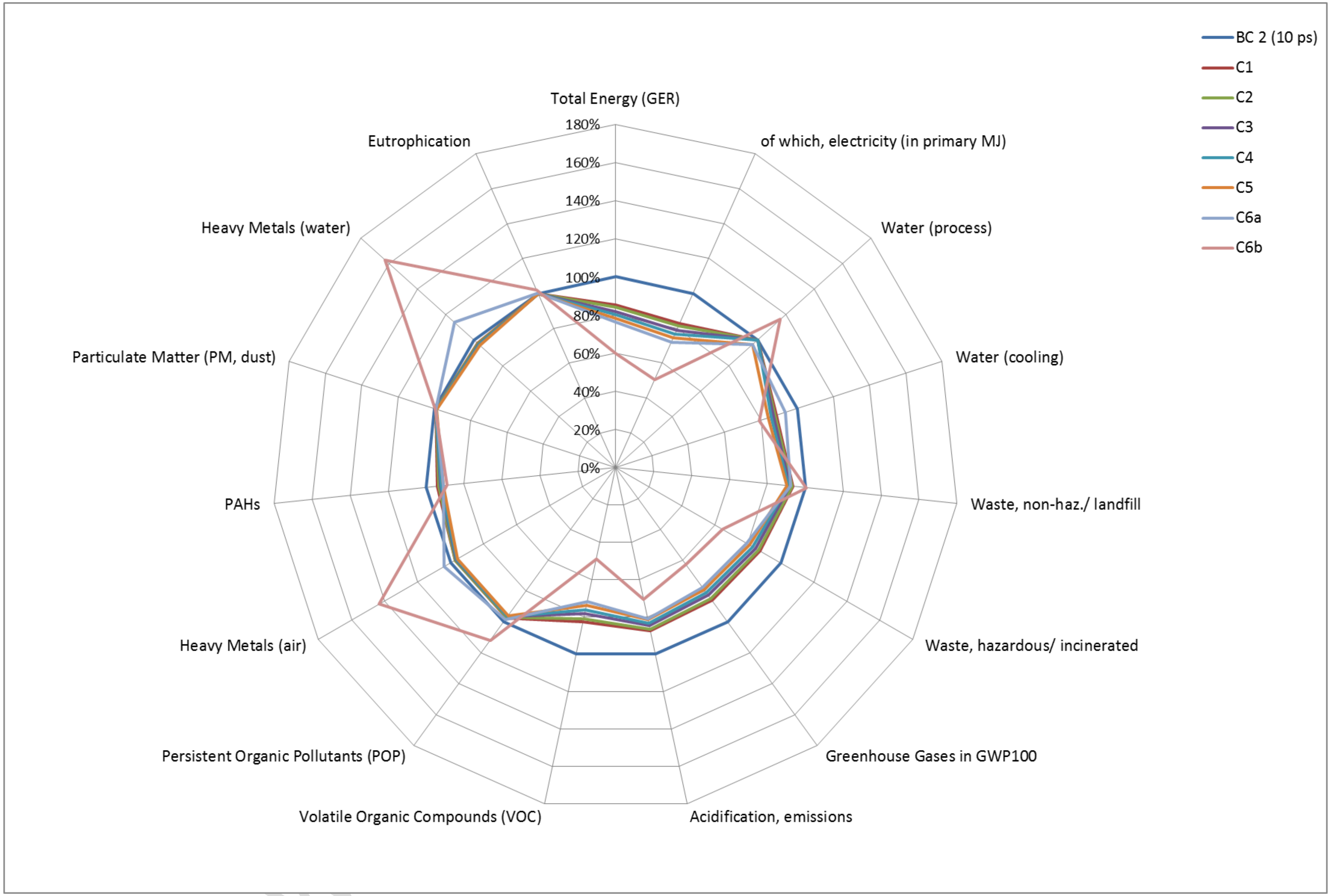

Figure 6-4: Relative environmental impacts of the combinations of design options compared to the slim-line Base Case 2 (10 ps)

Table 6-12: Environmental impacts of a standard household dishwasher with 10 place settings (Base Case 2) and the combinations of design options

		BC 2 (10 ps)	C1*	C2 *	C3*	C4*	C5*	C6a*	C6b*
Resources & waste									
Total Energy (GER)	MJ	39 118	33 354	32 911	32.026	31.365	30.578	29 919	23 368
			-15%	-16%	-18%	-20%	-22%	-24%	-40%
of which, electricity (in primary MJ)	MJ	33 432	27 667	27 224	26.307	25.646	24.860	24 092	16 854
			-17%	-19%	-21%	-23%	-26%	-28%	-50%
Water (process)	ltr	60 097	60 097	60 097	60.099	60.099	57.914	58 034	69 899
			0%	0%	0%	0%	-4%	-3%	16%
Water (cooling)	ltr	2 297	2 041	2 021	2.001	1.971	1.936	2 147	1 814
			-11%	-12%	-13%	-14%	-16%	-7%	-21%
Waste, non-haz./ landfill	g	45 360	42 390	42 161	41.731	41.390	40.984	41 881	45 620
			-7%	-7%	-8%	-9%	-10%	-8%	1%
Waste, hazardous/ incinerated	g	714	623	616	603	592	580	567	462
			-13%	-14%	-16%	-17%	-19%	-21%	-35%
Emissions (Air)									
Greenhouse Gases in GWP100	kg CO2 eq.	1 737	1 491	1 472	1.434	1.405	1.372	1 349	1 090
			-14%	-15%	-17%	-19%	-21%	-22%	-37%
Acidification, emissions	g SO2 eq.	8 745	7 656	7 573	7.403	7.278	7.129	7 067	6 176
			-12%	-13%	-15%	-17%	-18%	-19%	-29%
Volatile Organic Compounds (VOC)	g	735	606	596	576	561	543	528	360
			-18%	-19%	-22%	-24%	-26%	-28%	-51%
Persistent Organic Pollutants (POP)	ng i-Teq	498	485	484	481	480	478	490	558
			-3%	-3%	-3%	-4%	-4%	-2%	12%
Heavy Metals	mg Ni eq.	2 104	2 046	2 041	2.031	2.024	2.016	2 183	3 011
			-3%	-3%	-3%	-4%	-4%	4%	43%
PAHs	mg Ni eq.	222	208	207	205	204	202	202	197
			-6%	-7%	-7%	-8%	-9%	-9%	-11%
Particulate Matter (PM, dust)	g	3 269	3 246	3 244	3.241	3.238	3.235	3 247	3 250
			-1%	-1%	-1%	-1%	-1%	-1%	-1%

		BC 2 (10 ps)	C1*	C2 *	C3*	C4*	C5*	C6a*	C6b*
Emissions (Water)									
Heavy Metals	mg Hg/20	946	921	919	915	912	909	1 078	1 538
			-3%	-3%	-3%	-4%	-4%	14%	63%
Eutrophication	g PO4	4 849	4 848	4 848	4.850	4.850	4.850	4 866	4 938
			0%	0%	0%	0%	0%	0%	2%

*C1= D4 + D2 (fan + door opener)

C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)

C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)

C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)

C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)

C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + adsorption drying technology + consumer information mechanisms)

C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)

6.3. Costs

6.3.1. Life Cycle Costs of design options Base Case 1 (13 place settings)

Table 6-13 shows the life cycle costs of the single design options compared to the life cycle costs of Base Case 1 (13 ps) with reference to a unit of product and the considered lifetime of 12.5 years.

The life cycle costs for all the single design options are very similar. They range from -3% to +6% of the LCC of the base case. The single design option with the lowest LCC is D4 (fan for better air circulation). The single design option with the highest LCC is D6 (heat pump), which mainly results from the high purchase price (73% higher than base case). The high purchase price is to a large extent compensated for by the savings in the electricity costs (electricity costs are reduced by almost 40%

Table 6-14 shows the life cycle costs of the combination of the design options compared to the life cycle costs of the Base Case 1 (13ps) with reference to a unit of product and the considered lifetime of 12.5 years.

The life cycle costs of all combinations are very similar. They range from -6% to +4%. The LCC of all combinations are lower than those of the base case, except the LCC of combination C6b. This can be attributed to the high purchase price due to the inclusion of a heat pump. The purchase price of C6b is almost twice as high as that of the base case. In contrast the electricity costs are reduced by approximately 55% which results in an overall increase of the LCC of only 4% (84 € over the whole life cycle).

The life cycle costs of the combinations C1 to C5 are nearly the same: they vary only between -5% and -6% (maximum absolute difference: 18 € between C2 and C5). From C1 to C5 the purchase price is increasing whereas the electricity costs are decreasing by basically the same amount, resulting in practically identical LCC. The combination with the lowest life cycle costs is C5, including basically all design options except D3 (adsorption technology) and D6 (heat pump) which are the most expensive design options.

By inclusion of D3 (adsorption technology) in C6a or D6 (heat pump) in C6b, which are the most expensive design options, the life cycle costs increase compared to the previous combinations.

Table 6-13: LCC of single design options referred to a unit of product over its lifetime and compared to the base case (BC1)

	BC 1 (13 ps)	D1: water tank condenser	D2: automatic door opening system	D3: adsorption technology	D4: Fan for better air circulation	D5: moderate increase of programme duration	D6: Heat pump (R134a)	D7: advanced sensor technology	D8: consumer feedback mechanisms
in EUR									
Product price	526	557	546	623	546	526	915	546	546
Electricity	789	698	713	698	683	760	488	718	759
Water	152	152	152	152	152	152	182	140	147
Dishwashing detergent	560	560	560	560	560	560	560	560	560
Rinsing Agent	32	32	32	32	32	32	32	32	32
Regeneration salt	67	67	67	67	67	67	67	67	67
Repair & maintenance costs	15	15	15	15	15	15	20	15	15
Total	2 140	2 081	2 084	2 147	2 054	2 111	2 263	2 076	2 125
Relative difference of the LCC with respect to the base case		*-3%*	*-3%*	*0%*	*-4%*	*-1%*	*6%*	*-3%*	*-1%*

Table 6-14: LCC of combinations of design options referred to a unit of product over its lifetime and compared to the base case (BC1)

	BC 1 (13 ps)	C1*	C2*	C3*	C4*	C5*	C6a*	C6b*
in EUR								
Product price	526	565	584	596	615	635	682	1024
Electricity	789	638	626	602	584	562	542	345
Water	152	152	152	152	152	147	147	177
Dishwashing detergent	560	560	560	560	560	560	560	560
Rinsing Agent	32	32	32	32	32	32	32	32
Regeneration salt	67	67	67	67	67	67	67	67
Repair & maintenance costs	15	15	15	15	15	15	15	20
Total	2 140	2 028	2 035	2.023	2.024	2.017	2 044	2 224
Relative difference of the LCC with respect to the base case		*-5%*	*-5%*	-5%	-5%	-6%	*-4%*	*4%*

*C1= D4 + D2 (fan + door opener)

C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)

C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)

C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)

C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)

C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + adsorption drying technology + consumer information mechanisms)

C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)

6.3.2. Life Cycle Costs of design options Base Case 2 (10 place settings)

Table 6-15 shows the life cycle costs of the single design options compared to the life cycle costs of Base Case 2 (10 ps) with reference to a unit of product and the considered lifetime of 12.5 years.

The life cycle costs are very similar. They range from -4% to +8% of the LCC of the base case, which is a slightly bigger range compared to the single design options of Base Case 1. The single design option with the lowest LCC is D4 (fan for better air circulation). The single design option with the highest LCC is D6 (heat pump), which mainly results from the high purchase price (75% higher than base case). The high purchase price is to a large extent compensated for by the savings in the electricity costs (electricity costs are reduced by almost 40%).

Table 6-16 shows the life cycle costs of the combination of the design options compared to the life cycle costs of the Base Case 2 (10ps) with reference to a unit of product and the considered lifetime of 12.5 years.

As in the case of Base Case 1, the life cycle costs of all combinations are very similar. They range from -5% to +7%. The LCC of all combinations are lower than those of the base case, except the LCC of combination C6b. This can be attributed to the high purchase price due to the inclusion of a heat pump. The purchase price of C6b is almost twice as high as that of the base case. In contrast the electricity costs are reduced by approximately 55% which results in an overall increase of the LCC of only 7% (140 € over the whole life cycle) (which is slightly higher than in case of Base Case 1. This might partly be the effect of the lower purchase price of the base case (514 vs. 526 €) and at the same time applying the same absolute cost increase for the heat pump).

The life cycle costs of the combinations C1 to C5 are nearly the same: they vary only between -4% and -5% (maximum absolute difference: 10 € between C2 and C5). From C1 to C5 the purchase price is increasing whereas the electricity costs are decreasing by basically the same amount, resulting in practically identical LCC. The combination with the lowest life cycle costs is C5, including basically all design options except D3 (adsorption technology) and D6 (heat pump) which are the most expensive design options.

By inclusion of D3 (adsorption technology) in C6a or D6 (heat pump) in C6b, which are the most expensive design options, the LCC increase compared to the previous combinations.

Table 6-15: LCC of design options referred to a unit of product over its lifetime and compared to the base case (BC2)

	BC 2 (10 ps)	D1: water tank condenser	D2: automatic door open-ing system	D3: adsorption technology	D4: fan for better air circulation	D5: moderate increase of pro-gramme duration	D6: heat pump (R134a)	D7: advanced sensor technology	D8: consumer feedback mecha-nisms
in EUR									
Product price	516	547	535	613	535	516	905	535	535
Electricity	706	626	640	633	613	680	441	643	683
Water	169	169	169	169	169	169	203	155	163
Dishwashing detergent	560	560	560	560	560	560	560	560	560
Rinsing Agent	32	32	32	32	32	32	32	32	32
Regeneration salt	67	67	67	67	67	67	67	67	67
Repair & maintenance costs	15	15	15	15	15	15	20	15	15
Total	2 064	2 016	2 017	2 089	1 990	2 038	2 227	2 006	2 054
Relative difference of the LCC with respect to the base case		*-2%*	*-2%*	*1%*	*-4%*	*-1%*	*8%*	*-3%*	*-1%*

Table 6-16: LCC of combinations of design options referred to a unit of product over its lifetime and compared to the base case (BC2)

	BC 2 (10 ps)	C1*	C2*	C3*	C4*	C5*	C6a*	C6b*
in EUR								
Product price	516	555	574	586	605	625	672	1014
Electricity	706	573	563	541	526	508	490	316
Water	169	169	169	169	169	163	163	196
Dishwashing detergent	560	560	560	560	560	560	560	560
Rinsing Agent	32	32	32	32	32	32	32	32
Regeneration salt	67	67	67	67	67	67	67	67
Repair & maintenance costs	15	15	15	15	15	15	15	20
Total	2 064	1 970	1 979	1 969	1 973	1 969	1 998	2 204
Relative difference of the LCC with respect to the base case		*-5%*	*-4%*	-5%	-4%	-5%	*-3%*	7%

*C1= D4 + D2 (fan + door opener)

C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)

C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)

C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)

C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)

C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + adsorption drying technology + consumer information mechanisms)

C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms +heat pump)

6.4. Analysis LLCC and BAT

6.4.1. Selection of the combinations of design options

The single design options have been ranked according to their Simple Payback Period (SPP). The SPP has been calculated as follows:

SPP = dPP /dOE

With

dPP: extra investment in purchase price of the design option compared to base case

dOE: reduction in annual operating expense of the design option compared to the base case

Table 6-17 shows the single paypack periods for the design options for Base Case 1 in increasing order (the payback periods for Base Case 2 differ slightly, however the resulting order of the options is the same).

Table 6-17: Single Payback Periods (SPP) of the design options (BC1)

Design option	SPP (years)
D5: moderate increase of programme duration	0.0
D4: Fan for better air circulation	2.3
D7: advanced sensor technology	2.9
D2: automatic door opening system	3.2
D1: water tank condenser	4.3
D8: consumer feedback mechanisms	7.1
D3: adsorption technology	13.5
D6: Heat pump with R134a	18.3

The results show that for the single design options D5 to D8, the initial investment is recovered in a shorter time than the expected lifetime. This means that their estimated SPP values are lower than 12.5. These design options are therefore considered as economically favourable.

A second step in this study is to consider the combination of single design options. The combination of single design options are expected to have better performance from both the environmental and economic point of view. However, and as commented in section 6.1.5, the environmental and economic improvements of the combined single design options are not the direct sum since it depends on the interaction among the design options. How exactly this interaction works depends very much on the technologies, but it may well lead to a different ranking of combined options than the ranking of single design options.

Therefore, taking into account the ranking of SPP of single design options and stakeholder input on possible combinations the following combinations have been defined (order of design options according to SPP ranking, see Table 6-17):

- C1= D4 + D2 (fan + door opener)
- C2 = D5 + D4 + D7 + D2 (increased programme duration + fan+ + advanced sensor technology + door opener)
- C3 = D4 + D2 + D1 (fan + door opener + heat exchanger)
- C4 = D5 + D4 + D7 + D2 + D1 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger)

- C5 = D5 + D4 + D7 + D2 + D1 + D8 (increased programme duration + fan+ advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms)
- C6a = D5 + D4 + D7 + D8 + D3 (increased programme duration + fan+ advanced sensor technology + adsorption drying technology + consumer information mechanisms)
- C6b = D4 + D7 + D2 + D1 + D8 + D6 (fan + advanced sensor technology + door opener + heat exchanger + consumer feedback mechanisms + heat pump)

The assumptions, environmental impacts and cost calculations can be found in section 6.1.5 together with those of the single design options.

Table 6-18 shows the single payback periods (SPP) of the combinations of design options. IN accordance to the life cycle cost results (see section 6.3.1) it can be seen that only combination C6b has a payback time which is longer than the assumed life time of dishwashers of 12.5 years. All other combinations have shorter SPP which correspond to lower life cycle costs than the base case.

Table 6-18: Single Payback Periods (SPP) of the combination of design options (BC1)

Combination of design options	SPP (years)
C1	3.2
C2	4.5
C3	4.7
C4	5.5
C5	5.9
C6a	7.8
C6b	15.1

6.4.2. Least Life Cycle Cost calculations

The life cycle costs and the environmental impacts of the base case and the combinations of the single design options are plotted in one graph to give the least life cycle curve.

Figure 6-5 and Figure 6-6 show these graphs for each base case. As environmental impact indicator the total energy consumption (MJ) over the lifecycle is chosen (the absolute impacts/costs and the savings are already outlined in the previous sections 6.2 and 6.3 on the impacts and costs of the combinations).

It can be seen that the shape of the two graphs is nearly identical. For both base cases the total energy consumption decreases from combination 1 to combination 6a. As outlined in sections 6.2.2 and 6.2.4 this decrease would be in principle the same for the impact categories electricity consumption, hazardous waste, GWP, acidification, VOC and PAHs. For the impact categories PM and eutrophication no significant change occurred, therefore the combinations neither lead to savings nor increase in impact in these categories. Only for the impact categories water (process), water (cooling), POP and heavy metals (both to air and to water) the impacts decrease from the base case to combination C5 and then increase again for the combinations C6a and/or C6b.The life cycle costs of combinations C1 to C5 are approximately the same – the differences can be regarded as non-significant (see also sections 6.3.1 and 6.3.2). The life cycle costs of combination C6b (including design option D3 adsorption technology) is higher than those of combinations C1 to C5 but still lower than those of the base case. Only the life cycle costs of combination C6b (including design option D6 heat pump) are higher than those of the base case.

