Energy

Preparatory Studies for Eco-design Requirements of EuPs

(Tender TREN/D1/40-2005)

LOT 14: Domestic Washing Machines and & Dishwashers

Part I – PRESENT SITUATION

Task 3:
Economic and Market Analysis
Rev. 1.0

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Brief summary of the Study Tasks

Washing machines and dishwashers, also known as "wash appliances", have been the second and most studied EuP in the European Union with the goal to reduce their energy consumption. In 1995, the study of the Group for Efficient Appliances (GEA, 1995) provided the technical basis for the energy labelling Directive, and later also partially for the Eco-label awarding criteria. Its results and methodology were the starting point for the second study on washing machines (NOVEM, 2000, known as the WASH-2 study) promoted by DG TREN in 1998, which took into consideration the methodological, technical, economical and market developments and proposed a new structure for a revised label and the possible setting of efficiency targets, which then for various reasons were not fully accepted by Member States.
Contemporarily, the European Eco-label Board started to address these two product groups more from the environmental impact point of view with other studies, which resulted in the definition of eco-labelling awarding criteria, the latest being:

- for washing machines: on December 1999[1] the Commission adopted the criteria valid until December 1st 2002. These criteria were then prolonged to November 30th 2005 (Decision 2003/240/EC);
- for dishwashers: on August 1998[2] the Commission adopted the criteria valid until January 20th 2003 through the extension given by Decision 2001/397/EC. Criteria were revised in August 2001 (AEAT, 2001) and are valid until August 26th 2006.

In the meantime, a series of monitoring studies were promoted by the SAVE Programme to evaluate the impact of the EU legislation on the market transformation of washing machines and their energy consumption (ADEME, 2000; ADEME, 2001). Dishwashers were monitored through the annual reports presented by the European Association of Household Appliance Manufacturers (CECED) to the EC and the Regulatory Committee responsible for the management of the EU energy labelling scheme, describing the effectiveness of the industry "Voluntary Commitment on Reducing the Energy Consumption of Household Dishwashers" issued in 1999 and ended in 2004. Also washing machine market was monitored through CECED annual reports under the two Voluntary Commitments issued in 1997 and in 2002 for this product group.

Since markets and technologies change continually, including in response to past policy settings, the present study proposal takes the results and methodology defined in the last decade of studies as the starting point to be updated and upgraded where necessary to evaluate the technical, economic and market developments of cold appliances and the new aspects of these products to be covered following the indications of the eco-design directive 2005/32/EC[3]. This is necessary in order to define the need of implementing measures and possible targets for voluntary or mandatory policies.

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[1] Commission Decision of 17 December 1999 establishing the ecological criteria for the award of the Community eco-label to washing machines (2000/45/EC).
[2] Commission Decision of 20 July 1998 establishing the ecological criteria for the award of the Community eco-label to dishwashers (98/483/EC).
[3] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of eco-design requirements for Energy-Using Products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

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The study is divided in two working phases and seven Tasks or Chapters:

Part I: Present Situation that envisages the following five Tasks:

- Task 1 - Definitions
- Task 2 - Economic and Market Analysis
- Task 3 - Consumer Behaviour
- Task 4 - Product System Analysis
- Task 5 - Definition of base case

Part II: Improvement Potential, with the following two Tasks:

- Task 6 - Technical Analysis
- Task 7 - Scenario, Policy, and Impact and Sensitivity analysis.

Within the first part (Present Situation) the project team will set the study boundaries (Task 1), collect and organise the data for the economic, market (Task 2) and consumers behaviour analysis (Task 3), analyse the interaction of the studied appliances on the energy system to which the product belongs (Task 4) and set up the reference parameters, material, energy and costs inputs to define the starting base case (Task 5). All the data and information analysed within the first part of the study will serve as an input for the second part (Improvement Potential) during which the project team will carry out the technical and economic analysis to set up the optimal eco-design options of the analysed appliance (Task 6) and finally suggest the most suitable policies to achieve the recommended energy and ecological improvements (Task 7). A Glossary and References will be also included in the study.