As the life cycle costs of combinations C1 to C5 are practically the same the least life cycle point cannot be determined unambiguously – actually all combinations C1 to C5 can be seen as the "least life cycle point", with combination C5 having the lowest environmental impact. Combination C6b has by far the lowest environmental impact regarding total energy consumption and the highest life cycle costs. Note that for other impact categories this combination might result in worse performance compared to the base case.

It has to be considered however, that all differences between the life cycle costs are small. The LCC increase of option C6b compared to the base case is only 4% (BC1) and 7% (BC2), which is, especially compared to the difference in purchase price (almost double purchase price than base case appliance) very small (please note that the vertical axes in Figure 6-5 and Figure 6-6 do not start from zero).

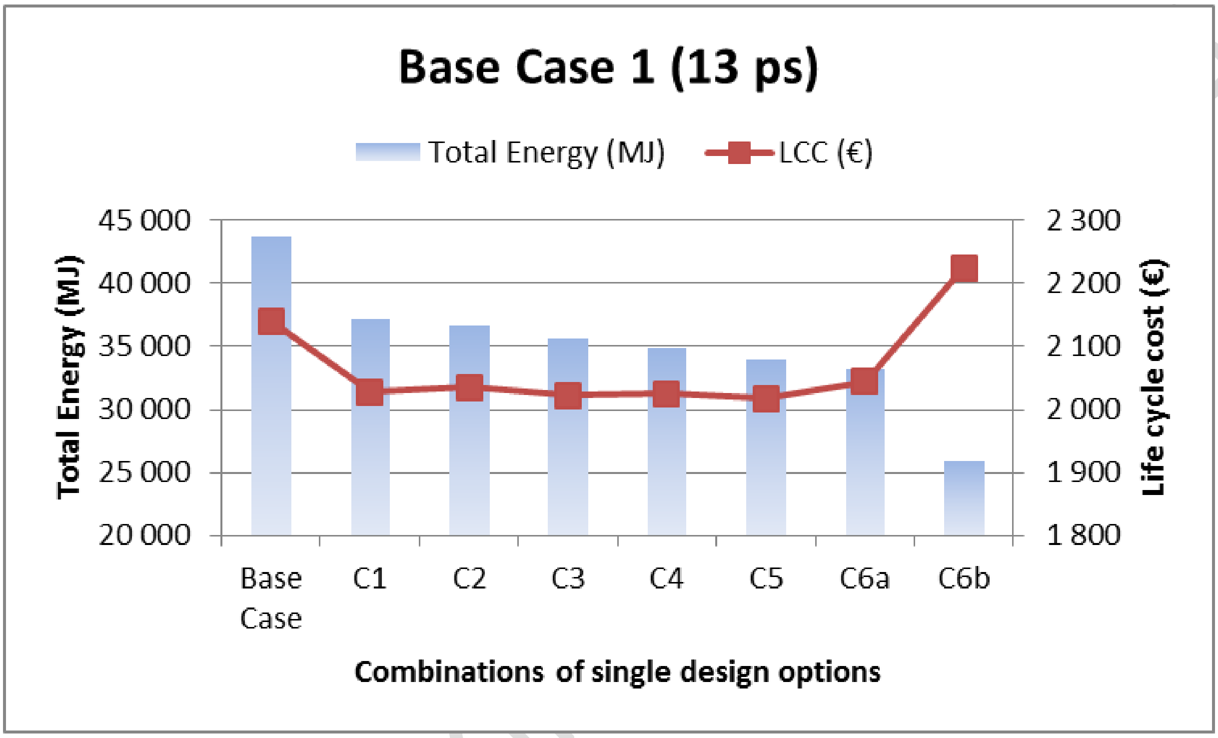

Figure 6-5: **Life cycle cost for the different combinations of single design options together with the total energy consumption over the lifetime for Base Case 1 (13 ps). Note that the vertical axes do not start from zero.**

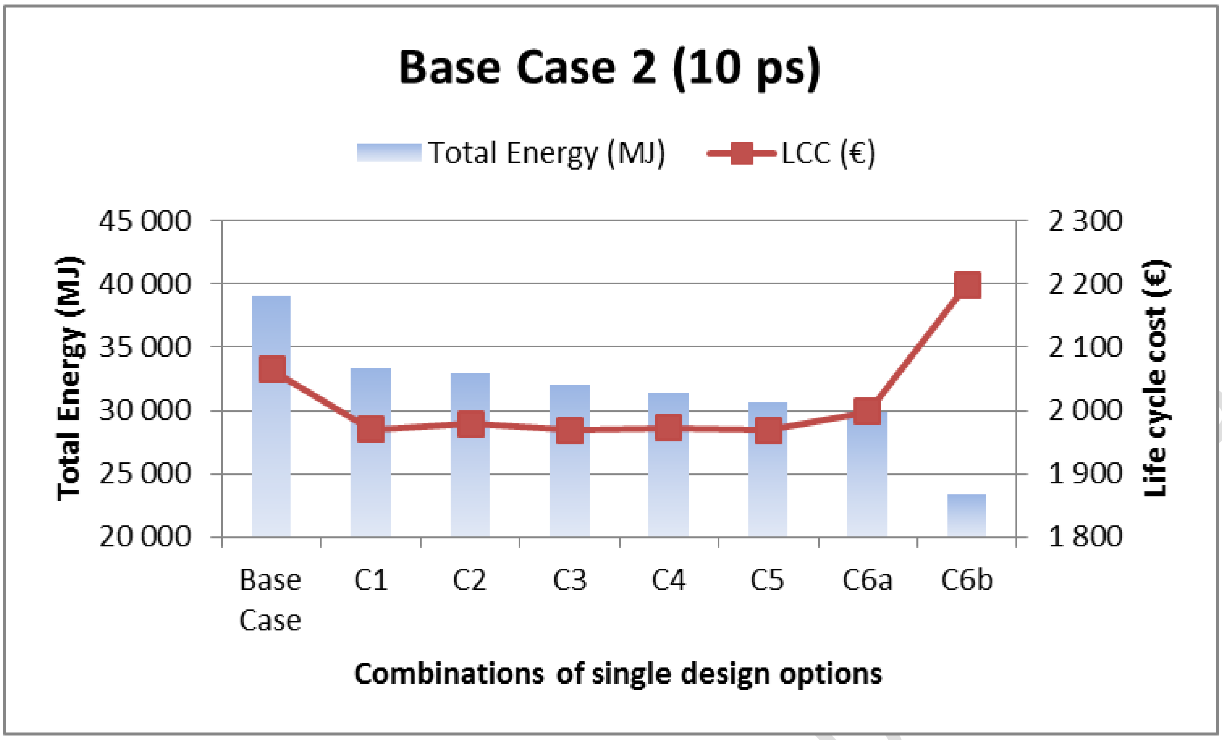

Figure 6-6: **Life cycle cost for the different combinations of design options together with the total energy consumption over the lifetime for Base Case 2 (10 ps). Note that the vertical axes do not start from zero.**

7. Task 7: Scenarios

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

A full list of potential policy options is provided in Annex 8.4 and Annex 8.5. After discussion with stakeholders a short-list of selected policy measures is discussed more in detail in the following sections. The expected benefits of these measures, possible drawbacks for the environment as well as for the consumers, industry and other stakeholders are described.

7.1. Policy analysis

7.1.1. Stakeholder consultation during the preparatory study

During the preparatory work a continuous stakeholder consultation has taken place. Stakeholders have been contacted bilaterally for information exchange and two technical working group (TWG) meetings are organised. The TWG is composed of experts from Member States' administration, industry, NGOs and academia. The first TWG meeting took place in Seville on 23 June 2015 while a second TWG meeting is organised in Brussels on 17 November 2015.

The first meeting focused on tasks 1-4 of the preparatory study, while the second meeting will focus on tasks 5-7. The project team has visited different manufacturers, test labs, recyclers and a trade fair to investigate the products in detail and to stay up to date with the latest developments. Two questionnaires have been distributed to the TWG along the process, addressing information and data updates, and gathering opinions on scope, definitions, and performance parameter specifications like electricity and water consumption, programme duration, etc. An online communication system BATIS has been set-up for easy exchange of documents between registered stakeholders. A website was made available to have the final working documents in the public domain.

More specifically regarding policy options, a comprehensive list of potential policy options including expected benefits and potential disadvantages, challenges and / or drawbacks was developed and circulated to stakeholders for further detailed feedback during summer 2015, cf. Annex 8.4 (energy and water) and Annex 8.5 (material resource efficiency).

7.1.2. Current status of household dishwashers in the policy landscape of Ecodesign and Energy Labelling

Household dishwashers already have a history when it comes to Ecodesign and Energy Labelling. The first Ecodesign and Energy Label requirements were published in 1997. The outcome of the first revision was published in 2010 with requirements reaching into 2016.

Given the fact that this is the second revision of Ecodesign and Energy Label requirements for household dishwashers, industry indicates in general that not much improvement potential on the energy consumption side is still to be harvested with current technologies. The market and sales data in Task 2 indeed show a slowing down of energy efficiency improvement for household dishwashers. However, in Task 6 different design options are described which still can improve the energy efficiency of household dishwashers.

Table 7-1 shows that only three label classes (i.e. A+, A++ and A+++) are allowed on the market for dishwashers with ps ≥ 11 since December 2013 and for dishwashers with ps ≤ 10 from December 2016. Only for dishwashers with ps ≤ 7, the label class A will still be available. In 2013 about 10% of the dishwashers that were sold on the market were A+++. Altogether, this calls for a revision of the energy label classes, especially in view of the upcoming revision of the Energy label Directive.

Table 7-1: Overview of the current requirements, which classes are phased out

Class	EEI	Tier Dec 2011	Tier II Dec 2013	Tier III Dec 2016
A+++	EEI < 50			
A++	50 ≤ EEI < 56			
A+	56 ≤ EEI < 63			
A	63 ≤ EEI < 71		Allowed for ps = 10 and width < 45cm Allowed for ps ≤ 10	Only allowed for ps ≤ 7
B	71 ≤ EEI < 80	Allowed for ps = 10, 9 and width < 45 cm		
C	80 ≤ EEI < 90	Banned for all machines		
D	EEI ≥ 90			

A sample of dishwashers sold in the EU in 2014 (CECED database) with ps ≥ 11 is shown in Figure 7-1 together with the current labelling classes and Ecodesign requirements. It shows improvement potential, especially for heat-pump equipped dishwashers. For a final evaluation of this technology the outcomes of the environmental assessment and LCC analysis performed in the previous sections should be taken into account.

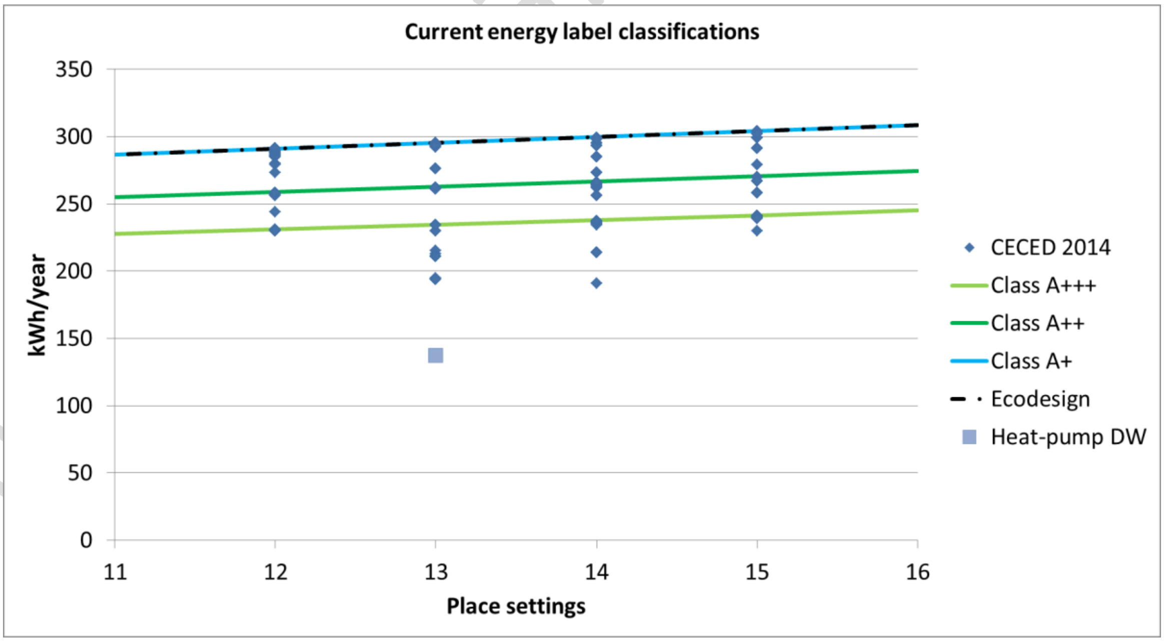

Figure 7-1: Yearly energy consumption of dishwasher models on the market in 2014 in function of their place settings for ps ≥ 11 together with the current labelling classes and Ecodesign requirement. A heat-pump equipped dishwasher is shown as reference for the most efficient dishwasher on the market

As the market of dishwashers is strongly influenced by the Energy Label it has to be investigated if more stringent MEPS are necessary.

Due to the relatively small improvement potential with current technologies regarding the energy performance of the dishwashers, other areas of improvement might become of higher importance. This can be the case for material efficiency and end-of-life management. Relevant information about these two areas has been commented along this study. The following list is a summary of this information:

- in general, there is an increasing need for finding feasible, operational metrics for implementing resource efficiency aspects into product policies, as reflected in a number of European Union strategic policy documents, including the revision of the Ecodesign and Energy Label Directives, and the drafts of the Action Plan on the Circular Economy

- there is an increasing number of examples of integration of resource efficiency matters (such as durability and facilitating end-of-life management of products) into specific product policy instruments like mandatory Ecodesign Regulations or voluntary ecolabels.

- there seems to be still a gap between the already implemented requirements/criteria in product policies, and the ongoing research in this field, which highlights the potential beneficial impacts of increased product-related resource efficiency.

- there is absence of sufficient standards which are applicable for testing and measuring resource-related criteria, including procedures for verification and market surveillance. Currently, a number of standards are somehow related to material efficiency (e.g. safety standards for durability, standards for recycling in end-of-life management), but they are primarily developed for other purposes (product safety, management at recycling operations) and are not directly addressing resource efficiency in the design phase.

- it seems that there are an increasing number of dishwashers that need to be repaired during their lifetime. According to (Prakash et al. 2015) the share of appliances that had to be replaced within the first 5 years due to a defect increased between 2004 and 2012 from 3.5 to 8.3% (share of total replacements sales, all large household appliances). Reasons for prematurely changing the dishwashers are several: breakdowns of components (although no recurrent components could be identified) and difficulties to be repaired, desire of the consumers for better machines, etc.

- reparability of dishwashers seems to become more difficult for reuse and repair centres due to lack of access and costs of spare parts, lack of access to service manuals, software and hardware as well as to product design which hinders disassembly of the appliances to repair. Also for the users, the repair of the machines become less attractive due to the relatively high costs (depending on the defective component between 100-300 euros) compared to decreasing prices for the purchase of a new appliance.

- regarding EoL-management, there are currently well established recycling processes in place in accredited WEEE installations. Appliances with heat pumps would have to be processed separately for depollution (extraction and incineration) of the F-gas refrigerants. Permanent magnet motors in dishwashers have been highlighted as relevant subject of manual disassembly to recover rare earth and copper content. However, recent stakeholder feedback indicates that newer permanent magnet motors do not contain rare earths and copper is replaced by aluminium, both because of lower cost and equal performance of the alternative.

- the collection rate of waste dishwashers through the accredited WEEE collection systems, mostly in connection with producer responsibility systems, is in some Member States (e.g. IT, ES, PT, GR) only around 1/3 of the appliances sold on the market and treated in accredited installations. In other Member States, this share is around 2/3. In both cases, large flows are apparently not treated following WEEE prescriptions. Pathways of appliances not collected and registered in official statistics might be prolonged storage in households, recycling within the EU but in non-accredited installations that do not report to official Member State statistics, or export as used EEE or end-of-life equipment to non-European destinations. The revised WEEE Directive has set specific measures to try to address these enforcement issues. The upcoming Action Plan on a Circular Economy may likely address how to improve producer responsibility systems, by imposing minimum operation rules (e.g. transparency of fees and costs, no-profitability) and proposing fees to manufacturers based on the recyclability of their appliances (for which clear definitions and measurement of recyclability will be needed).

Against this background a list of different potential policy options on material efficiency and EoL management of household DWs are investigated. The options are split into two main sections durability (including reparability) and EoL management.

An initial overview of possible policy options was developed and circulated to stakeholders for further detailed feedback during summer 2015 (see Annex 8.4 and Annex 8.5). A selection of the portfolio of policy options described in these annexes is discussed more in detail in the following sections. A differentiation has been made for policy options related to energy and water consumption, and policy options related to end-of-life and durability measures.

7.1.3. Policy options related energy and water consumption

Table 7-2 shows an overview of selected policy options for further discussion related to water and energy consumption. The options are discussed more in detail in the sections below.

Table 7-2: Summary overview of the pre-selected policy options to be discussed in this section

Pre-selection of policy options for DW related to energy and water consumption	Options	Expected benefits	Possible drawbacks and risks
TEST CYCLE	Changing the test cycle for better alignment with consumer behaviour (inclusion of other programmes or inclusion of partial load)	Better alignment with real-life conditions	Less transparency, higher test burden
CYCLE TIME	Adding the programme time of the standard Eco-programme on the Energy label	Manufacturers will try to reduce the time	One cannot be sure that shorter programme times will indeed be realized by this measure and how consumers will react
	Cap on the maximum programme time for the standard Eco programmes	Unrealistic cycle times will be avoided	Less market differentiation
WATER CONSUMPTION	Cap on water consumption per cycle	Lower water consumption	Less performance, worse rinsing
ENERGY LABEL CLASSES and ECODESIGN REQUIREMENT	Review of label class limits	Incentive for energy efficiency improvement	Energy improvement at the expense of other environmental impacts
	Review of energy efficiency Ecodesign requirement	More efficient appliances	Less market differentiation
LOW-POWER MODES	Integration in the AEC calculation	Alignment with real-life consumption	Test burden, less transparency
	Specific cap for certain low-power modes	Avoidance of increasing consumption	
ENERGY LABEL	Cycle time, cleaning perfor-	Better information for	Information over-

INFORMATION	mance, hot fill, energy per year or per cycle	consumer, more targeted consumer choice	load, unclear consumer reaction
RINSING	Include a rinsing performance minimum Ecodesign requirement	Rinsing performance guaranteed and controlled	Test burden

7.1.3.1. Programme responsible for the Energy Label and Ecodesign requirements

According to the Ecodesign requirement introduced in the last revision and implemented since 2013 the Eco-programme shall be the standard programme which is responsible for the Energy Label and Ecodesign requirements. The Eco-programme is the most efficient programme in terms of energy and water which is designed to clean normally soiled tableware. The definition of this programme makes it suitable for daily housework and this is reflected in the Ecodesign requirement of setting the Eco-Programme as the default programme option. According to the last revision the Eco-programme shall be

(i) a programme recommended for normal use, to clean normal soiled tableware,

(ii) clearly identifiable on the appliance programme selection device and named 'Eco-programme',

(iii) the default machine programme for dishwashers equipped with an automatic programme selection/function or with the capability to maintain the selection of a given programme. In addition it shall be declared in the booklet of instructions along with information that this programme is to clean normally soiled tableware and that it is the most efficient programme.

New dishwashers that appear on the EU market since 2013 are equipped with the Eco-programme as default option.

Two options can be hypothesized regarding this Ecodesign requirement:

a) keep the Eco-programme as default option

Given the fact that it has been implemented only recently, it is difficult to fully quantify the effect of having the Eco-programme as default consumer choice. However, it seems that the share of consumers that choose the Eco-programme as the daily used programme is increasing. According to the user behaviour survey results Figure 7-2, an increased use of the Eco-programme is noticed for machines which are younger than three years. This could be related to the implementation of the Eco-programme as default programme in the previous revision.

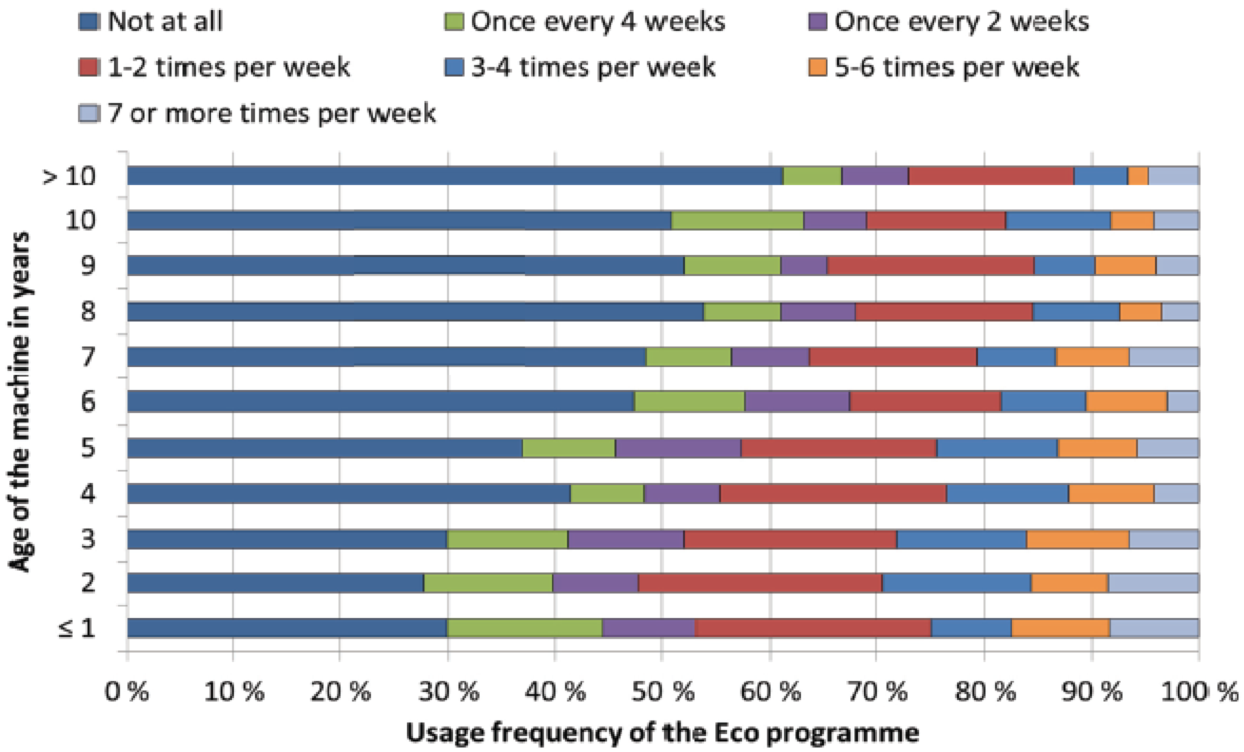

Figure 7-2: Usage of Eco-programme based on the age of the machine

Manufacturers claim even a bigger increase of the use of the Eco-programme. This is an indication that the measure has still potential to deliver better results in the coming years.

This proposal would keep the Eco-programme as the basis for Energy Label and Ecodesign requirements. Several advantages have been identified in case of a continuation of the current situation, such as the existence of a recently updated standard and the simplification of test procedures compared to the following option.

b) not keeping the Eco-programmed as default option

Even if the Eco-programme is designed to clean normally soiled dishes, most of the consumers have the need of washing dishes at different programs (e.g. intensive, automatic, shorter cycle times, etc.). Therefore, some stakeholders call for a change in programme testing related to the Energy Label classification and Ecodesign requirements. Testing a combination of programs (e.g. normal and eco or full and half loads) would complicate testing, verification and market surveillance. This option implies more complicated and costly testing as several programmes should be measured for each model. Testing the automatic program for the energy label classification would be very difficult regarding standardisation and reproducibility issues. Another drawback of testing the automatic program would be that this program could become standardised in a way, therefore losing much of its improvement potential.

Transparency to the consumer could be lost since the final energy and water consumption will have to be calculated from different programs (e.g. by an arithmetic or weighted average). Moreover, a change to other programs could invite manufacturers to be creative with the names of the programs and circumvent the goal of this measure.

Further, it is observed that the real-life energy consumption of the dishwashers is not fully reflected in the Energy Label and Ecodesign requirements. It is estimated that the energy consumption of the Eco-programme differs around 12 % from the real-life energy consumption (Table 5-1).

7.1.3.2. Cycle time

From Figure 2-21, a tendency on the market toward longer cycle times in the dishwashers can be seen from 2010 to 2014. This seems to have stabilized in 2015. The increase in cycle times can be explained by the Sinner cycle where time is among the variables that affect the cleaning results and the energy consumption. In other words, and considering the conditions set up for a dishwasher, for a certain cleaning performance level, an extension of the cycle time leads to a reduction of the energy consumption.

The incentive of increasing the cycle time for reducing the energy consumption has led to longer programme cycles that average 196 minutes for the Eco-programme. From the last user behaviour survey it is not 100% clear (Figure 7-3) how consumers think about long cycle times for dishwashers, but this revision should prevent that programmes are developed with long cycle times which are finally not used by the consumer. This is what has happened in the washing machine case where the most efficient programmes may last up to 6h. Furthermore, as discussed before, for technical reasons it might be that dishwashers would not end up with unrealistic cycle times because of technical reasons (see Table 6-1, design option 3).

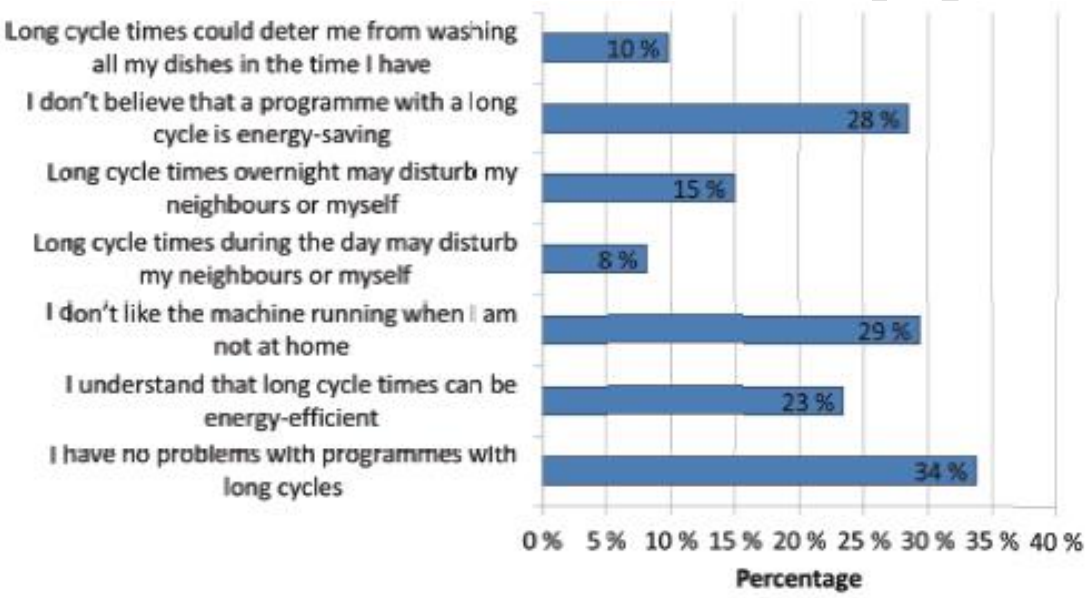

Figure 7-3: Acceptance of long program cycles ("What is your opinion of cleaning programmes with long cycle times?")

In order to prevent this situation, several measures could be hypothesized:

a) A cap on programme time as an Ecodesign requirement

The inclusion of a cap (e.g. Eco-programme duration no longer than x min) that limits the duration of the ECO-programme could be included as an Ecodesign requirement. There are several possibilities on the level of strictness and how to specifically apply this. As a preventive measure, a cap that avoids the development of unrealistic long cycle times could be set e.g. at 3.5 hours. A step further would be a stricter cap, e.g. 2 hours, to encourage consumers to use more often the Eco-programme.

A cap on programme time as an Ecodesign requirement may prevent manufacturers from innovation and new developments (e.g. efficient heat pumps need longer programme durations). Moreover, it would prevent consumers who would generally accept longer programme times to go for the most efficient washing cycle, thereby limiting the energy saving potential. Additionally, this measure would reduce differentiation among the machines.

If a cap on timing would be introduced, the 'standard' programme in the Regulation should refer to a program which is recommended for normally soiled dishes, but not necessarily the most efficient one. The manufacturer should be given the choice to still add a more efficient program on the machine. A change in definition of the standard programme would thus be needed for the implementation of this measure.

b) Cycle time information on the label

Another possibility is to provide information about the Eco-programme duration on the label. This information is already provided to the consumers in the user manual and product fiche. The main aim of this measure is to help consumers to take a well-informed decision prior to purchase of the machine.

The information on the label might stimulate innovation and competition and shift the market towards machines with shorter cycle times (even more than with a cap) without preventing others from reaching better energy performances.

On the other hand, such a measure might be counterproductive as consumers might start to focus on the cycle time instead of the energy efficiency. Improvement potential could get lost. Previous experience on providing the information of the cycle time could be found in the Energy Label requirements for household tumble driers Regulation (EU) No 392/2012.

In order to implement this idea successfully, a better definition of how this information should be included in the label should be developed.

7.1.3.3. Water consumption

Water consumption is addressed in the current Regulation by the indication of the water consumption per annum on the label. An additional step could be a cap on water consumption as an Ecodesign requirement.

However, since the water consumption in the dishwashers is already low a further reduction of the water consumption seems difficult from a technical point of view. Water consumption is related to the cleaning performance and the rinsing performance. Both performances may be affected by a further reduction in water use. The introduction of a water cap should therefore be carefully evaluated in terms of effective benefits and potential negative impact on consumers.

Technically, the energy consumption is related to the water consumption, since part of the energy consumption is used to heat up the washing and rinsing water. Therefore, setting incentives to decrease the energy consumption will probably lead to an overall decrease in water consumption, as already happened as a result from previous implementing measures.

7.1.3.4. Adaptation of the energy label classes and Ecodesign requirements

a) Rescale the current labelling scheme to A-G

According to the current Regulation only those products classified under the three top levels can be found on the market, as described in detail in Table 7-1. A new set of energy label classes going from class G to class A could be created in accordance with the outcomes of the revision of the Energy Labelling Directive (European Commission 2015).

The effects of the new labelling system on the dishwashers could mean a concentration of most of the models under energy label classes D and E and the best performing appliance, currently the heat-pump equipped dishwasher, in energy label class C.

If the label will be followed by consumers as before, it could favour an increase of appliances on the market which are equipped with a heat pump. Life cycle assessment with the EcoReport tool shows however that it might not be the best choice regarding life cycle cost (see Figure 6-5). Moreover, it would increase the price of this kind of dishwashers considerably which could hamper the increase of penetration rate in countries where dishwashers are not that much in use (mainly East-Europe). Also the environmental profile of the heat pump technology compared to other design options (see Figure 6-1) should be taken into account.

b) Update of the existing minimum energy performance standard (MEPS)

The existing specific Ecodesign requirements and the energy label classes are defined as a function of the machine capacity (in terms of place settings). Two standard annual energy consumption reference lines are used for the calculation of EEI, different for a machine with 10 or more place settings and a machine with 9 or less place settings. The standard annual energy consumption (SAEC) of dishwashers is currently a linear function of the place setting and is based on a per cycle energy consumption which is multiplied by 280 for an overall annual energy consumption.

The slight increase in capacity of the dishwashers in the last years is believed to be independent from these linear reference lines proportional to the place settings. However, and increase in the number of place setting for a given machine would make it easier to get a better EEI as the SAEC proportionally depends on the number of place settings. This fact could be a cause why machines with a higher capacity are more efficient per place setting. They do however consume more energy in absolute terms.

The biggest machines now have 15-16 place settings and this seems to be the limit given the fixed outer volume of the dishwasher. The outer volume is standardised according to kitchen requirements. Moreover, with the update of the new standard, manufacturers might decrease their amount of place settings again.

An alternative would be to adopt reference lines independent of capacity. A differentiation between slim-line (45 cm) and standard (60cm) dishwashers is probably still necessary. These types of dishwashers have different dimensions and are therefore more or less restricted when it comes to implementing improvement options.

As most of the dishwashers already perform well (the worst class is now A+ for standard dishwashers), it might not be necessary to adjust the minimum energy performance standards (MEPS), but only adapt energy label classes.

7.1.3.5. Low power modes: Standby, left-on (with power management system), smart connections

Currently, to evaluate the annual energy consumption (AEC) of a DW, the energy consumption per cycle is multiplied for an agreed number of cleaning cycles (280 cycles/year) and added with the energy consumption of low-power modes. The AEC formula consists of three parts related to the dishwashing cycle, the off-mode and the left-on mode. When a power management system is implemented, the left-on mode reverts to off mode within a defined time.

These kind of low power modes are in general regulated by the Standby Regulation (EC) No 1275/2008. A review study of this Regulation has been launched in June 2015 (see http://www.ecostandbyreview.eu).

The off mode is, according to Standby Regulation (EC) No 1275/2008, a condition in which the equipment is connected to the mains power source and is not providing any function. The off mode is regulated by that regulation and shall not exceed 0.50W

Specifically in the dishwasher the ‘off-mode’ means a condition where the household dishwasher is switched off using appliance controls or switches accessible to and intended for operation by the end-user during normal use to attain the lowest power consumption that may persist for an indefinite time while the household dishwasher is connected to a power source and used in accordance with the manufacturer’s instructions.

Where there is no control or switch accessible to the end-user, 'off-mode' means the condition reached after the household dishwasher reverts to a steady-state power consumption on its own.

The left-on mode is, according to the Regulation (EC) No 1016/2010, the lowest power consumption mode that may persist for an indefinite time after completion of the programme and unloading of the machine without any further intervention of the end-user. In some products the left-on mode is equivalent to the off mode.

Other low power modes that for the time being are not included in the AEC formula, but are present or start being common in this type the machines are the delay start mode and the smart connectivity mode. Smart connectivity of appliances to the internet is seen as an upcoming trend. It could help for better connection between manufacturer, consumer and appliance. Appliances with this function have been presented at the IFA 2015 fair in Berlin. This kind of smart connectivity mode might fall under network standby as defined in Regulation (EU) No 801/2013 amending the Standby Regulation.

The stand-by mode is, in accordance with Regulation (EC) no 1275/2008, 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 indefinite time:

- reactivation function or reactivation function and only an indication of enabled reactivation function (being the maximum power consumption 0.50W), and/or
- information or status display (being the maximum energy consumption 1.00W)

Additionally, the stand-by regulation requires that when an equipment is not providing the main function, or when other energy-using products are not dependent on its function, equipment shall unless inappropriate for the intended use, offer a power management function that switches equipment after the shortest possible period 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 of the off mode and /or standby mode when the equipment is connected to the mains power source.

The delay start mode is similar to a standby mode regarding its function but it is not considered as a standby mode because it has a limited duration. Currently the delay start mode can last up until 24 hours having an energy consumption that currently varies between 0.3W and 3W per hour (Stiftung Warentest, personal communication 2015). In practice these kinds of modes normally do not exceed 8 hours and are not used for every cycle. On the other hand, the delay start function might be understood as a reactivation function.

An option could be to keep on calculating AEC as it is done in the current Regulation and add additional low power modes, e.g. the delay start function. It has to be noted however that these low power modes were introduced in the calculation before the Standby Regulation went into force. Therefore, the left-on mode and the off-mode are already regulated. If the delay start function can indeed be understood as a reactivation function, it is already regulated. The same holds if smart connectivity falls under networked standby. However, if these functions are not regulated, a specific cap on their energy consumption could be introduced.

Given that these low power modes generally contribute little to the overall energy consumption, most stakeholders would like to see these modes taken out of the AEC calculation to account for more simplicity and reduce the complexity in testing and the associated market surveillance.

In Australia, New-Zealand and the US, the delay start mode is left out from the calculation to avoid penalization of this mode which was recognized to have an overall positive impact by allowing the delay of the cleaning cycle to off-peak hours.

Keeping the low power modes outside of the EEI calculation makes the formula simpler and more transparent. Therefore, one alternative to the existing EEI formulae would be to define a new one considering only the product's primary function, i.e. cleaning dishes.

7.1.3.6. Additional information on the label, e.g. cleaning and drying performance, hot fill, etc., energy per cycle or per year

The energy label is a powerful communication tool among producers and consumers. Moreover, it is a kind of marketing channel that helps manufacturers to differentiate their products.

Information provided in the energy label should be clear and should allow consumers to make informed purchase decisions. Several aspects have been highlighted as candidates to be included in a revised energy label for dishwashers, for example:

- Cycle time of the Eco-programme: this information will provide an idea of the cycle duration of the recommended programme for normally soiled dishes (see section on cycle time).

- Cleaning and drying performance: this information would not make any difference among the products as all dishwashers have to reach the highest cleaning performance class A as an Ecodesign requirement. Further differentiation in this highest cleaning performance class is believed to not be feasible as one would have to differentiate between clean and cleaner. Clean is clean and the current thresholds seem to be set in an appropriate way. Having this information on the label would not differentiate between products as they all would carry class A for cleaning performance. It could however show to the consumer that cleaning performance is an Ecodesign requirement and that they can be sure that the dishwasher is functioning well.

- Hot fill: the possibility to connect the dishwasher to a hot pipeline is available in all the products. However, this is not beneficial for all the households (see section 6.1.3). Information about those cases where the hot fill should be used could be included in the label. However, this option seems to be too complicated due to the limited dimensions and space on the label.

- Consumption (energy and water) per cycle or per year: the information regarding the energy and water consumption should be provided to the consumers to allow them to compare among the different models in the market. The question is if this information should be provided on a cycle basis or on an annual basis. In the first case, the information is more transparent but the displayed numbers could be too low and close to each other making the comparison more challenging for the consumer. In the annual basis option, 280 cycles/year are assumed before reporting the annual energy or water consumption. This assumption does not reflect each specific consumer situation. During the Energy Label revision study, it has also been mentioned that not all consumers understand the expression "per annum".