This report present the results of the survey on consumers behaviour carried out in task 3.

DESCRIPTION AND ABSTRACT OF TASK 3

The behaviour of the consumer with household appliances influences the environmental impact because of the usage of resources like water and/or energy and/or chemicals.

[4] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of Eco-design requirements for Energy-Using Products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

An extensive consumer survey (almost 2 500 households interviewed from ten European countries) was developed to identify the "real life" consumer behaviour when using/handling household appliances, especially washing machines and dishwashers, and to evaluate the differences between the standard and the real life conditions affecting the impact of the appliances, including their effect on the energy and water consumption.

The participants are also were asked about their opinion about energy saving issues in general and infrastructural options in particular.

In European households washing machines are available in almost 100 % of the households (not necessarily in the own apartment), while dishwashers ownership is lower, going from households without the dishwasher to more than 60 %. But since these appliances remain in the household for normally ten years and more, their energy/water consumption and performance is as it was at the time of the production. Eco-design improvements will therefore take more than ten years to get fully implemented in the market. This time is even longer when second-hand appliances are used. As the survey has shown, the second-hand models account for only a minor share of the market.

Consumers asked about the relative influence of **washing machines** on the total energy consumption of a household considered this appliance as the most energy using product. This is associated with a high level of willingness to use energy saving options.

Consumer behaviour has been identified as being the main source of influence on the actual energy consumption and environmental impact on the washing process. In particular:

- the average nominal washing temperature is 45,8 °C and the most frequently used programme is at 40 °C (including all programmes for wool, silk, synthetics, etc),
- nevertheless, the cotton 60 °C programme is still the most frequently used programme and consumes more energy than a cotton 40 °C programme,
- the average wash frequency is 4,9 cycles per week,
- most consumers normally use the full loading capacity of their washing machine, but it is agreed that this does not mean that the rated capacity is really used,
- delay start options are only used in approximately 8 % of the cycles with a shift of the washing starting time by an average of 3 hours (no reason could be identified for this delay),
- at programme end the machine may stay in this mode in about 50 % of the cases for an average of 3 hours. Afterwards in about 90 % of the cases the machine is switched off.

This information about the consumer behaviour and recent data on the energy consumption allow us to estimate the average energy and water consumption of laundry washing per household per week: for an average household size of 2,9 people using the average 2005 washing machine model under real life conditions the energy consumption is 3,5 kWh and the water consumption 230 litres. This is 28 % less energy consumption than the same number of cycles calculated for a machine operated under standard conditions. The difference is mainly due to the lower average temperature of the wash programmes as well as by the effect of under-loading the machine.

Nevertheless it should be highlighted that the use of the washing machine at the rated capacity would increase the washing energy efficiency and would reduce the energy consumption. The difference of the water consumption under real life and standard conditions is 9 %.

Standby and other low power modes have been estimated to contribute on average between 4 and 8 percent of the real life energy consumption. These figures may be higher if consumers do not switch off the washing machine after unloading; showing again that the individual consumer behaviour has a major influence on the amount of energy and water used in the specific household.

Therefore consumer training and education is a very important element for the further decrease of the energy and/or water and/or chemicals consumption in real life. The second element to be taken

into consideration is that the definition of measurement methods in the European standards should be made more in line with the consumer real life behaviour.

Consumers asked about the relative influence of **dishwashers** on the total energy consumption of a household considered this appliance as having as moderate to great impact. This is associated with a high level of willingness to use energy saving options.

The manual dishwashing process done in all households that do not own a dishwasher causes – on average – a higher consumption of energy and water. But also households owning a dishwasher do manual dishwashing for some part of their tableware and even some of the items are then loaded into a dishwasher and undergo a pre-cleaning process. This last process of manual dishwashing is closely linked to the automatic dishwashing process but it is not requested by dishwasher manufacturers and could be avoided through correct information provided to the consumers. It was initially considered in the shown calculation as an additional consumption under real life conditions for the dishwashers. All other consumption related with manual dishwashing is not considered, but may be higher than those of the automatic dishwashing machine.

Consumers asked about the relative influence of **dishwashers** on the total energy consumption of a household considered this appliance to have a moderate to great impact: for nearly 15% of the consumers the high energy and water consumption is an element against the purchasing of a dishwasher. This opinion is more important in those countries where the penetration of the dishwasher is lower. Another negative element (for nearly 23,5 % of the consumers) is the initial purchasing price. In general there is also a high level of willingness in using energy saving options in automatic dishwashing.

Consumer behaviour has been identified as having a high influence on the energy and water consumption of the automatic dishwashing process under real life conditions. It is shown, that

- the average dishwashing temperature is at a nominal temperature of 59,3 °C and the most frequently used programme, followed by eco- and automatic programmes
- the average automatic dishwashing frequency is at 4,1 cycles per week
- most consumer are using normally the full loading capacity of their dishwasher, but it is not known if this means that the rated capacity is used
- delay start function is only used in approximately 10 % of the cycles with an average shift of 3 hours (it was not identified for what reason this shifting is done)
- at programme end the machine may stay in this mode in about 50 % of the cases for an average of 3 hours. Afterwards in about 70% of the cases the machine is switched off.

All the information about the consumer behaviour and the recent data on the energy consumption allows estimation of the average energy and water consumption per household per week: for an average household size of 2,9 people using the average 2005 dishwasher model under real life conditions, the amount of electricity used for automatic dishwashing is at 5,63 kWh and the amount of water is at 86 litres, when the manual pre-rinsing is included. It is 4,88 kWh and 63 litres when pre-rinsing is not considered. This is 29,4 % higher in electricity than when calculated under standard conditions, which is reduced to +12,2 % when the pre-rinsing is not taken into account. Main differences are caused by the high average (nominal) temperature of the programmes used as well as by the additional energy consumption for the manual pre-rinsing of the dishes.

Nevertheless, it should be highlighted that the use of the dishwasher at the rated capacity would increase the automatic dishwashing energy efficiency and would reduce the energy consumption.

The water consumption under real life is 39 % higher than under standard conditions when the manual pre-rinsing is considered, and almost the same if the latter is not taken into account.

Standby and other low power modes have been estimated to contribute on average between 3 and 10 % of the real life energy consumption. These figures may be higher if consumers do not switch off the dishwasher after unloading; showing again that the individual consumer behaviour has a major influence on the amount of energy and water used in the specific household.

These figures may be higher if consumer do not switch off the machine after unloading, showing again, that the individual consumer behaviour has a major influence on the amount of energy and water used in the individual case.

Therefore consumer training and education is a very important element for the further decrease of the energy and water consumption in real life. The second element to be taken into consideration is that the definition of measurement methods in the European standards should be more in line with the consumer real life behaviour.

3 Task 3: Consumer behaviour and local infrastructure[5]

3.1 DESCRIPTION OF TASK 3

The data concerning this part of the study will be collected through a survey having the aim to identify actual consumer behaviour and consumer reactions on EuP design options. The following areas will be investigated:

- Actual use conditions of washing machines and dishwashers
- Program selection (type and temperature)
- Additional features selected (extra water, no spin, etc)
- Amount and type of laundry
- Detergent used (amount, type)
- Importance and acceptance of environmental conscious features
- Use of energy saving program option
- Use of halve load button or trust of fuzzy control
- Information on energy and water consumption
- Remote control (safety warning)
- Remote control (use of green energy – time delay)
- Use of hot water supply.
- The survey will be prepared and carried out according to the following steps:
- Identification of areas where energy savings in real use situations might exist. The energy usage of wet appliances is mainly influenced by following consumer relevant factors:
    - Size (capacity) of the purchased appliance and usage of this size
    - Temperature setting
    - Actual load size (kg of laundry or place settings)
    - Frequency of use (number of washing cycle/year)
- For dishwashers, the washing of dishes by hand has to be investigated in parallel, as this is the alternative way the dishes might be cleaned. Consumer acceptance and preferences for either way have to be explored.
- Preparation and design of a questionnaire to verify the existence of these areas in real household usage
- Carrying out the survey via Internet service on a relevant number of households in 10 EU countries (UK, DE, IT, FR, ES, SE, PL, HU, FI and CZ each with 250 people). To do so, the questionnaire will be transferred into an electronic format, where answers can be easily marked by ticking on predefined fields or added verbally. A link to this questionnaire will then be send to customers of a specialised Internet service provider that then will fill in the questionnaire. Answers are collected centrally. To achieve a good coverage, appropriate criteria will be used for selection of the customers who are invited to participate on this survey.
- Analysis of results in terms of real consumer behaviour and potential for optimisation.