7.1.3.7. Rinsing performance

Some stakeholders advocate for an Ecodesign requirement on the rinsing performance of the dishwasher. A protocol for measuring the rinsing performance has not been standardised yet. Moreover, different interpretations can be given to rinsing performance. Rinsing can be interpreted as related to left-overs of chemical components from the dishwasher detergent on the tableware or related to stains that can be left on the tableware. Tracking down left-overs of detergent on the tableware to prevent e.g. allergic reactions could be a difficult task as all the tableware should be checked with specific characterisation techniques. Given that there is no standard available for any of the interpretations of cleaning performance, it would be difficult to set requirements in this revision.

7.1.4. Policy options related to end-of-life

7.1.4.1. Durability and reparability

The improvement of energy efficiency is expectedly limited for household dishwashers with current technologies. In the context of Ecodesign, durability and reparability measures might thus become more relevant. Durability can be understood as an extension of the lifetime of the machine under the same performance conditions. Such an extension of lifetime can be established either by increasing the original lifetime of the product or by extending the use phase of products, e.g. through repair activities. Lifetime and durability tests are still to be defined and for the time being, they are not standardised; a standardization request M/529 to the European standardization organisations (ESOs) is still being drafted.

The following causes decreasing the durability of products or the use time by the consumer have been identified:

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

The stakeholder feedback received to the list of options on durability and reparability reflects disagreement between environmental / consumer NGOs, Member States representatives and industry. The general need is seen for requirements on improving durability, such as information about the expected operational lifetime of the products, or design for upgrades and repairs, but the lack of practicability of these approaches is often mentioned as an obstacle, due to missing definitions or measurement standards.

The policy options presented in Table 7-3 were seen as least feasible according to stakeholder feedback. On the other hand there is a set of policy options that have been more welcome by stakeholders, mainly on reparability of products, and are presented in Table 7-4. These will be followed up for discussion.

Table 7-3: Policy options on improving durability seen as least practicable by stakeholders

Option	Policy option	Reasons for the option to be less feasible
1a	Requirement on performing durability tests of certain components which are known to be prone for early failures	• No clear evidence which components usually fail more often; effective measures would have to be set to all main components (definition of "main"?) • Definitions of components difficult due to different designs – a too wide definition would make consistency checks complicated; a too narrow definition would be easy to circumvent • Durable components do not lead to durable products automatically • High effort / costs for testing, also for market surveillance • No standard / test available; existing safety standards cannot be taken to measure durability • Durability / availability of after sales service is seen as market differentiation / competition issue
1b	Requirements on minimum operational lifetime of certain components which are known to be prone to early failures	• No clear evidence which components usually fail more often; • Durable components do not lead to durable products automatically • High effort / costs for testing, also for market surveillance; long-time needed for tests or accelerated tests • No standard / test available; no definition of "operational lifetime" against different usage patterns in EU
1c	Consumer information about the operational lifetime of certain components, e.g. motor	• No definition / measurement standard available to underpin this information • Does not hinder breakdown of machines • Might misguide consumers as e.g. the lifetime of a single component cannot be taken as indication for the overall quality of the product
2a	Requirement on performing durability tests of the whole product (e.g. endurance tests, tests under extreme conditions)	• Cf. arguments under option 1a, although this option is partly favoured over option 1a • Non-compliant 1-year lifetime test would only be able to force products from the market 1 year after entry
2b	Requirements on minimum operational lifetime of the whole appli-	• Cf. arguments under option 1b • For long living products such as DW a minimum operational lifetime must be quite high

Option	Policy option	Reasons for the option to be less feasible
	ance (e.g. machines to run a certain minimum number of cycles)	to be meaningful. Even if it would be set at 50% of the Average Expected Product Lifetime (AEPL), it is more crucial that it can be repaired if it fails after the minimum operational lifetime has expired.
3b	Compulsory direct feedback on necessary maintenance intervals via the machine's display	• Increasing appliance costs, especially for low-price machines without display so far • Impact not clear, i.e. if consumers really would change their maintenance behaviour
3c	Consumer information about the environmental (and economic) benefits of prolonged product use	• Long lasting DW are usually rather not replaced due to fashion and design • Better proper information on disposal and more efficient WEEE collection / recycling • Educational effects might be limited • Work with second hand market might be more effective
4d	Information requirements on reparability (e.g. repair label); indicating if the machine can be repaired or not; indicating which components are not repairable	• Self-declared claims are prone to market distortion • Requires a comprehensive standard such as ONR 192102 • No certainty that repairs will be done by consumers in the end (e.g. depending on the costs for repairs compared to the purchase price for a new product) • Reparability and after-sales services are market differentiation / competition issues
4e	Consumer information about access to professional repairs	• Common practice of most (all?) manufacturers, although a standard format might help enforcement of such requirements • It might be better that such requirements are not set on a product by product case • Reparability and after-sales services are market differentiation / competition issues
4j	Mandatory consumer information about commercial guarantees, i.e. the number of years the producer guarantees the full functioning of the appliance for free and without passing the burden of proof to the consumer	• Cf. arguments under option 4i

Table 7-4: Policy options on improving durability to be followed-up

Option	Policy option	Benefits	Challenges / drawbacks
2c	Consumer information about the expected operational lifetime of the whole product (e.g. label, manual)	• When buying new appliances, consumers are not informed about the lifetime expectancy of the product, if used and maintained properly. With such information, consumers are enabled to reward manufacturers who produce long-lasting and/or repairable goods.	• No existing definition / standard • High risk of market distortion if claims are not backed up by harmonised testing procedures and market surveillance
3a	General consumer information about correct use and maintenance of appliances	• Although often being available, this information should additionally been promoted • Use of further dissemination possibilities, e.g. NGOs and test institutes	• A standard format could help enforcement of such requirements • Rather for consumer information campaigns than for Ecodesign / Energy label regulations
4a	Design for upgrades and repairs: components being prone to early failures should not be designed in a manner prohibiting repairs (e.g. high integration of different components)	• Seen as very important by some stakeholders	• No clear evidence which components usually fail more often • Precise specifications of how this design might look like are missing • Certain designs might favour energy efficiency and durability at the expense of reparability.
4b	Design for upgrades and repairs: components being prone to early failures should be easily accessible and exchangeable by the use of universal tools	• Seen as very important by some stakeholders • Already applied by some manufacturers	• Cf. arguments under option 4a • Early failures are covered by the warranty and defects liability regulation
4c	Appliance internal failure diagnosis systems to report error specific messages to the user	• Already applied by some manufacturers • Particular relevant for electronic control systems which may make identification of defects difficult for repairers	• External diagnostic tools should also be made available to independent repair operators to make them understand the error codes. Manufacturers are hesitant to provide this information to external people.

Op-tion	Policy option	Benefits	Challenges / drawbacks
4f	Information about the availability (and price) of spare parts (current practice: from 0 to 10-15 years after production)	• Seen as very important by some stakeholders • Already applied by some manufacturers • Cf. French law with regard to a legal requirement on information about the time for which spare parts will be available	• Risk of market distortion if claims are not backed up by harmonised testing procedures and market surveillance • Other legislation (e.g. REACH, RoHS, Ecodesign on certain components being integrated in appliances such as motors or fans) might ex post restrict the availability of spare parts
4g	Guarantee of public availability of spare parts for a certain period following the end of the production of the model; ensure original and backwardly compatible spare parts	• Seen as very important by some stakeholders • Already applied by some manufacturers	• No clear evidence which components usually fail more often • A guarantee bears the risk of changes in the policy framework (cf. 4f) and an oversupply of spare parts that become WEEE at a later point in time • Detailed research on costs and effects of this option needed • Verification is difficult as this requirement is targeted to the future and not when the product is placed on the market
4h	Repair manual: clear disassembly and repair instructions to enable non-destructive disassembly of product for the purpose of replacing key components or parts for upgrades or repairs. Information publicly available or by entering the products unique serial number on a webpage to facilitate access for recognized / independent repair centres. A diagram of the inside of the housing showing the location of the components available online for at least 5 years	• Seen as very important and prerequisite for reparability by some stakeholders • Repair manuals are already in place for approved service providers which undergo specific in-house training / qualification programmes	• Having access to electronic repair software might be even more relevant to repairers as DW become electronically more complex • Public availability of repair manuals bears the risk of abuse causing liability issues or damage to consumers • Making repair manuals available to repairers but not making them publicly available would be very difficult to implement legally: one would need to define "repair cafe", they would need to register, etc. • Reparability and after-sales services are market differentiation / competition issues
4i	Commercial guarantee providing a minimum of 3 years guarantee effective from the purchase of the product during which manufacturers shall ensure the goods are in conformity with the contract of sale (without passing the burden of proof to the consumer). It includes service agreement with a pick-up and return option.	• This requirement would have the advantage that the manufacturer guarantees the proper functioning of the product e.g. for a certain number of cycles or years (whichever occurs first), i.e. that the manufacturer has to prove misuse by the consumer, and not the other way around that the consumer has to prove that the failure was due to a manufacturing fault). This approach might facilitate reducing early failures. An extended guarantee would also mean that manufacturers will pay attention to the availability of spare parts. • The guarantee should include a take back requirement by the manufacturer, so that it can be properly recycled or components be reused if the product cannot be repaired.	• A commercial guarantee by its definition cannot be a legal obligation as it is undertaken by the trader / producer in addition to his legal obligation relating to the guarantee of conformity. • Ecodesign is not the appropriate framework to extend guarantees • The effect might be limited given the calculated technical lifetime of 12.5 years for DW

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

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

   -> the product information sheet and the information on the website of the manufacturer shall contain a warning on that.

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

-> this information shall be on the product information sheet and the website of the manufacturer.

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

-> this information shall be on the product information sheet and the website of the manufacturer.

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

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

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

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

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

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

7.1.4.2. Recyclability

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

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

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

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

Consensus has been received from stakeholders in rejecting a requirement on the use of recycled material. They argue that most metals are indeed stemming from a mix of virgin and recycled origin. For plastics, it is difficult to use recycled technical plastics, as it is not certain that they will meet specific performance requirements. In other cases, the use of plastics with recycled content would increase the dimensions of components to deliver the same mechanical properties (not always possible for space reasons), or are not available in a given colour (e.g. white) that is needed for aesthetic reasons. Finally, no widely accepted standard methodology is so far available to determine this.

Some of the proposed policy options focus on easy manual dismantling of certain components of the machine, as from a theoretical point of view the separation of certain components would lead to a higher quality and a higher yield of the recyclate streams. This is proposed in contrast to a procedure of shredding followed by mechanical sorting. In this line, the following initiatives have been tabled in some studies:

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

The requirements above refer usually to the composition of appliances currently on the market and to appear for EoL 12.5 years from now. They refer to the present recycling techniques, which are mainly based on shredding. It is argued that the technology of recycling is very slow moving. Given that dishwashers have an average lifetime of 12.5 years, it is difficult to judge how the future recycling techniques will have evolved when e.g. more appliances with displays come to the end of their lives. Recycling business models vary: some recyclers work on high flows, and generate large volumes of not very pure fractions of e.g. copper, steel, aluminium, or plastics, while others treating specific appliances individually, e.g. manually, and obtain higher material yields from which they obtain a compensatory profit. One-fits-all recipes have to be considered cautiously, as recyclers with business models based on high flows would probably not benefit from requirements of manual dismantling of specific components of the machine. Thus the effect on the real-life recycling praxis is still not clear. Components are also different in different appliances. For example, Printed Circuit Boards of domestic appliances are not comparable to those of Information and Communication Technologies, as the former have a lower content of copper and precious metals. This makes measures in this field less effective than some studies may suggest.

In conclusion, in order to be widely accepted and implemented, the proposals will need measurement and verification standards, and incorporate profound knowledge of the market mechanisms that drive recycling.

8. Annexes

8.1. Annex I – Input data ErP-Ecoreport tool – Base Case 1 (13 ps)

Table 8-1: DW BC1 Inputs 'Materials extraction and production'

Pos	MATERIALS Extraction & Production	Weight	Category	Material or Process	Recyclable?	
nr	Description of component	in g	Click &select	select Category first !		
1	Bitumen	5400,4	7-Misc.	56 -Bitumen	No	
2	ABS	884,2	1-BlkPlastics	11 -ABS	Yes	
3	CC-sheet / colored	3712,0	3-Ferro	22 -St sheet galv.	Yes	
4	chipboard /	2240,0	7-Misc.	57 -Cardboard	No	
5	corrugated cardboard / Q. 1.4	0,0	7-Misc.	57 -Cardboard	Yes	
6	Cr / Coil 1.4016	3166,4	3-Ferro	26 -Stainless 18/8 coil	Yes	
7	crepe tape /	0,9	7-Misc.		No	
8	CrNi / Coil 1.4301	6464,8	3-Ferro	26 -Stainless 18/8 coil	Yes	
9	CrNi / stainless steel screw 0- 3g	18,8	3-Ferro	26 -Stainless 18/8 coil	Yes	
10	Cu / tube	67,7	4-Non-ferro	30 -Cu wire	Yes	
11	CuZn /	8,8	4-Non-ferro	32 -CuZn38 cast	Yes	
12	double-sided adhesive tape /	0,1	7-Misc.		No	
13	EPDM / for PDC	395,6	1-BlkPlastics	1 -LDPE	Yes	
14	EPS / white	4,3	1-BlkPlastics	6 -EPS	Yes	
15	Fe / Coil	129,1	3-Ferro	22 -St sheet galv.	Yes	
16	Fe / Coil zinced	2933,9	3-Ferro	22 -St sheet galv.	Yes	
17	Fe	4921,3	3-Ferro	22 -St sheet galv.	Yes	
18	LDPE / shrinking foil	0,0	1-BlkPlastics	1 -LDPE	Yes	
19	PA 6	131,7	2-TecPlastics	12 -PA 6	Yes	
20	PC / transparent	14,0	2-TecPlastics	13 -PC	Yes	
21	PC + ABS	216,5	2-TecPlastics	13 -PC	Yes	
22	PE	136,4	1-BlkPlastics	2 -HDPE	Yes	

Pos	MATERIALS Extraction & Production	Weight	Category	Material or Process	Recyclable?	
nr	Description of component	in g	Click &select	select Category first !		
23	PMMA / transparent	69,0	2-TecPlastics	14 -PMMA	Yes	
24	POM	366,7	1-BlkPlastics	2 -HDPE	Yes	
25	PP	6523,0	1-BlkPlastics	4 -PP	Yes	
26	PP G20	15,3	1-BlkPlastics	4 -PP	Yes	
27	PP G20 / 20% glasfiber added	3,8	2-TecPlastics	19 -E-glass fibre	Yes	
28	PP G30	104,4	1-BlkPlastics	4 -PP	Yes	
29	PP G30 / 30% glasfiber added	44,8	2-TecPlastics	19 -E-glass fibre	Yes	
30	PUR / flexible foam	370	2-TecPlastics	17 -Flex PUR	Yes	
31	PUR / Moltopren	6,8	2-TecPlastics	16 -Rigid PUR	Yes	
32	PVC	389,5	1-BlkPlastics	8 -PVC	Yes	
33	rating plate / self-adhesive A4	498,8	7-Misc.	58 -Office paper	No	
34	Silicon / liquid silico	10,9	1-BlkPlastics		No	
35	spring steel / Ø	207,3	3-Ferro	23 -St tube/profile	Yes	
36	TPE / hiqh quality	24,0	2-TecPlastics	13 -PC	Yes	
37	Vlies /	1162,4	1-BlkPlastics	10 -PET	Yes	
38	zinc diecast / Z410	5180,0	4-Non-ferro	32 -CuZn38 cast	Yes	
39	electronics	1381,5	6-Electronics	98 -controller board	Yes	
40	cable	574,7	4-Non-ferro	30 -Cu wire	Yes	
41	**packaging**					
42	corrugated cardboard / Q. 1.4	407	7-Misc.	57 -Cardboard	Yes	
43	EPS / white	787,92	1-BlkPlastics	6 -EPS	Yes	
44	LDPE / shrinking foil	138	1-BlkPlastics	1 -LDPE	Yes	
	TOTAL	**49113**				

Table 8-2: DW BC1 Inputs 'Manufacturing and distribution'

Pos	MANUFACTURING	Weight	Percentage	Category index (fi-xed)
nr	Description	in g	Adjust	

201	**OEM Plastics Manufacturing** (fixed)	11799		21
202	**Foundries Fe/Cu/Zn** (fixed)	5189		35
203	**Foundries Al/Mg** (fixed)	0		36
204	**Sheetmetal Manufacturing** (fixed)	21346		37
205	**PWB Manufacturing** (fixed)	0		54
206	**Other materials** (Manufacturing already included)	10778		
207	**Sheetmetal Scrap** **(Please adjust percentage only)**	1067	5%	38

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	60
209	**Is it an installed appliance (e.g. boiler)?**		NO	61
				63
210	**Volume of packaged final product in m^3**	in m3	0,4	64
				65

Table 8-3 DW BC1 Inputs 'Use phase'

Pos nr	USE PHASE direct ErP impact Description		unit	Subtotals
226	**ErP Product (service) Life in years**	**12,5**	years	
	Electricity			
227	**On-mode: Consumption per hour, cycle, setting, etc.**	303,3	kWh	303,3
228	**On-mode: No. of hours, cycles, settings, etc. / year**	1	#	
229	**Standby-mode: Consumption per hour**	0	kWh	0
230	**Standby-mode: No. of hours / year**	0	#	
231	**Off-mode: Consumption per hour**	0	kWh	0

232	Off-mode: No. of hours / year	0	#		
	TOTAL over ErP Product Life	3,79	MWh (=000 kWh)		66
	Heat				
233	Avg. Heat Power Output	0	kW		
234	No. of hours / year	0	hrs.		
235	Type and efficiency (Click & select)			86-not applicable	
	TOTAL over ErP Product Life	0,00	GJ		
	Consumables (excl, spare parts)			material	
236	Water	3,057	m^3/year	84-Water per m3	
237	Auxilliary material 1 (Click & select)	5,6	kg/ year	81 -Detergent dishw.	
238	Auxilliary material 2 (Click & select)	0,84	kg/ year	82 -Rinsing agent dish	
239	Auxilliary material 3 (Click & select)	5,32	kg/ year	83 -Regen. Salt dishw	
240	Refrigerant refill (Click & select type, even if there is no refill)	0	kg/ year	1 -none; 0000	
	Maintenance, Repairs, Service				
241	No. of km over Product-Life	160	km / Product Life		87
242	Spare parts (fixed, 1% of product materials & manuf.)	491	g		1%

Table 8-4: DW BC1 Inputs 'Disposal and recycling'

Pos nr	DISPOSAL & RECYCLING Description				
253	product (stock) life L, in years	12,5	Please edit values with red font		
		current	L years ago	period growth PG in %	CAGR in %/a
254	unit sales in million units/year	7,000	5,504	27,2%	1,9%
255	product & aux. mass over service life, in g/unit	196604	196604	0,0%	0,0%
256	total mass sold, in t (1000 kg)	1376,226223	1082,107019	27,2%	1,9%

nr	Per fraction (post-consumer)	1 Bulk Plastics	2 TecPlastics	3 Ferro	4 Non-ferro	5 Coating	6 Electronics	7a Misc., excluding refrigerant & Hg	7b refrigerant	7c Hg (mercury), **in mg/unit**	8 Extra	9 Auxiliaries	***TOTAL (CARG avg.)***
263	EoL mass fraction to re-use, in %						1%			1%		0%	*0,2%*
264	EoL mass fraction to (materials) recycling, in %	29%	29%		94%		50%	64%	30%	39%	60%	0%	*14,9%*
265	EoL mass fraction to (heat) recovery, in %	15%	15%		0%		0%	1%	0%	0%	0%	0%	*0,6%*
266	EoL mass fraction to non-recov. incineration, in %	22%	22%		0%		30%	5%	5%	5%	10%	0%	*1,1%*
267	EoL mass fraction to landfill/missing/fugitive, in %	33%	33%		5%		19%	29%	64%	55%	29%	100%	*83,2%*
268	TOTAL	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100,0%*
269	EoL recyclability****, (click& select: 'best', '>avg', 'avg' (basecase); '< avg'.; 'worst')	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	***avg***
		0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	