[5] Note: the paragraph numbering of this report starts with the number three to be consistent with the final report paging.

- Analysis of the country specific trends.

The following areas will be investigated in detail via Internet survey for both washing machines and dishwashers:

- Demographic data
- Washing machine and Dishwasher (two separate questionnaires)
- Age of machines (classes of age)
- Capacity and use of capacity
- Program selection
- Usage habits (e.g. degree of filling)
- Satisfaction
- Problems associated with cleaning and drying performance
- Use of energy saving options
- Reaction on energy improvement/eco design (see above) measures
- Market preferences and cultural and social aspects relating to purchase (when and why the appliance will be substituted, product life expectancies, attitude toward the second-hand market)
- Level of information on the energy efficiency categories (labelling) and, in general, on the EU or national initiatives on the environmental protection
- Source of information/advice in case of purchasing of a new appliance (general or specialised magazines, shops, maintenance services…)
- Other questions concerning the electricity tariffs and how the consumer deals with them (i.e. how and if to take advantage of possible night tariffs and related problems like the appliances noise).

3.2 THE BASIC CRITERIA AND GOALS OF THE CONSUMER SURVEY

The behaviour of the consumer with household appliances influences the environmental impact because of the usage of resources like water and/or energy and/or chemicals. Although some studies on the consumer behaviour with washing machines are available in Europe[6], they are neither complete nor updated to allow an actual assessment of the consumer behaviour on the environmental impact.

The aim of the survey was to identify the "real life" consumer behaviour concerning the use/handling of household appliances and to identify differences between the real use pattern and the standard test conditions (potentially) affecting the environmental impact of the appliances. With the support of an external market research institute[7] 2 497 European households in 10 European countries were interviewed via an online questionnaire (Figure 3.1). The participants were asked about their behaviour when using selected household appliances and about their opinion on this topic as well as on the energy saving issues. Demographic data were recorded additionally.

The selected countries nearly represent 75 % of the European population. 250 households were interviewed per country, with the exception: Czech Republic with only 247 households.

[6] E.g. SAVE II: Revision of energy labelling & targets washing machines (clothes), Novem (NL), March 2001

[7] ODC Services GmbH, 80636 **Munich**

Households for this survey were selected to be - as much as possible - representative of the population in the country and to fit with the scope and needs of the study.

The following selection criteria and quotas were chosen:

- Indicator of citizenship: total
- Distribution of gender: not less than 50% female persons
- Selected age groups:
  - between 20 – 39 years
  - between 40 – 59 years
  - between 60 – 74 years
- Household size: 1, 2, 3, 4 and ≥4 persons.