Table 8-5: DW BC1 Inputs for EU-Totals and LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	**12,5**	years
B	Annual sales	7,0	mln. Units/year
C	EU Stock	84,6	mln. Units
D	Product price	€ 526,00	Euro/unit
E	Installation/acquisition costs (if any)	€ 0,00	Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	€ 0,208	Euro/kWh
H	Water rate	€ 3,98	Euro/m3
I	Aux. 1: None	€ 8,00	Euro/kg
J	Aux. 2 :None	€ 3,00	Euro/kg

K	Aux. 3: None	€ 1,00	Euro/kg
L	Repair & maintenance costs	€ 15,00	Euro/ unit
M	Discount rate (interest minus inflation)	4%	%
N	Escalation rate (project annual growth of running costs)	4%	%
O	Present Worth Factor (PWF) (calculated automatically)	12,50	(years)
P	Ratio efficiency STOCK: efficiency NEW, in Use Phase	0,925	

8.2. Annex II – Input data ErP-Ecoreport tool – Base Case 2 (10 ps)

Table 8-6: DW BC2 Inputs 'Materials extraction and production'

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
1	Bitumen	4954,3	7-Misc.	56 -Bitumen	No
2	ABS	699,2	1-BlkPlastics	11 -ABS	Yes
3	CC-sheet / colored	3712,0	3-Ferro	22 -St sheet galv.	Yes
4	chipboard /	1680,0	7-Misc.	57 -Cardboard	No
5	corrugated cardboard / Q. 1.4	0,0	7-Misc.	57 -Cardboard	Yes
6	Cr / Coil 1.4016	2541,0	3-Ferro	26 -Stainless 18/8 coil	Yes
7	crepe tape /	0,7	7-Misc.		No
8	CrNi / Coil 1.4301	5456,2	3-Ferro	26 -Stainless 18/8 coil	Yes
9	CrNi / stainless steel screw 0- 3g	18,8	3-Ferro	26 -Stainless 18/8 coil	Yes
10	Cu / tube	66,4	4-Non-ferro	30 -Cu wire	Yes
11	CuZn /	8,8	4-Non-ferro	32 -CuZn38 cast	Yes
12	double-sided adhesive tape /	0,1	7-Misc.		No
13	EPDM / for PDC	362,1	1-BlkPlastics	1 -LDPE	Yes
14	EPS / white	4,3	1-BlkPlastics	6 -EPS	Yes

15	Fe / Coil	129,1	3-Ferro	22 -St sheet galv.	Yes
16	Fe / Coil zinced	3342,9	3-Ferro	22 -St sheet galv.	Yes
17	Fe	3518,4	3-Ferro	22 -St sheet galv.	Yes
18	LDPE / shrinking foil	0,0	1-BlkPlastics	1 -LDPE	Yes
19	PA 6	131,6	2-TecPlastics	12 -PA 6	Yes
20	PC / transparent	9,9	2-TecPlastics	13 -PC	Yes
21	PC + ABS	216,5	2-TecPlastics	13 -PC	Yes
22	PE	128,5	1-BlkPlastics	2 -HDPE	Yes
23	PMMA / transparent	69,0	2-TecPlastics	14 -PMMA	Yes
24	POM	351,9	1-BlkPlastics	2 -HDPE	Yes
25	PP	4860,55	1-BlkPlastics	4 -PP	Yes
26	PP G20	15,32	1-BlkPlastics	4 -PP	Yes
27	PP G20 / 20% glasfiber added	3,83	2-TecPlastics	19 -E-glass fibre	Yes
28	PP G30	104,44	1-BlkPlastics	4 -PP	Yes
29	PP G30 / 30% glasfiber added	44,8	2-TecPlastics	19 -E-glass fibre	Yes
30	PUR / flexible foam	277,5	2-TecPlastics	17 -Flex PUR	Yes
31	PUR / Moltopren	0,0	2-TecPlastics	16 -Rigid PUR	Yes
32	PVC	352,4	1-BlkPlastics	8 -PVC	Yes
33	rating plate / self-adhesive A4	498,8	7-Misc.	58 -Office paper	No
34	Silicon / liquid silico	12,4	1-BlkPlastics		No
35	spring steel / Ø	203,4	3-Ferro	23 -St tube/profile	Yes
36	TPE / hiqh quality	24,0	2-TecPlastics	13 -PC	Yes
37	Vlies /	776,0	1-BlkPlastics	10 -PET	Yes
38	zinc diecast / Z410	5180,0	4-Non-ferro	32 -CuZn38 cast	Yes
39	electronics	1205,7	6-Electronics	98 -controller board	Yes
40	kabel	574,7	4-Non-ferro	30 -Cu wire	Yes
41	packaging				
42	corrugated cardboard / Q. 1.4	305,3	7-Misc.	57 -Cardboard	Yes
43	EPS / white	665	1-BlkPlastics	6 -EPS	Yes
44	LDPE / shrinking foil	103,5	1-BlkPlastics	1 -LDPE	Yes
	TOTAL	42609			

Table 8-7: DW BC2 Inputs 'Manufacturing and distribution'

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	**OEM Plastics Manufacturing** (fixed)	9213		21
202	**Foundries Fe/Cu/Zn** (fixed)	5189		35
203	**Foundries Al/Mg** (fixed)	0		36
204	**Sheetmetal Manufacturing** (fixed)	18718		37
205	**PWB Manufacturing** (fixed)	0		54
206	**Other materials** (Manufacturing already included)	9489		
207	**Sheetmetal Scrap** **(Please adjust percentage only)**	936	5%	38

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	60
209	**Is it an installed appliance (e.g. boiler)?**		NO	61
				63
210	**Volume of packaged final product in m^3**	in m3	0,303	64
				65

Table 8-8 DW BC2 Inputs 'Use phase'

Pos nr	USE PHASE direct ErP impact Description		unit		Subtotals
226	**ErP Product (service) Life in years**	**12,5**	years		
	Electricity				
227	**On-mode:** **Consumption per hour, cycle, setting, etc.**	271,55	kWh	271,55	

228	**On-mode:** No. of hours, cycles, settings, etc. / year	1	#		
229	**Standby-mode:** Consumption per hour	0	kWh	0	
230	**Standby-mode:** No. of hours / year	0	#		
231	**Off-mode:** Consumption per hour	0	kWh	0	
232	**Off-mode:** No. of hours / year	0	#		
	TOTAL over ErP Product Life	**3,39**	**MWh (=000 kWh)**		66
	Heat				
233	**Avg. Heat Power Output**	0	kW		
234	**No. of hours / year**	0	hrs.		
235	**Type and efficiency** (Click & select)			86-not applicable	
	TOTAL over ErP Product Life	**0,00**	**GJ**		
	Consumables (excl, spare parts)			**material**	
236	**Water**	3,401	m^3/year	**84-Water per m3**	
237	**Auxilliary material 1** (Click & select)	*5,6*	kg/ year	**81 -Detergent dishw.**	
238	**Auxilliary material 2** (Click & select)	*0,84*	kg/ year	**82 -Rinsing agent dish**	
239	**Auxilliary material 3** (Click & select)	*5,32*	kg/ year	**83 -Regen. Salt dishw**	
240	**Refrigerant refill** (Click & select type, even if there is no refill)	0	kg/ year	**3-R404a; HFC blend; 3920**	
	Maintenance, Repairs, Service				
241	**No. of km over Product-Life**	160	km / Product Life		87
242	**Spare parts** (fixed, 1% of product materials & manuf.)	426	g		1%

Table 8-9: DW BC2 Inputs 'Disposal and recycling'

Pos nr	DISPOSAL & RECYCLING Description		
253	product (stock) life L, in years	**12,5**	Please edit values with red font

		current	L years ago	period growth PG in %	CAGR in %/a
254	unit sales in million units/year	1,100	0,896	22,8%	1,7%
255	product & aux. mass over service life, in g/unit	190035	190035	0,0%	0,0%
256	total mass sold, in t (1000 kg)	209,0390101	170,2717755	22,8%	1,7%

	Per fraction (post-consumer)	1	2	3	4	5	6	7a	7b	7c	8	9	
		Bulk Plastics	TecPlastics	Ferro	Non-ferro	Coating	Electronics	Misc. , exclu-ding refrigant & Hg	refrigerant	Hg (mercury), **in mg/unit**	Extra	Auxiliaries	***TOTAL (CARG avg.)***
263	EoL mass fraction to re-use, in %						**1%**			1%		**0%**	*0,2%*
264	EoL mass fraction to (materials) recycling, in %	29%	**29%**		94%		**50%**	**64%**	**30%**	**39%**	**60%**	**0%**	*12,3%*
265	EoL mass fraction to (heat) recovery, in %	15%	**15%**		0%		**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	*0,6%*
266	EoL mass fraction to non-recov. incineration, in %	22%	**22%**		0%		**30%**	**5%**	**5%**	**5%**	**10%**	**0%**	*1,1%*
267	EoL mass fraction to landfill/missing/fugitive, in %	33%	**33%**		5%		**19%**	**29%**	**64%**	**55%**	**29%**	**100%**	*85,9%*
268	TOTAL	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100,0%*
269	EoL recyclability****, (click& select: 'best', '>avg', 'avg' (basecase); '< avg'.; 'worst')	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	**avg**	***avg***
		0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	

Table 8-10: DW BC2 Inputs for EU-Totals and LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	**12,5**	years
B	Annual sales	1,1	mln. Units/year
C	EU Stock	13,7	mln. Units
D	Product price	€ 516,00	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit

F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	€ 0,208	Euro/kWh
H	Water rate	€ 3,98	Euro/m3
I	Aux. 1: None	€ 8,00	Euro/kg
J	Aux. 2 :None	€ 3,00	Euro/kg
K	Aux. 3: None	€ 1,00	Euro/kg
L	Repair & maintenance costs	€ 15,00	Euro/ unit
M	Discount rate (interest minus inflation)	4%	%
N	Escalation rate (project annual growth of running costs)	4%	%
O	Present Worth Factor (PWF) (calculated automatically)	12,50	(years)
P	Ratio efficiency STOCK: efficiency NEW, in Use Phase	0,925	

8.3. Annex III – Selected EcoReport results

Table 8-11: Environmental impacts of a standard household dishwasher with 13 place settings (use of eco programme)

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total
	Unit	**Material**	**Manufacturing**	**Total**			**Disposal**	**Recycl.**	**Total**	
Resources & Waste										
Total Energy (GER)	MJ	5.641	829	6.470	590	32.943	205	-554	-349	39.654
of which, electricity (in primary MJ)	MJ	2.740	497	3.236	1	30.364	0	-144	-144	33.458
Water (process)	ltr	1.442	7	1.449	0	47.458	0	-251	-251	48.657
Water (cooling)	ltr	971	232	1.202	0	1.358	0	-64	-64	2.496
Waste, non-haz./ landfill	g	34.005	2.750	36.755	346	18.930	903	-9.003	-8.100	47.931
Waste, hazardous/ incinerated	g	204	0	204	7	539	0	-9	-9	741
Emmissions (Air)										

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total
Greenhouse Gases in GWP100	kg CO2 eq.	314	46	360	39	1.409	1	-38	-37	1.772
Acidification, emissions	g SO2 eq.	2.543	199	2.743	118	6.412	8	-273	-265	9.008
Volatile Organic Compounds (VOC)	g	54	0	55	8	679	0	-11	-11	731
Persistent Organic Pollutants (POP)	ng i-Teq	531	11	542	2	93	0	-120	-120	518
Heavy Metals	mg Ni eq.	2.445	27	2.472	18	331	3	-486	-483	2.337
PAHs	mg Ni eq.	156	0	156	20	77	0	-7	-7	247
Particulate Matter (PM, dust)	g	2.674	31	2.704	1.368	162	48	-406	-358	3.876
Emmissions (Water)										
Heavy Metals	mg Hg/20	1.166	1	1.166	1	159	0	-275	-275	1.051
Eutrophication	g PO4	36	0	36	0	3.758	1.025	-8	1.017	4.811

The following table shows the environmental impacts of a household dishwasher with 10 place settings over the whole lifecycle of 12.5 years, when only the eco programme is used.

Table 8-12: Environmental impacts of a household dishwasher with 10 place settings (use of eco programme)

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total
	Unit	**Material**	**Manufac-turing**	**Total**			**Disposal**	**Recycl.**	**Total**	
Resources & Waste										
Total Energy (GER)	MJ	4.873	682	5.555	474	30.350	222	-551	-329	36.051
of which, electricity (in primary MJ)	MJ	2.379	409	2.787	1	27.776	0	-197	-197	30.367
Water (process)	ltr	1.221	6	1.227	0	49.989	0	-210	-210	51.006
Water (cooling)	ltr	782	191	973	0	1.241	0	-53	-53	2.161
Waste, non-haz./ landfill	g	30.091	2.271	32.362	288	17.559	884	-7.316	-6.432	43.776
Waste, hazardous/ incinerated	g	173	0	173	6	498	0	-12	-12	665
Emmissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	272	38	310	32	1.299	1	-35	-35	1.606

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total
Acidification, emissions	g SO2 eq.	2.235	164	2.398	96	5.921	9	-258	-249	8.166
Volatile Organic Compounds (VOC)	g	49	0	49	6	621	0	-10	-10	667
Persistent Organic Pollutants (POP)	ng i-Teq	491	10	501	2	86	0	-98	-98	491
Heavy Metals	mg Ni eq.	2.119	23	2.143	15	302	3	-389	-386	2.073
PAHs	mg Ni eq.	136	0	136	16	71	0	-8	-8	215
Particulate Matter (PM, dust)	g	2.393	25	2.418	1.036	149	51	-398	-347	3.257
Emmissions (Water)										
Heavy Metals	mg Hg/20	999	1	1.000	0	146	0	-214	-213	933
Eutrophication	g PO4	30	0	31	0	3.758	1.067	-7	1.060	4.848

Table 8-13: Life Cycle Costs for the base cases both using the eco programme and under real life conditions over the whole product life cycle (in Euro)

		Base Case 1 (13 ps)			**Base Case 2 (10 ps)**		
	Unit	Real life usage	Use of Eco-programme	Change	Real life usage	Use of Eco-programme	Change
Product price	€	526	526	0%	516	516	0%
Electricity	€	789	696	-12%	706	636	-10%
Water	€	152	136	-11%	169	143	-15%
Dishwashing detergent	€	560	560	0%	560	560	0%
Rinsing agent	€	32	32	0%	32	32	0%
Regeneration salt	€	67	67	0%	67	67	0%
Repair & maintenance costs	€	15	15	0%	15	15	0%
Total	€	**2 140**	**2 031**	**-5%**	**2 064**	**1 968**	**-5%**

8.4. Annex IV – Full list of policy options for household dishwashers regarding energy and water consumption

The following Table 8-14 provides a full list of policy options for household dishwashers. The policy instruments addressed are the Energy label (EL), generic and/or specific Ecodesign-measures (ED), standards and measurement methods (SM), as well as consumer information (CI) measures.

Table 8-14: Full list of policy options for household dishwashers regarding energy and water consumption

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
1a	The consumer survey reveals that the **ECO programme is not used so much in real-life**, there are other "most used" programmes (mainly automatic and short programmes). Currently, the basis / target of Ecodesign "ECO" programmes is not clear (most used <=> most efficient programme?)	Define the **"most used" programme for 'normally soiled tableware' as standard programme** (not the "most efficient" one as today); e.g. by an open formulation "The programme to be used is the one recommended by the manufacturer for everyday use for normally soiled dishes, and which is the one that is most easily accessible on the appliance"; the standard would have to be ready for all programmes, including an automatic programme	ED / EL / SM / CI	Better alignment to real-life conditions	The "most used" programme is different for each consumer! The survey shows the use of dishwashing machines currently IN STOCK, which is presumably different to how people would use a NEW machine (e.g. DW machines in stock do not necessarily indicate it "ECO", also a default set-up of the ECO programme only became mandatory a short time ago). Consumer choice of most used programmes might further change in future
				Additional stakeholders'input: - an open formulation would improve the policies' relevance for real life, the test programme would be the most use programme for a higher share of real-life cycles. - It seems reasonable to define the ''most used'' program as standard program. It is possible that the consumer behaviour will change in the future but it is currently not predictable	**Additional stakeholders'input:** - more potential disadvantages than benefits - better leave it at the ECO programme - It would complicate the test, and in some cases it might not be clear which programm would have to be tested. It is key that no longer the Eco program, but a 'normal' program (automatic or normal) is tested in the future - The last data of the consumer

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					behaviour study clearly showed that the Eco programme is used with new DWs much more than with older ones. This is a clear indication that the Ecodesign requirement "ECO as defalt" is working well and should not be ''disturbed' by controverse requirements
1b	cf. 1a	**Include further cleaning programmes** (e.g. automatic and/or short programme) into the test procedure and calculation formulae for energy and water consumption. The consumption value could be a (weighted?) average value from the different standard programmes	ED / EL / SM	Better alignment to real-life conditions, realizing further improvement potentials of Ecodesign/Energy labelling measures (e.g. incentive to improve the other programmes as well)	Increasing testing effort for manufacturers and also market surveillance authorities. Currently, automatic programmes in the test procedure cannot deliver repeatable and reproducible results. The declared energy consumption becomes less transparent because it is a calculated average value based on different programmes.
				Additional stakeholders'input: - Best option to increase the declaration's relevance for real-life energy consumption. Partly because it could be linked to a max. program duration requirement for one of the test programmes. This would gurantee that users who do not like long programs have a program at hand that is both not too long and optimised regarding energy efficiency. - This would probably lead to more exact values for energy and water consumption.	**Additional stakeholders'input:** - Based on the outcome of the consumer survey, there is little scope for adding these cycles which have scored low usage percentages: - 12% short cycle - 10% automatic cycle -Such policy option would also increase the complexity of market surveillance and would deter them from performing physical tests. - Standards for testing other programs are not available yet. - too costly - due to the fact that the energy and water consumption is in any case different for each consumer, it

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					does not seem reasonable to complicate the test procedure. Leaving it as it is today seems sufficient for a good estimation of energy and water consumption - each programme is defined to deal with specific load and soil, but each manufacturer is doing that on their own. Additionally, the term "automatic' is not defined. There are a lot of sensors in the market and automatic should not be restricted only to load and soil. Otherwise furture developments can be prevented.
1c	cf. 1a; consumers might not be aware of the performance values (energy & water consumption, cycle time etc.) of other programmes compared to the ECO programme	Standardized format of the consumer information on the programme time, energy and water consumption for the main cleaning programmes. Definition of "main programmes".	CI	Programme values should become comparable between different machines / manufacturers	There are too many possible combinations of programmes and options to be able to reference them in a cost effective manner. If more data (consumption values of other programmes) is provided, they may need to be verified which requires more testing effort by manufacturers and market surveillance authorities. However, results of ATLETE II (for washing machines) reveal bad compliance regarding implementation of information requirements on programme values. Thus, a way is needed to ask for declaration without verification of the values.
				Additional stakeholders'input: - interesting proposal - as voluntary agreement by manufacturers - information is necessary and an	**Additional stakeholders'input:** - Mandatory information in the display is not acceptable as not all models have a display. Besides, all display technology (e.g. entry level)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
				identical way of providing those information may be beneficial - very important for consumers to do informed choices - according to Regulation (EC) No 1016/2010, information of the consumption values for the main programmes should be available in the material delivered with the appliance (user manual, short manual, CD, etc). - the programme time is often already shown on the display, so it seems to be possible to show also energy and water consumption on the display, at least for the standard and ECO programs	does not allow for comprehensive/complex information to be displayed. - better indicate in ranges to avoid misleading information - overload of information should be avoided - a rather simple measure, with however limited impact - not sure how consumers would react - there would be a super efficient ECO program - due to the fact that the programmes are defined to serve for specific load and/or soil it might not be possible to compare programmes form one manufacturer to another manufacturer. Therefore even a standardized format will not help for comparison.
1d	cf. 1a	Ways of information: - on the display a programme choice (in case of a display available), - in the manual and/or - the label fiche; - also a QR code might be possible.	ED	Avoids the washing machine situation where the main programmes are duplicated to reach better energy label classes	Prevents product innovation / market variety / consumer choices
				Additional stakeholders'input: - the requirement maight be necessary to avoid having ''hidden'' standard programms and other programms, which have nothing to do with the declaration - similar programs that have a clearly different purpose could be allowed (eg normal/ normal cool) this would not mean any innovation	**Additional stakeholders'input:** - the legitimacy of such provision under the Ecodesing regulation is dubious. Smarter ways of reaching the same goal are needed (eg communicate program duration) - some programmes are suitable for various applications (eg short programmes for light vs normal for heavy soil)

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
				prevention	- this prescription would probably be too restrictive for the manufacturers - according to the user behaviour study, the QR-code is the least efficient information channel, but maybe relevant tool in the future. - this kind of requirement will only improve the creativity to rename programmes not to name it short or automatic and will not solve the problem which does not exist on DWs
2a	Consumers might not use the ECO programme (most efficient for normally soiled tableware) as it is often optimised by **increased programme duration** which is not convenient for consumers (cf. survey results). Also, consumers might believe that short programmes consume less energy compared to the ECO programme.	Cap for maximum **programme duration** of the ECO programme, for example 2 - 4 hours. During the stakeholder meeting and as result of the 2015 consumer survey (60-70%) rather 2 hours were favourized. The 2015 consumer survey reveals that only few consumers (around 5% during daytime, around 20% during nighttime) are willing to accept programmes of 4 hours or more.	ED	Unrealistic cycle times will be avoided. Consumers might use the ECO programme more often if the cap is rather short and convenient (e.g. 2 hours). On the other hand, a more flexible cap (e.g. 3.5 hours) would leave enough freedom for manufacturers for differentiation. The increase of energy consumption, if the programme duration is shortened (see drawbacks), however, should not have an effect under real life conditions as at the moment the (very efficient) standard programme is only used in 22% of the cases. It can also be an incentive for manufacturers to find other possibilities to reduce the energy consumption than just increasing the duration of the cycle. Despite a cap, manufacturers still can offer longer and thus more energy saving programmes (as an	Energy consumption in the ECO programme would increase. Consumers which would generally accept longer programme times would not find programmes which are really saving a lot of energy. If the cap of the programme duration is too strict, machines might not differ any more in their energy consumption. Within the Sinner Circle, the following factors are directly or indirectly limited by current regulations: - temperature: limited due to energy efficiency targets, certain temperature level needed to maintain performance (particular drying); - mechanics: indirectly limited by consumer expectations in regard to noise emission (also depicted on Energy label) - chemistry: EN50242 limits the amount of detergent to a certain maximum amount per place setting Thus, time is the only truly flexible

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				extra/competitive feature). However this should not be the "standard programme" as people are not willing to use it as "standard" if it is too long.	factor left in the development of high performing, energy and water efficient Eco programmes. Other shorter programs can still be offered and selected. New innovation / developments are possibly prevented (e.g. efficient heat pumps need longer programme durations). The accuracy of measuring the rinsing performance has to be increased to avoid workarounds circumvention (the effect could be a reduction of rinsing cycles to reach shorter cycle times, i.e. worse rinsing performance or higher water consumption).
				Additional stakeholders'input: - maximum 2.5 h (it would be good if it was clear for the consumer when the dishing cycle is ready and the machine is only drying) - It should rather serve to avoid excesses (> 5h). If there are 2 standard program (e.g. 'normal' and ECO) the cap could be applied to only one of these, then an a bit a tighter cap might be thinkable. On the other hand it might be an option to inform consumers about the advantages of long program duration. - agreement with a cap for the maximum program duration of the standard program (even if it is not the ECO program) of 2hours	**Additional stakeholders'input:** - The outcome of the consumer survey study does not justify this requirement. Informing consumers on the energy saving potential by using long programmes is a better option. - more potential disadvantages than advantages - If the 'Eco' programme remains the only standard programme and the only one with a time cap, this would create a strange situation: all other programs would have the potential to use less energy (because they can last longer). If the ECO programm must be the most energy saving program, this would prohibit longer duration completely as energy efficiency option. We

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					think it would be better to link a max. duration requirement to a different (standard) programme, but not to the ECO programme. If linked to a 'normal' standard program this is an option for us. - Better not too strict time cap, as it would prevent higher efficiency.
2b	cf. 2a	Information about the maximum (average) programme duration of the ECO programme and/or the most used programm(s) on the Energy Label	EL / CI	Consumers might use the ECO programme more often; better consumer information before a purchase decision; consumers might choose DW with shorter cycle times which might lead to an overall market shift / competition towards machines with shorter cycle times (even more than a cap) and thus stimulating manufacturers to reduce the time, driven by competition, i.e. with other innovations to reach better Energy efficiency classes	Overload of label information; with this explicit information, consumers might choose machines with shorter programme durations resulting in higher energy consumption. The accuracy of measuring the rinsing performance has to be increased to avoid workarounds circumvention (the effect could be a reduction of rinsing cycles to reach shorter cycle times, i.e. worse rinsing performance or higher water consumption).
				Additional stakeholders'input: - Programme time of the Eco programme shall be already communicated in the product fiche, and also for other main programmes in the user manual. If available, it is also depicted via the display. - reasonable way to reduce programme times. Indication of the ECO programme durarion on the label could be a compromise. Requesting only the duration of the ECO programme ont h label would be a possibility to stimulate innova-	**Additional stakeholders'input:** - "Maximum (average) programme duration" needs further clarification. - risk of performance reduction due to the competition on time - Should be combined with developing a standard for measuring rinsing performance, and put requirement on good enough rinsing. - indicating the durationof seveal programmes on the label is likely to distract the attention from the energy efficiency. Consumer might buy

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				tion and competition without confusing the consumer. - Not nessesary on the label. But important to show the consumer the duration of the programmes in the booklet or on the display/machine.	less efficient but quicker DWs.. - even if you would be able to find a technology (eg hypothetically nuclear fusion) with which you are able to clean nad dry quicker and with less energy, these appliances would be much more expensive and the payback point is never reachable for the customer within the product life time. - giving a max programme duration would unjustly favour appliances with a higher amount of programmes.
2c	cf. 2a	Adjust the measurement standard so that long programme times do not longer add benefit to the drying performance as the drying phase is usually responsible for the longer cycle times This could be done by introducing a time cap into the measurement standard when the programme has to end and the evaluation start (e.g. 1 hour after the last water intake or the highest temperature).	SM	Would reduce programme time for ECO programme of today	Still the ECO programme might not be used sufficiently in real life. But risk of circumvention, as this point of the time cap in the measurement is not well defined or can easily be circumvented. Better would be to give the cycle/programme time a high visibility to the consumer at the purchasing state, so those appliances taking long times will not be bought (cf. option 2b)
				Additional stakeholders'input: - Better to assure it is clear when the drying starts so consumers could choose to open then	**Additional stakeholders'input:** - Any type of measurement procedure should be objective and not subjective; it should also not affect performance. - Any "time cap" or adjustment would be counterproductive in regard to energy or performance. - In theory the legislation could set a malus to long lasting programs,

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					but this would entail a degree of subjective evaluation, while objective consumer information is preferable. - According to consumers survey there are more than 30% of consumers for whom longer duration is not a problem. - It might lead to higher temperature (and higher energy use) in the last rinse, in order to reach A in drying performance on a shorter time. - better drying efficiency by longer drying time should not be prohibited. To get rid off moisture in shorter time you have to increase the temperature so that the remaining water can evaporate faster. temperature can only be increased by heating up the DWs, that means higher energy consumption
2d	cf. Option No 2a; also, people do not understand that long programmes can save energy (they assume that longer programmes automatically consumer more energy).	Better / mandatory consumer information about the environmental benefits of a longer programme duration in terms of energy savings (e.g. leaflets, stickers, educational campaigns, …) which also result in economic benefits for consumers when using primarily the ECO programme. Furthermore, more information is needed about using the dishwasher during the night: consumers are aware that electricity may be cheaper, but according to the 2015 user survey, there seems to be some reluctance in using	ED / CI	Consumers might use the ECO programme more often (i.e. overcome the misperception of consumers that longer programmes consume more energy	Consumer information is difficult to be regulated by Ecodesign measurements (cf. ATLETE II results for washing machines with regard to (non-) compliance of consumer information measurements)
				Additional stakeholders'input: - support the development of better information to the consumer in conjonction with NGOs. - Better information on energy saving programmes is necessary but not only the manufactures are responsible for this. Also other stake-	**Additional stakeholders'input:** - Mandatory requirement should be avoided as it creates unecessary burden, also for market surveillances authorties. - rather easy option, but unclear impact.

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		the appliance at night, most probably by fear of accidents. The consumer should be more informed that appliances are safe and that many appliances are equipped with water safety functions (e.g. Aquastop)		holdes should increase their efforts to inform consumer on a sustainable way to use their household appliances. - it could be additional to other measures	
3a	Trend to increasing number of place settings vs. non-increasing households sizes/ loads: The overall trend to higher capacities might compensate (at least partly) the efficiency gains due to their better efficiency classes as the absolute energy consumption of larger machines might be similar compared to that of smaller ones. In addition, the situation could be worse under real life conditions as the real life loading is expected to be rather lower than the declared rated capacity.	Cap for absolute energy consumption independent of the number of place settings (maybe differentiation between tabletop, compact and standard machines might be necessary)	ED	Smaller machines with less absolute consumption in real life; no thrive for bigger machines just to reach a better energy label class. Avoid the increase of ps within a category as it is mainly a marketing argument which consumers are happy to take ('I get one more ps for the same price of the machine' **Additional stakeholders'input:** - Consumption caps are generally welcome to us, as it is a very clear signal and measure.	No clear evidence if this measure is able to affect the market trend to increasing capacities at all. **Additional stakeholders'input:** - The data from consumer survey study shows that, on average, users tend to fill their dishwasher "at full capacity without overloading it". Therefore, cap for absolute energy consumption does not make sense as it would constitute an incentive for consumers to buy smaller appliances, which would lead to an increase of the number of cycle and, in fine, an increase of the total energy consumption. - there cannot be a cap for all programmes but only for the ECO programme, otherwise all programmes would immediately have the same conditions as the Eco-programme and there would be no diversification between the programmes any

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					more. - There is no gain in energy efficiency evaluation by adding an extra place setting. Differentiation is already included in calculation of energy consumption for big and small size dishwashers. Today, Ecodesign requirements and energy label classes are calculated on the basis of energy efficiency, intended as the energy consumption to carry out a specific task or provide a particular service. This represents a balanced approach and should be maintained. - No justification in setting caps for the absolute energy consumption or to introduce malus in the calculation of energy efficiency – to prevent larger appliances from qualifying for the top classes. The choice should be left to the consumer, who buys an appliance due to its performances and features. The legislator should refrain from "over-advising" consumers in this respect. - Ideas like an artificial malus for larger appliances could be even detrimental to the effort of reducing the overall energy consumption. In some circumstances, consumers could be driven to purchase two smaller appliances rather than a larger but more efficient one – which would be badly ranked due to an artificial malus – leading to an increase in total consumption.

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					- It is a rather 'harsh' measure with unclear effect, especially if the real-life-relevance of the declared energy consumption remains unclear. - increasing size / energy consumption is not a big issue in DWs.
3b	cf. 3a	Cap for absolut water consumption independent of the number of place settings	ED	More smaller machines with less absolute consumption in real life	cf. 3a
				Additional stakeholders'input: - Since water consumption is not (or only indirectly) considered in the Label's main message, the efficiency class, a cap might indeed be an option to avoid excessive water use. A cap should be introduced at a high enough level to guarantee a good rinsing performance.	**Additional stakeholders'input:** - The water consumption obtained with current dishwasher technology is already extremely low (eg 6-7 litres per cycle), this becomes particularly obvious when comparing to manual dishwashing. - Any reduction/ limitations would be difficult to obtain and could be counterproductive in terms of performances. Consumer will very likely start to prewash there heavily soiled items again and therefore will waste water and energy - Water consumption is decreasing toghether with the energy consumption and a cap might worsen the rinsing performance if this step is omitted. - Better to develop a standard for measuring rinsing performance, and put requirement on good enough rinsing.
3c	cf. 3a	Different calculation formulae for smaller and larger machines, being stricter for larger machines	ED / EL	The different levels for small and large machines might promote that small households buy more likely small DW (otherwise they might buy	No clear evidence if this measure is able to affect the market trend to increasing capacities at all; the definition of "small" and "large" dish-

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				large DW based on their better Energy efficiency class not knowing that the absolute consumption might be the same or even higher compared to small ones; and in the end the large DW is not appropriate for small households when it cannot be full-loaded).	washers might be reconsidered - today it is based on a combination of width and number of place set-tings
				Additional stakeholders'input: - already done but with bending curves for the largest ones. It's easiest to keep it this way (even if unclear impact). - The SAEc for large DWs is pretty flat, also a horizontal line is thinka-ble. - support to options 3c and 3d be-cause this could promote that con-sumers buy devices with lower absolute energy consumption	**Additional stakeholders'input:** - There is no logical justification to such policy option. Users tend to fill their DWs "at full capacity without overloading it". Therefore, promoting small appliances would be counter-productive in terms of energy effi-ciency. - Strictly linear efficiency definitions always make it easier for larger models to reach better efficiency classes - this should certainly be avoided for DWs. - this requirement does not help to change the situation. 60cm is the most common width for DWs be-cause it is a standard size for kitch-ens. 45cm DWs are more common in countries where flats are smaller. Both dimensions are standardised by the kitchen furniture industry.
3d	cf. 3a	Progressive (bended) curves / calculation of EEI, i.e. stricter for larger machines	ED / EL	cf. 3c	cf. 3c
				Additional stakeholders'input: - sticking to the current formulas would be easier, as increasing size is less of a prolem for DWs than for other products.	**Additional stakeholders'input:**

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				- To keep the current approach of a flatter SAEc for larger DWs should be sufficient.	
4a	The standard load is difficult to reach under real life conditions; also the standard includes heavy soiling. Under standard test conditions, sensors (adapting energy & water consumption better to the real life conditions) have to be switched off.	Take the automatic programme as "standard" programme which adapts the energy and water consumption by sensors to real life loading and soiling. Allow sensors to be switched on during standard measurements.	ED / SM	Real life has normally less soil / less dishes. Machines equipped with intelligent sensors should be able to adapt the programme accordingly and realize savings.	Sensors are not measured in the standard programme performance test so far, i.e. no effect on EEI; sensor use is difficult to measure (reproducibility) - the mandate M481 asks to develop a measurement method that makes sure that the cycle tested is always the same in order to deliver reproducible and repeatable results; In case of heavily soiled dishes the consumption could even increase with sensor use. Price of low cost machines might increase if sensors become mandatory.
				Additional stakeholders'input: - interesting option, but better for the future	**Additional stakeholders'input:** - consumers should be and are encouraged to always fill the available space completely, coupled with the ECO cycle as this remains the best energy efficiency option. -today's Auto programmes in the EU market, has a good adaptation to soil levels and load size (amount of dishes loaded), resulting in a clear differentiation regarding energy and water consumption for different response levels. This could no longer be the case if the automatic programme were to be standardised. Automatic programmes might have up to 90 programmes cycles.

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					- The latest RRT showed that re-peatability and reproducibility of the cleaning and drying results is rather low even with a fixed programme structure; it is assumed that this would worsen for measurements of a sensing programme. - no test standard available - doubts about how much DWs can adapt water and energy consump-tion to the load and especially to the soiling - this would complicate the test procedure very much

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4b	cf. 4a	Sensor use in the measured standard programme(s): Measurement of dishwashers in the standard programme(s) not only with full load and full soil, but also with half load and half soil. Proposal: 3 x full load/soil + 4 x half load/soil	ED / EL / SM	Sensor will be active also in half load cases; better alignment to real-life conditions (according to the 2015 consumer survey, consumers fill their dishwashers at the full volumetric fill, which is assumed to be less than the standard full load). Stiftung Warentest and University of Bonn already conduct automatic programme tests (sensor driven programme) with "half load" as well as less or more soil than in the standard programme.	Increased testing effort (Fall back option could be e.g. 3x full + 2x half). Currently, to use automatic programmes / sensors in the test procedure, cannot deliver repeatable and reproducible results. Consumer studies show that half load cycles are not often used. The IEC 60436 4th edition already better reflects real life user behaviour, e.g. including plastic items, pots & pans. Further, measurements show that for high efficient appliances, the effect of reducing the energy consumption is significantly lower than for less efficient appliances; therefore, half load testing for the declaration would be counterproductive. Having partial loads included in the test procedure might also give a wrong signal to consumers as it may encourage them to use their appliances half loaded.
				Additional stakeholders'input: - Indeed the use of sensors in the test makes much more sense if also half load is tested. - it is more important to include additional programs to the test than half load.	**Additional stakeholders'input:** - This proposal would increase test burden and be costly for market surveillance authorities. - It should not be recommended to use half-load, as half load Eco or half-load normal programme does not consume half of the energy necessary for Eco or normal programme. - the use of half load would clearly

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					favour less efficient DWs because in these DWS the heating phases are longer than in the high efficient DWs and therefore the effect of lower load is higher. It will get more and more difficult to sell high effi-cient DWs.
5	The current EN standard test method does not reflect real life con-sumer behaviour e.g. with regards to com-bined cleaning and drying and plastic items	Align EN test procedure to new IEC per-formance standard	SM	Is a must! The new IEC standard aligns testing conditions better to real-life (e.g. more plastic items etc.)	None
				Additional stakeholders'input: - total agreeement	**Additional stakeholders'input:**
6	The new IEC standard includes a measure-ment method for the rinsing performance, however, without test-ing experiences so far with regard to repeata-bility	Introduce minimum requirements for measuring the rinsing performance within the next few years (issuing a mandate for a standard on rinsing per-formance for DW)	SM / ED	Consumers get a guarantee of a certain minimum rinsing perfor-mance in the standard programme, i.e. energy efficiency gains are not realized at the expense of rinsing performance	Additional testing effort for manu-facturers and also market surveil-lance authorities
				Additional stakeholders'input: - Working on a rinsing performance methode should be intensified, before setting requirements. - Very important! - Rinsing is one of the primary fun-tions of a DW, so a sufficient rinsing performance should be guaranteed.	**Additional stakeholders'input:** - There is no sufficiently reliable test procedure to measure rinsing performance, nor a proper definition of the term. - A clear definition is needed of what is meant by "rinsing perfor-mances": a) getting rid of detergent afetre the main wash b) spots and stains remaingin on dishes. Rinsing performance can not be sufficently/reliably assessed using the standard water for testing, as artificial hardening of water is done with calcium hydrogen car-