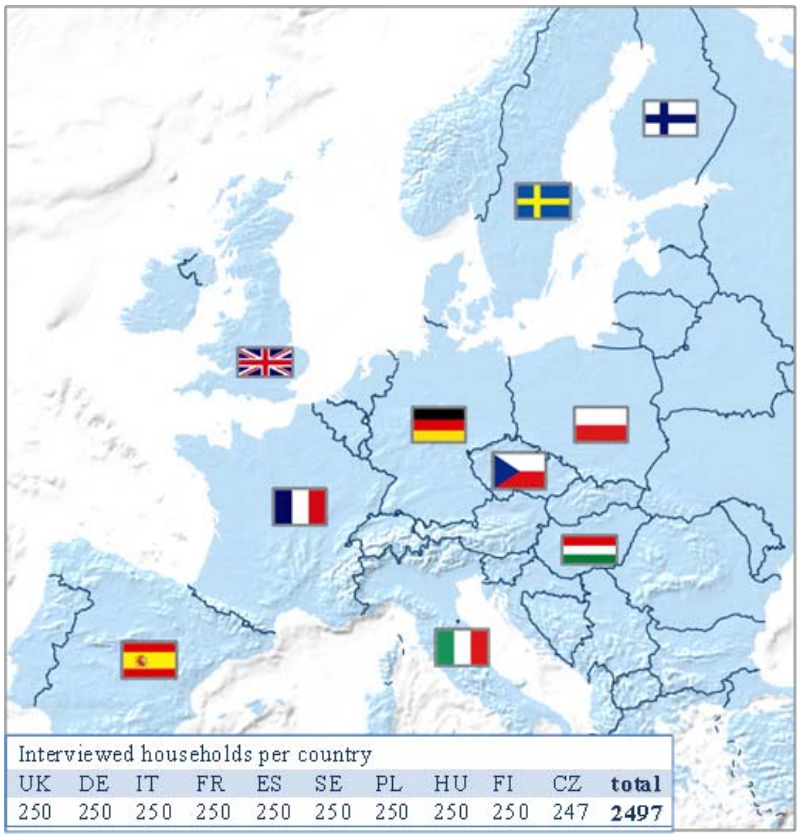


Figure 3.1: geographic coverage and sample size of the survey[8]

Also specific quotas about the presence of selected household appliances were set:

- not less than 50 % of all interviewed persons per country should possess a dishwasher,
- 100 % of all interviewed persons per country should possess a washing machine,
- 100 % of all interviewed persons per country should possess a refrigerator,
- not less than 70 % of all interviewed persons per country should possess a freezer,

to insure a sufficient coverage of the interested products and a better comparability of the results:

[8] Figure own creation with Map Creator Version.1.0 (free edition)

The selection of gender and age groups were made to interview the persons who most likely were involved in housekeeping. To guarantee the interviewed sample to be representative of the age group and household size distribution, Eurostat[9] data about the distribution of the population by age group and household size for each country were used to normalise the sample (Table 3.1). Maximum differences of ± 5 % resulted between the Eurostat distribution and the sample in the survey (Annex 1- 1).

Table 3.1: population by household size and age group: comparison of results of own survey vs. Eurostat data[10] e.g. UK

United Kingdom		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat [11]	1 person	4 %	5 %	5 %	*14 %*
	2 persons	10 %	13 %	12 %	*36 %*
	3 persons	10 %	9 %	2 %	*21 %*
	4 persons	10 %	8 %	1 %	*19 %*
	more than 4 persons	6 %	4 %	0 %	*11 %*
	total	*41 %*	*39 %*	*20 %*	*100 %*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
participation in survey	1 person	3,9 %	7,1 %	4,2 %	15,1 %
	2 persons	11,6 %	12,2 %	10,6 %	34,4 %
	3 persons	11,6 %	10,9 %	1,6 %	24,1 %
	4 persons	8,0 %	8,7 %	1,0 %	17,7 %
	more than 4 persons	4,8 %	3,9 %	0,0 %	8,7 %
	total	*39,9 %*	*42,8 %*	*17,4 %*	*100,0 %*
		Age group			
		20-39 years	40-59 years	60- 74 years	
Differences between Eurostat data and participation in survey	1 person	0,1 %	-2,1 %	0,8 %	-1,1 %
	2 persons	-1,6 %	0,8 %	1,4 %	1,6 %
	3 persons	-1,6 %	-1,9 %	0,4 %	-3,1 %
	4 persons	2,0 %	-0,7 %	0,0 %	1,3 %
	more than 4 persons	1,2 %	0,1 %	0,0 %	2,3 %
	total	*1,1 %*	*-3, 8%*	*2,6 %*	*0,0 %*

3.3 THE GENERAL SURVEY RESULTS

3.3.1 Demography

On average 56 % of all interviewed people were female and 44 % male (Figure 3.1). The highest value of nearly 70 % of females was found in the United Kingdom (Table 3.2). In general, the

[9]EUROSTAT:http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/popul/popula/cens/cens_n2001/cens_nhou&language=de&product=EU_population_social_conditions&root=EU_population_social_conditions&scrollto=162

[10]Own calculation: Population by household size and age group based on EUROSTAT data.