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					bonate, which causes water stains. Any other setup/ water for testing would increase test burden. - The link between reducing water consumption and detergent residue on the dishes should not be forgot-ten. This is not part of the proce-dures available. - much more work is needed and as long as there is no consolidated experience on the topic, a min re-quirement for measureing the rins-ing performance is absolutely no possible.
7	Consumers often do not know that a certain minimum cleaning per-formance of the stand-ard programme is man-datory and might mis-trust the performance especially when getting knowledge about longer times in this pro-gramme	Information about the cleaning perfor-mance provided on the label	CI / EL	Confirmation of good cleaning per-formance in standard programme might lead to consumers choosing this programme more often despite knowledge about longer duration	Does only make sense if perfor-mance level of machines differs (but there seems no need to differ-entiate the todays A-class cleaning performance of all machines even more); overload of label information
				Additional stakeholders'input: - Clear information to the consum-ers about cleaning performance is supported. - important to show the consumer cleaning information in the booklet, on the display or on the label	**Additional stakeholders'input:** - It should be considered whether such information should be on the label or only on the fiche. - not needed on the label - The evaluation of the cleaning performance has a high standard deviation according the RRT 2014. Therefore a differentiation of today A-class seems not feasible because otherwise the standard deviation is bigger than the width of the clean-ing efficiency class. Therefore the cleaning performance should remain as a min requirement in the ED

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8a	Standby consumption is covered by Ecodesign regulations 1275/2008 and 801/2013 on standby/networked standby anyway; low contribution to total energy consumption	Leave standby-values totally out of the calculation formulae	ED / EL	Simplyfies the measurement which saves costs for manufacturers and market surveillance authorities	The energy consumption of the standby modes might be enough - at the annual level - to pass from one energy efficiency class to another (if not taken into account any more)
				Additional stakeholders'input: - due to the requirements of Regulation (EC) No 1275/2008 the contribution of the low power modes are already limited (<4kWh/year) so the risk that appliances are just shifted to the next efficiency class is reduced. Most of the Dws are defined just to reach the class but not to just miss it by 4 kWh/year.	**Additional stakeholders'input:** - Appliances' consumption levels for the low power modes should be below the threshold specified in the relevant regulation, without claiming for exceptions. -This should be adressed within the framework of the new standby regulation. - Standby energy consumption has only a minimal effect on the displayed energy consumption and makes the calculation much more difficult to understand for the consumer and to assess for the manufacturer. Should be left out. - It should be aligned with the regulation of washing machines - the formula can be simplied, and it allows to go to a per cycle basis for energy declaration
8b	Delay start is not covered by Standby-regulation as it is not an "unlimited" mode; delay start might become relevant in context of smart appliances / smart-grid-ready appliances	Include delay start mode into standby measurement / calculation of machine's total energy consumption	ED / EL / SM	Might avoid delay start modes with high wattages. Assuming 8 hours delay for each cycle with 5 or 10 W could contribute between 10 to 20% to the total annual energy consumption.	This mode only is assumed to have only minor contribution to the overall energy consumption of the machine. May lead to a less acceptance of delay start-mode. Higher test burden (for manufacturers and market surveillance authorities) if measurement in an extra test cycle would be needed.

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				Additional stakeholders'input: - It need not go into the EEI / consumption calculation formula, but should be covered by an ecodesign power cap.	**Additional stakeholders'input:**
8c	cf. 8b	Set MEPS / power cap for delay start mode as it is the case for standby mode	ED	Avoids delay start modes with high wattages. Assuming 8 hours delay for each cycle with 5 or 10 W could contribute between 10 to 20% to the total annual energy consumption.	This mode only is assumed to have only minor contribution to the overall energy consumption of the machine. May lead to a less acceptance of delay start-mode. Higher test burden if measurement in an extra test cycle would be needed. Ideally, this mode would also be covered by the horizontal Ecodesign regulation(s) on standby (Regulation (EC) no 1275/2010 and 801/2013)
				Additional stakeholders'input: - Horizontal regulation would be an option. Networked standby could be included here. From other products (e.g. settop boxes, UHD TVs) we know that if the power of standby modes is neither declared nor capped or anything it can reach very high values (e.g. 20 or 30W), because nobody cares. Therefore, precautions should be taken.	**Additional stakeholders'input:** - in the delay start mode the consumer wants to stay informed about the remaining waiting time so some indication has to be provided. A little bit higher consumption value should be allowed to provide the information to the consumer. This timely small increase in energy consumption will be largely compensated by the cost saving of using energy at a lower tariff or green electricity during the programme run
8d	cf. 8b	Provide "allowances" on delay start consumption for DW with smart-grid functionality (at least for a certain time of market introduction)	ED	Smart-grid ready appliances are an important instrument within the total energy transition system and thus should be favoured; too strict limit values might hinder product innovations	No standards / no real smart grids available yet. Demand-response ability does not make the appliance more efficient. Allowances for certain functions should be avoided as far as possible

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					within Ecodesign; also, using the EU Energy label for promoting these functions of smart appliances would not be compatible with the primarily role of the label (information tool for consumers on energy efficiency and selected other aspects which have a direct impact on operating costs such as water consumption, or which are relevant because of convenience issues, such as noise level). Networked standby should ideally be covered by the horizontal Ecodesign regulation on standby/networked standby; new product innovations should comply ideally with existing energy efficiency targets.
				Additional stakeholders'input: **-** Important not to give allowances in order not to increase energy consumption.	**Additional stakeholders'input:** - It would be better to tackle this in the framework of the standby/network standby regulations. - strange: 2h are max. accepted for the programme duration, but for delayed start many hours are accepted. Better to allow 5h programme time - this would enable real energy savings!
8e	cf. 8a/8b	Set MEPS / power cap (e.g. max. 2 W) for any other standby-modes of dishwashers in case they are not covered by existing Ecodesign regulations 1275/2008 and 801/2013 so far, e.g. in the context of smart-grid functionality	ED	The introduction of smart-grid appliances (or other functionalities) should not lead to an overall increase of the energy consumption only due to the supply of this functionality	Smart-grid ready appliances are an important instrument within the total energy transition system and thus should be favoured; too strict limit values might hinder product innovations.

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					Ideally, these modes would also be covered by the horizontal Ecodesign regulation(s) on standby (1275/2010 and 801/2013)
				Additional stakeholders'input:	**Additional stakeholders'input:** - double regulation should be avoided - maybe problematic because the modes are not well defined.
9	A large part of the dishwashing impact is due to consumers' **pre-rinsing** of a lot of items (see results of consumer survey)	Mandatory consumer information on ecological drawbacks of **pre-rinsing**	ED / CI / (EL)	Consumers might less pre-rinse	Overload of (label) information might lead to no effect in the end
				Additional stakeholders'input: - Most manufacturers already inform consumer that pre-rinsing is not necessary and should be avoided. - Link to CECED specific page on good use of DW: http://www.ceced.eu/site-ceced/media-resources/Consumer-Tips/Dishwashers.html. - include to the best practice list mentioned below - this could be a standard formulation for the manual, no need to be on the label	**Additional stakeholders'input:** - overloading of the label
10	Nearly all DW do have a possibility to connect the machine directly to the hot water tap; in practice, this option is rather seldom used	Mandatory consumer information on **hot fill option** (e.g. symbol on EL for hot fill connection; further consumer information under which conditions hot fill is beneficiary)	CI / EL	For DWs, a direct connection to the hot water tap could be beneficiary in terms of overall electricity savings; with better consumer information, this option might be used more often as consumers might not be aware of this electricity saving option.	Overload of (label) information might lead to no effect in the end; might still be difficult to understand and implemented by consumers. Benefits will only be realized depending on the type of heating system in the house (e.g. renewable sources) and the length of the pipe, i.e. hot fillings linked to unproper hot

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				Normally the hose is not long as hot water storage is close to taps and the kitchen anyway.	water systems (e.g. a circulator) can increase the energy consumption. For those consumers explicitly looking for those types of appliances, the information of hot water supply is already available in the manual at the point of sale.
				Additional stakeholders'input: - Other option could be to indicate this information in the fiche. - Mandatory information in the booklet, not on the label. - An icon would be easier, renewables are on the rise, so htis could inform consumers about this option. - Perhaps a small mandatory symbol on the label and detailed information in the manual could be a solution.	**Additional stakeholders'input:** - This policy is not appropriate as benefits depend on the heating and plumbing system. - Such information is not relevant for all consumers. - Having it on the label would overload the energy label while this information is already available in the user manual. - Also you might not get full benefit of the detergents, as some work best at lower temperatures. - Too complicated to be completely displayed on the label. - recommendation of the Australian government suggests not to use hot water in DWs if the water feed is too long and the water is heated up with other means than renewable energy.
11a	Current consumer survey reveals that the EU average number of use cycles is still near to 280 cycles/year; these are average and theoretical numbers for relative comparison of	Keep number of annual cleaning cycles (280) as they are	ED / EL	continuity; better understandable in terms of annual savings	For smaller or larger households these average numbers do not represent their individual behaviour (cf. Consumer survey results)
				Additional stakeholders'input: - agreement	**Additional stakeholders'input:**

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	machines				
11b	cf. 11a	Indication of total energy consumption per cycle, not annual average consumption. Alternative: to keep some differences visible, it could be declared per 100 cycles	ED / EL	Better understandable and scalable for consumers. The choice of the Latin expression "kilowatt hours per annum" alleviates the burden of expressing "yearly" in all the languages of the single market. In a survey 2012/2013 of 1,006 German consumers, more than 70% did not understand correctly (or did not understand at all) the meaning of "per annum" on the energy label. In the 2015 consumer survey, the option of providing the consumption value "per cycle" was reached an importance of around 60%, whereas the option "per annum" reached an importance of around 40%. "Per cycle" communicates more clearly that the energy consumed depends on usage.	The consumption values (kWh and litres) are already at a very low level; differences between machines (decimal places) might become insignificant for consumers whereas yearly consumption values deliver greater numbers, where differences between appliances become more obvious and easier to quantify by users (in favour of energy efficient appliances). Coherence with the energy labels of other products would be omitted as for all other products the consumption is indicated per year.
				Additional stakeholders'input: - Both! information about both annual average consumption and total energy consumption per cycle would be beneficial on the label (or otherwise in the booklet). - It is not the Label's purpose to allow for a cross-product category comparison. We favour a per cycle declaration, and this would also facilitate the declaration of semi-pro DWs.	**Additional stakeholders'input:** - indicating the saving potential per year is also clearer than per cycle.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
				- Better per cycle, differences are still visible, per 100 is already less clear.	
12a	Consumers do not use the appliance in its best way (programme choice, loading, detergent dosage, pre-rinsing,...)	Develop an agreed list of Best Practice Tipps and include them as 'Beipackzettel' (= product insert, instruction leaflet) to each machine. Proposals include: - Advice to full load whenever possible - Advice that programmes at lower temperatures save energy; - Advice to use the pre-wash programme only when needed - Advice on the best use of rinse and hold options if applicable; - Advice to adjust salt dosing with regard to the local water hardness; - Advice on the correct installation in order to minimise the noise emitted; - Advice on correct maintenance of the dishwasher such as cleaning of the filter; - Advice on whether the machine can be operated with hot-fill water or not;	CI	If branded by EU it will give some confidence in the best way of using the machine; improved consumer behaviour, thus realising further efficiency potentials	Additional costs, also for compliance checks; overload of information might lead to no effect in the end
				Additional stakeholders'input: - Interesting proposal, industry is ready to cooperate with NGOs - Even though this is written already in many consumer manuals this information should be provided in many different ways. - It does not mean high additional costs because these should be general advices which are almost equal for each dishwasher.	**Additional stakeholders'input:** - Additional effort is very small - CECED has alrady created a list of Best Practice Tips and is available at CECED webpage. It is a summary of all user manual advices of all manufacturers. This request is already fulfilled since years
13a	In general, consumer information requirements are difficult to be regulated by Ecodesign measurements (cf. ATLETE II results for washing machines with regard to (non-) compliance of consumer information measurements)	Introduce a template for the most relevant information requirements of the main programmes (e.g. consumption per cycle, programme duration, ...)	ED/CI	Easier to fill out, easier to check compliance; facilitates better comparability between programmes and/or appliances for consumers	Not all the consumers would consider the same pieces of information as relevant. If more performance data of additional programmes are provided, they may need to be veryfied, thus more testing would be necessary. A way is needed to ask for declaration without verification of the values.
				Additional stakeholders'input: - The layout could be standardized - If a way for declaration without verification can be found the addi-	**Additional stakeholders'input:** - Manufacturers should be free to maintain different names and amount of information.

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
				tional information might be helpful. - a simple standardised table in the beginning of the booklet giving the most important facts of the machines and some programmes (duration, temperature, energy use etc)	- The way the communication is provided should not lead to additional burdens. - Today's situation is that a manufacturer can provide the data either in the user manual, the short manual, a CD/DVD or anything delivered with the appliance. If the template has to be copied exactly like predescribed the information might be part of the user manual and not on the short manual any more which could have been used in a faster way
13b	cf. 13a	Use of a QR code to provide consumer information	ED/CI	Modern form of consumer information, more flexible; might address younger consumers better	Not all consumers have access to this kind of information tool (QR-code reader necessary)
				Additional stakeholders'input: - Manufacturers are open to consider this policy option.	**Additional stakeholders'input:** - Should be decided by the manufacturer or seller and not be obligatory. - QR code should be for standardised information for all products, not for random information. Not enough evaluated. Source of least importance to today's consumers. - other alternative technologies should be considered
13c	cf. 13a	Compulsory information via the display of the appliance when the programme is chosen	ED/CI	Modern form of consumer information, direct feedback and influence possibilities	Not all appliances are equipped with a display so far; communication such information can only be done with special displays (TFT e.g.). Such indications would be subject to certain tolerances which would make to only rough estimations; the more accurate it is required to measure,

No.	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					the more costly would be the technology to measure. Significant raise of the appliance prices expected, especially on low range models; would not help improving resource efficiency (more materials needed for display); impact is not clear (if consumers are really changing their behaviour).
				Additional stakeholders'input: - Compulsory on display or on the machine: information about duration and possible when drying cycle starts - More information on the display when a certain programme is chosen seems to be the most effective way of consumer information..	**Additional stakeholders'input:** - This is not feasible for most displays. Besides, many models do not have a display. - Disadvantages prevail. - difficult to implement

8.5. Annex V – Full list of policy options for household dishwashers regarding material resource efficiency

Table 8-15 provides a full list of policy options for household dishwashers. The policy instruments addressed are the Energy label (EL), generic and/or specific Ecodesign-measures (ED), standards and measurement methods (SM), as well as consumer information (CI) measures.

Table 8-15: Full list of policy options for household dishwashers regarding material resource efficiency

No	Rationale	Possible Policy Measures	Addressed policy instru-ment	Expected benefits	Potential disadvantages, challenges and/or drawbacks
1a	**Unsatisfactory me-chanical robustness / durability** of certain components and/or the whole appliance which lead to early failure rates There are standards on safety that could be used as starting point to handle such aspects.	Requirement on **performing durability tests of certain components** which are known to be prone for early failures	ED / SM	Decreased failure rate of appliance components	No clear evidence of certain compo-nents which usually fail more often (might be different from appliance to appliance); high effort / costs for testing; quality of just performing tests might be variable from manu-facturer to manufacturer; testing alone would not lead automatically to higher durability **Additional stakeholders'input:** - Measurement standards need to be available and the feasibility (costs and time) for manufacturer and market surveillance need to be considered, application of EN 60335-1 in general and EN 60335-2-7 for washing machines might be a first step. - security tests are not suitable for endurance testing due to their dif-ferent testing purpose (conditions for safety testing mostly do not reflect normal use) Compared to a whole device, testing of components may be easier but

No	Rationale	Possible Policy Measures	Addressed policy instru-ment	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					does not secure prolonged life time of the whole product .- is a fall-back option if testing of the whole product (2a) turns out to be not reliable or too costly - durability of product is highly in-fluenced by usage paterns of con-sumers (place of installation, fre-quency of utilisation, maintenance etc.). - manufacturers should be free to make strategic choices according to the brand image they have or they wish to develop. This allows for a large offer of brands and price lev-els on the EU market from which the consumer, according to his wishes, expectations and purchasing power, can make the most appropriate choice. - there is no proof of early failures of certain components (cf UBA Study on Obsolescence - Intermediary report). - an assessment of what have been done for vacuum cleaners should be done before to impose it for new products. - safety standards are not the right tools to measure durability and

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					lifetime. - high effort / costs for testing, not only for manufacturers but also for market surveillances. - supporting the activity of CEN/CENELEC's Ecodesign Coordination Group TF 4: all requirements which are mandated under the draft standardisation request on material efficiency aspects to CEN/CENELEC and lead to a harmonised standard, will be accepted.
1b	cf. 1a	Requirements on a **minimum operational lifetime** of certain components which are known to to be prone to early failures	ED / SM	Decreased failure rate of appliance components	Measurement standard needed; high effort for market surveillance authorities **Additional stakeholders'input** - does not hinder breakdown of a device due to other failure parts. Harmonised testing standards are needed. - should be favoured over option 1a - there is no definition of "operational lifetime" available.
1c	cf. 1a	**Consumer information on the operational lifetime** of certain components (e.g. motor)	ED / SM / CI	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this as a competitive argument	Claims on operational lifetime must be backed with verifiable durability tests (not only marketing instrument); does not ensure that other components / the whole appliance are defective due to other reasons

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					Additional stakeholders'input - risk of market distortion and consumer misinformation if not massively controlled by market surveillance authorities. - such detailed information might not influence consumers when making their purchase decision but is a fall-back option if 2c turns out to be not reliable - this type of requirements is dependent on the availability of standardised methods and definitions
2a	cf. 1a	Requirement on **performing durability tests of the whole product** (e.g. endurance tests; and/or tests for extraordinary constraints like shocks, vibratio, accidental drop, high temperatures, water, ...)	ED / SM	Decreased failure rate of appliances	Specification of typical extreme stresses for those appliances needed; measurement standards needed; high effort / costs for testing; quality of just performing tests might be variable from manufacturer to manufacturer; testing alone may not lead automatically to higher durability **Additional stakeholders'input** - does only make sense in conjunction with requirements on minimum lifetime of the whole product. Testing conditions should reflect standard conditions. - the time required to test lifetime can be prohibitively expensive for manufacturers and market surveil-

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					lanc - should be favoured over option 1a - by no means, it can be compared to durability tests. Indeed, durability tests cannot be performed under extreme conditions, but should be close to the average usage partterns of consumers. - there are currently no available standards to test whole devices
2b	cf. 1a	Requirements on a **minimum operational lifetime** of the whole appliance (e.g. machines to run a minimum number of cycles)	ED/SM	Decreased failure rate of appliances	cf. 1b; further: market intervention which might hinder/prevent innovations; few incentives for manufacturers to design the appliance beyond this mandatory minimum lifetime; disadvantage for those manufacturers providing already better quality (as market surveillance might not be effective enough to override bad quality products to a large extent); must be combined with legal rights for consumers to claim if the minimum lifetime is in practice not reached **Additional stakeholders'input** - Testing conditions need to reflect normal use patterns which means that testing procedures are lengthy and expensive. This bears significant risk of market distortions as market surveillance

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					authorities cannot manage this task, let alone in a timely manner. Infringers would not have to fear prosecution. - even if it would be set at 50% of the Average Expected Product Lifetime (AEPL), it is more crucial that it can be repaired if it fails after the minimum operational lifetime has expired.
2c	cf. 1a	Consumer information about the **expected operational lifetime of the whole product** (e.g. label, manual)	ED / SM / CI / EL	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this information as a competitive argument	cf. 1c **Additional stakeholders'input** - this would probably not lead to an additional benefit for the consumer because also manufacturers of rather low priced appliances would probably not indicate a shorter expected operational lifetime, and until standards are available to test this, it cannot be enforced. Poor quality device manufacturers could say depends on usage: e.g. lifetime 10 years …when used once a week. - must be easily understood and not misleading, based on a solid measurement standard corresponding to the one for energy consumption? Could include information on certain components (1c)

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
3a	**Wrong user behaviour leading to defects** of appliances (e.g. incorrect use, insufficient maintenance)	**General consumer information about correct use and maintenance** of appliances	ED / CI	Decreased misuse, decreased defects of appliances	Those consumer information is already mostly available in the manuals; is does not generally prevent consumers from misuse (precondition is that they read the information at all and act accordingly) **Additional stakeholders'input** - in general manufacturers provide information about the correct use and maintenance of appliances in the user's manual. Also trouble shooting information is included. - a standard format could help enforcement of such requirements
3b	cf. 3a	Compulsory **direct feedback** on necessary maintenance intervals via the machine's **display**	ED / CI	Possibly more regular maintenance done by consumers	Not all appliances are equipped with a display so far; communication of such information requires special displays (TFT; text to be displayed) and a sensoric which measures the next maintenance interval to be necessary (e.g. counting number of cycles); significant raise of appliances prices expected especially in the low-price segment; impact is not clear (if consumers would really change their behaviour) **Additional stakeholders'input** - compulsory feedback will not ensure consumer maintenance actions. - there is no proof that consumers

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					will implement the feedback of the machine, as, often, maintenance implies extra-costs which can be high compared to the initial price of the product. - such messages risk to disturb consumers and would increase resource usage. Maintenance by a technician is not necessary. - not all aplliances have displays; making such feature compulsory would imply extra costs. There would also be additional extra costs due to the technology necessary to monitor the user behaviour. - this service is a competitive feature
3c	Early replacement of appliances due to **changes in consumer preferences and needs** (e.g. larger / newer products, design, …)	**Consumer information about the environmental (and economic) benefits of prolonged product use** (e.g. campaign, sign on the appliance etc.)	ED / CI	Might reduce early replacements by consumers	No clear evidence of the impact; consumers might have still other predominant arguments / reasons for exchanging products **Additional stakeholders'input** - this is rather a general issue for which general information campaigns could be appropriate. - educational effects might be limited. - 30-40% of large appliances are replaced by consumers while they

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					are still functionning. Therefore, proper information on disposal and more efficienct WEEE collection/recycling should be the priority.
4a	In case of a defect, appliances are increasingly discarded although a **repair** might have increased the lifetime; reasons might be e.g. a certain product design impeding repairs, missing and/or no access to spare parts, high costs for repairs compared to purchase of a new product etc.	**Design for upgrades and repairs**: components being prone to early failures should **not be designed in a manner prohibiting repairs** (e.g. high integration of different components)	ED	Modular design facilitates repairs in a cost-effective manner: otherwise whole component groups might have to be exchanged in case of a defect of only a single component which is more costly	Modular design might be more expensive. No clear evidence of certain components which usually fail more often (might be different from appliance to appliance); market intervention possibly hindering innovations; highly integrated components might have advantages themselves (e.g. better quality of the whole component group due to integration) **Additional stakeholders'input** - manufacturers offer after-sales service and thus are familiar with requirements of repair, which are part of the design considerations. Reasons for not repairing are different and cannot be addressed by ecodesign in their entirety. Evaluation of design options with regard to enabling / prohibiting repairs would be challenging. - this requirement would need to be specificly aimed at certain components to be effective. - there is no clear evidence which components usually fail more often. - accessibility for repairing is an

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					aspects that can be verified. This can be verified via the provision of a disassembly report (similarly to the dismantling report used for the recyclability), or limiting non-reversible fastening for some key components
4b	cf. 4a	**Design for upgrades and repairs**: components being prone to early failures should be **easily accessible and exchangeable** by the use of universal tools	ED	Facilitates repairs in a cost-effective manner	No clear evidence of certain components which usually fail more often (might be different from appliance to appliance); high effort / costs for testing / market surveillance; "easily accessible" should be well defined **Additional stakeholders'input** - this is already the case. However, early failures of products are covered by the warranty and defects liability regulation.
4c	cf. 4a	**Appliance internal failure diagnosis systems** to report error specific messages to the user	ED	Digital pre-diagnosis of the specific failure would reduce duration and costs of repairs	Not all appliances are equipped with such a system and display so far; communication of such information requires special displays (TFT; text to be displayed) and a system which recognizes the kind of failure; significant raise of appliances prices expected especially in the low-price segment; impact is not clear) **Additional stakeholders'input** - this is particularly relevant for electronic control systems, which may make finding defects difficult for repairers. - seems to be more important to us

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					that external diagnostic tools are available also to independent repair operators who can also understand the error codes - relevant information is already given for most of the appliances.This information should target the after-sale services.
4d	cf. 4a	**Information requirements on reparability** (e.g. repair label), e.g. 1) indicating if the machine can be repaired or not; 2) indicating which components are not reparable	ED / CI / (EL)	Transparency for consumers; they might choose products being better reparable or which contain e.g. modular components	1) Manufacturers would always claim reparability; difficult to define / measure, i.e. difficult to prove non-compliance (standard needed) 2) Difficult to define; in general, most components will be reparable or exchangeable - cost factor **Additional stakeholders'input** - this kind of self-declared claims is prone to creating market distortion - first a respective methodolgy for assessing the reparability would need to be established at the European Level. A first step should be 4e and 4f providing most benefit for the consumer. Even if an old product is repairable, if the costs of repair are 150 euros, purchasing a new product may be more desirable for the consumer. - requires a comprehensive standard such as ONR 192102. It does not

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					say if repair is costeffective measure. Maybe it should refer only to non-destructive dis- and re-assembly so that key components can be replaced (see 4b)
4e	cf. 4a	**Consumer information about access to professional repairs** (e.g. information in user instruction / manufacturer's website / on the appliance itself to let the user know where to go to obtain professional repairs and servicing of the product, including contact details)	ED / CI	Facilitates the possibilities for repairs	Those consumer information is already mostly available in the manuals; (precondition is that they read the information at all and act accordingly); it does not generally prevent consumers from not repairing the devices as other reasons might play a role (e.g. costs of repairs, inconvenience of long waiting times); often only authorized repair shops listed which might be more expensive than independent ones **Additional stakeholders'input** - it seems questionable if such requirements should be set on a product by product case or if an overarching respectively horizontal regulation would be more advantageous - a standard format could help enforcement of such requirements - such information is already provided by manufacturers. Repairs should always be undertaken by properly qualified repair service personnel. - manufacturers provide repair doc-

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					umentation/software to recognised repair services that are qualified to undertake repairs safely. For safety and liability reasons, it is crucial that no obligation is set to make repair and disassembly information available to end-consumers. - the repair of products needs appropriate technical skills that most consumers do not have.
4f	cf. 4a	**Information about the availability (and price) of spare parts** (current practice: from 0 to 10-15 years after production)	ED / CI	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this information as a competitive argument	Price indications are variable and dependent on several factors; costs for spare parts is only one factor of the total costs of repair (labour costs, travel costs); indication of prices in advance might even discourage consumers from doing repairs **Additional stakeholders'input** - detailed documentation of spare parts availability should be reserved to professionals. A general information, in principle, would be feasible. However, it would be difficult to verify the claims and false claim would endanger producers with a strong performance (and high costs) in this field. - is a key prerequisite for reparability and should be favoured over e.g. 4d and 4e

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					-Prices of spare parts do not only depends on manufacturers but also on independant repairs centers. - several pieces of legislation, in particular REACH, can also negatively affect the possibilities to repair products. As contrary to RoHS Directive, where the principle "repair as produced" is foreseen as a legal provision, within REACH this principle is not implemented. It is essential to provide equivalent items to ensure the repair is safely done. However, due to the frequent addition of substances to the Authorisation and Restriction lists of REACH, the production of spare parts could be limited. - the issue becomes even more complex when are considered the current discussions on the review of ecodesign requirements for fans and other products integrated into products. In this case, exemptions have been proposed for a limited period of time for spare parts - it is not easy to check the claims of availability (and price) of spare parts. This could be helped by on-going standardisation works.

No	Rationale	Possible Policy Measures	Addressed policy instru-ment	Expected benefits	Potential disadvantages, challenges and/or drawbacks
4g	cf. 4a	**Guarantee of public availability of spare parts** for a certain period follow-ing the end of the production of the model; ensure original and backwardly compatible spare parts	ED, EL, CI	Facilitates that products can be repaired for a long period and by repair centres which are not manu-facturer-bound	Costly for manufacturers to hold a stock of spare parts for a long time; for longlasting large household ap-pliances, this period might be at least 5 years to cover early breaks, but up to 10-15 years; environmen-tal benefits not clear (if spare parts are not needed in this period, the might be destroyed without being used); **Additional stakeholders'input** - a guarantee bears the risk of 1) changes in the policy framework (see above) and 2) an oversupply of spare parts that become WEEE at a later point in time. - need for a detailed investigation of costs and effects of this option - should be favoured over mere information requirements such as in 4f
4h	cf. 4a	**Repair manual: clear disassembly and repair instructions** to enable non-destructive disassembly of product for the purpose of replacing key com-ponents or parts for upgrades or repairs. **Information publicly available** or by entering the products unique serial number on a webpage **to facilitate access for recognized / independent repair centres**. A diagram of the inside	ED	Might decrease of repair costs for consumers if independent repair organisations and approved re-use centres have information access and are able to perform repairs	Accountability (e.g. safety, lifetime, guarantee) and confidentiality of manufacturers might not be ensured if information is public available / non-authorized repair centres can do the repairs **Additional stakeholders'input** - repair manuals are available for approved service providers. Those

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
		of the housing showing the location of the components available online for at least 5 years			undergo specific in-house training programmes in order to secure the consumer satisfaction after a repair, which implicitly is part of maintaining the brand value. Public availability bears the risk of abuse causing liability issues or damage to consumers - the repair manual should be available for repair centres. Having access to electronic repair software may be more relevant to repairers as dishwashers become more electronically complex.
4j	cf. 4a	**Commercial guarantee** providing a minimum of 3 years guarantee effective from the purchase of the product during which manufacturers shall ensure the goods are in conformity with the contract of sale (without passing the burden of proof to the consumer). It includes **service agreement** with a pick-up and return option.	ED	Manufacturers might improve the quality of their products to prevent claims	Costly for manufacturers; risk that costs are transferred to the total product purchase price; risk that appliances (especially low-cost) would be replaced by a new model instead of being repaired; for the long-lasting large household appliances, 3 years are quite a short time. **Additional stakeholders'input** - two types of guarantees are existing : the legal guarantee (2 years of conformity set by the 1999 Directive) and the commercial guarantee which is a service offfered by manufacturers/retailers to their customers on competitive markets. Guarantees should not be tackled under ecodesign and should remain

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					under the solely responsibility of DG Justice. Existing rules on commercial guarantees have prooven their efficiency in ensuring a high-level for protection of consumers.
4h	cf. 4a	**Mandatory consumer information about commercial guarantees**, i.e. the number of years the producer guarantees the full functioning of the appliance for free and without passing the burden of proof to the consumer	ED / CI	Transparency to consumers; they might choose higher quality products; manufacturers can actively use this information as a competitive argument	**Additional stakeholders'input** - those information are already available in the contract signed by a consumer byuing the appliance. The 1999 Directive sets minimum requirements at EU level, with the possibility for Member States to increase the protection at national level : 2 years of period of conformity and 6 months of the reversal of the period of the burden of the proof - any commercial guarantee applied by a manufacturer is part of its commercial strategy and thereby de facto a competitive issue. We take for granted that any manufacturer offering additional commercial guarantees will highlight this in its communication towards the consumer as it differentiates him from competition.
5a	**The design of appliances can influence the practicability of recycling facilities at the EoL** according to WEEE requirements (dismantling	**Design for recovery and recycling** which allows better / easier access to dismantle / separate WEEE relevant components or components containing valuable resources	ED	These requirements are devised to help recyclers to better comply with the WEEE directive by providing information relevant for depollution, disassembly and or shredding operations	Measurement standard needed otherwise it would be too generic; high effort for manufacturers and market surveillance authorities **Additional stakeholders'input**

No	Rationale	Possible Policy Measures	Addressed policy instru-ment	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	of certain PCBs, displays, refrigerant containing components like heat pumps etc.) or to recover valuable resources (e.g. rare earth elements in permanent magnets of motors)				- current technologies involve only a minimum of manual labour in dis-mantling, mainly for depollution. Thus design has a limited influence on this stage of the life cylce. Fur-ther, future technologies in WEEE treatment cannot properly be antici-pated in the design phase - this is a very general formulation. As in the case of the TV revision, specific components should be named, e.g. printed circuit boards etc. Components with particular environmental relevance (and reus-ability?) should be easy to separate from the machine: e.g. heat pumps, permanent magnet motors. - setting a dismantling description would be meaningful only if prod-ucts were actually dismantled in the prescribed way at the end of life - PCB of domestic appliances is not comparable to those of ICT, having a lower content of copper and precious metals. This makes measures in this field less effective than some stud-ies suggest - recycling is following price signals in the up taking markets and the level of material recovery (in a broad sense) depends more on the profita-bility of the recycling activity than on

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					parameters the producers of products can influence by design.
5b	cf 5a	Clear **marking of** special components and/or identification of **appliances with heat-pumps** (recyclers of category 1 waste (large household appliances") are not always certified to also treat appliances with refrigerants)	ED	Better transparency for recycling facilities to treat separately refrigerant-containing appliances	New WEEE categories will be introduced from August 2018 which restructures large household appliances with refrigerants into another category (temperature exchange equipment) **Additional stakeholders'input** - with the new F-Gas Regulation 517/2014, new labelling requirements on gas contained in appliances (including heat pump) have been put in place (cf. Article 12). Those new labelling requirements are sufficient for recyclers to identify appliances relying on gases to allow temperature exchanges, like heat pump tumble dryers
5c	cf 5a	Clear **marking of appliances** with permanent magnet motors containing **rare earth elements**	ED	A clear marking would facilitate the motors being manually removed before a subsequent shredding process and separately treated to improve the recycling potential of the rare earths which would otherwise be lost	Might have no relevance if not or nearly not applied to a large extent to motors of WM/WD/DW; only effective if such motors are treated separately in the recycling facility **Additional stakeholders'input** - should be aligned with the proposals on the same issues for the motors and fans regulation

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
5d	cf 5a	**Marking of plastic parts containing hazardous substances** (e.g. halogenated flame retardants); example: brominated fire retardants logo as proposed in the ED draft for electronic displays	ED	Might improve to get recyclates without hazardous substances (avoid contamination)	Effective only ifit is possible to separate the recycled plastic streams (those free from hazardous substances) **Additional stakeholders'input** - this faces a number of issues as in the televisions lot. A minimum threshold must be set and all components must be checked for compliance by market surveillance. Br-free logo implies no retardants in device, however small fittings or cables may still contain these. Testing is difficult for market surveillance to carry out. Large parts with markings may be useful, but it depends on recycling regimes (shredding or manual separation). Is the future more likely to be automated separation by shredding? - should be aligned with the proposals on the same issues for electronic displays regulation
5e	cf 5a	**"End-of-life report"** for recyclers containing information relevant for disassembly, recycling and recovery at end-of-life at least on exploded diagram of the product labeling the targeted components defined together with a documentation of the sequence of dismantling operations needed to access to the components	ED	These requirements might help recyclers to better comply with the WEEE directive by providing information relevant for depollution, disassembly and or shredding operations	In the daily recycling practice such documents might not be used at all. **Additional stakeholders'input** - feedback from recyclers signals that any written documentation had little value for the recycling process. Our experience with this kind of information is that it has not been asked for since years, though specif-

No	Rationale	Possible Policy Measures	Addressed policy instru-ment	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					ic diagrams were available.
5f	cf 5a	Declaraton of the **recyclability index** for products indicating the share of recyclable materials, as for example proposed in the ED draft for electronic displays	ED	Transparency, market differentia-tion of machines	Well developed and widely accepted procedures needed; so far only a theoretical number as the real treatment of the specific appliances and thus their recyclability depends of further factors; does not help to improve the real recycling process **Additional stakeholders'input** - there is no consensus about the recyclability of single materials; this currently is item to research and should be subsequently item to standardisation. The declaration would not be relevant for consum-ers, but invite freeriders for provid-ing unrealistic values that cannot be verified - recyclers should be asked if this is useful; for consumers it is not likely to be major selling point, whilst the recycling rates for washing ma-chines are already fairly high - added value of this information needs to be verified as it does not guarantee recycling of certain mate-rials in real life. As an aggregated index it might be too simplistic com-pared to targeted measures to pro-mote recovery of key materials

No	Rationale	Possible Policy Measures	Addressed policy instrument	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					- this type of requirements was discussed within the first draft of electronic displays. However, it is still affected by problems for verification. For this reason it was not included in the last version of the draft regulation for electronic displays.
6a	**Effectiveness of EoL efforts only if proper collection and treatment of appliances after use is ensured.** Ongoing standardization activity within CENELEC in collaboration with recyclers that covers collection, transport, storage, separation and recycling of the product	Require the **mandatory application of the standard** that CENELEC is developing	ED	Activity supported by industry	A standard is not yet available **Additional stakeholders'input** - not clear if this standard refers only to collection and treatment of waste products or if it addresses product design. Only in the latter case it could be interesting to derive specific information or design requirements.
6b	cf 6a	Require the **mandatory presence of a code / chip to track the appliance**	ED	Possible track of the appliance	Availability of tools and infrastructures; does not solve the issue alone **Additional stakeholders'input** - could be useful to promote enforcement of WEEE obligations or to transfer information to recyclers, but the practicability needs to be tested in real life - due to the long life of white goods, it cannot be guaranteed that the tags will still be on appliances and that it will be useful. In the daily recycling practice such code/chip

No	Rationale	Possible Policy Measures	Addressed policy instru-ment	Expected benefits	Potential disadvantages, challenges and/or drawbacks
					might not be used at all.

Added stakeholder proposal:

7. Specific requirements focusing on **reuse** could be beneficial. Some of the previous requirements (e.g. 3a, 3c, 4a, 4d, 4f, 6b) could be tailored to promote reuse (as design for disassembly, access to repair information for non-authorised repairers, availability of diagnosis software (for free or under fee), tracking of appliances to avoid illegal shipments). Also the option of adopting reduced thresholds (on e.g. energy requirements) for devices reusing some components could be explored (see example on enterprise servers).

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