[11]Own calculation: via crosstabs of EUROSTAT.data of population by household size and age group.

differences among the actual gender distributions in European countries and the results of this survey are between less than 1 % and 18 % in favour of female participation.

Table 3.2 results consumer survey: share of female persons (percentage per country)

Gender	County	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Female		68,8 %	59,6 %	60,8 %	50,0 %	50,8 %	62,4 %	50,8 %	50,0 %	56,8 %	47,4 %

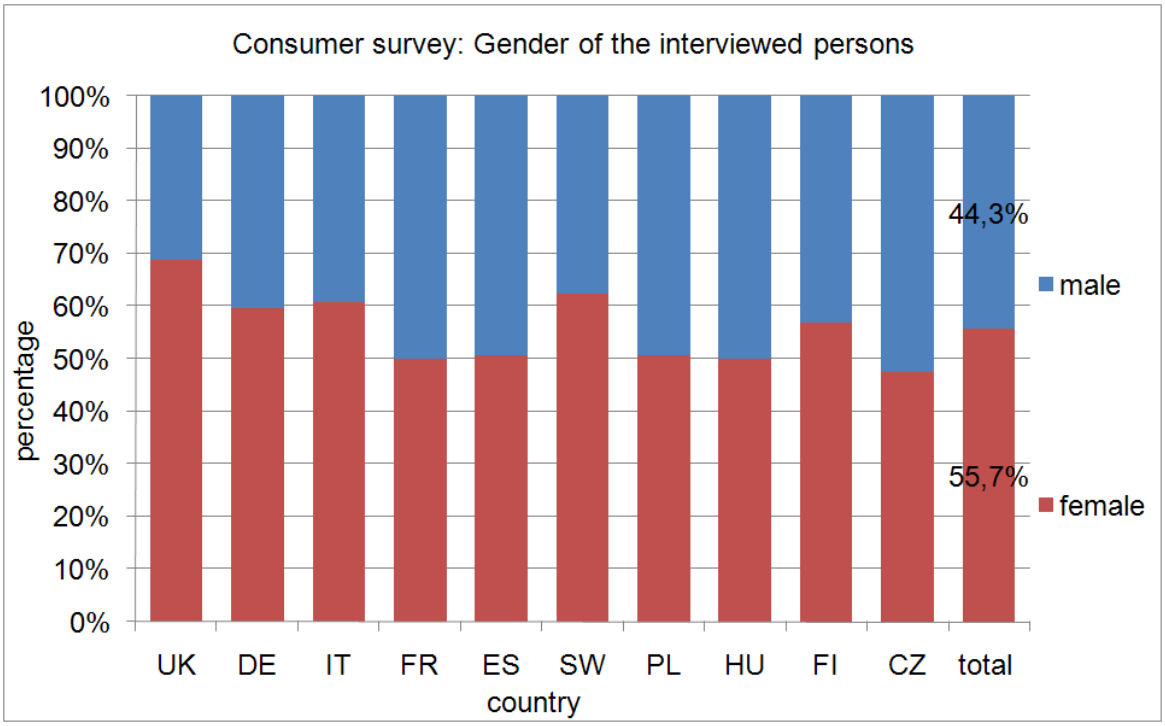


Figure 3.2: distribution: gender of the interviewed persons (per country)

Due to the self-declaration of the age by the survey participants, only persons with an age between 20 and 74 years were interviewed. People with an age between 20 and 39 years as well as 40 and 59 years resulted in nearly 40 % of the entire sample. No significant differences could be found with the European countries statistics, where the percentage of the two mentioned age groups lay between 39 and 42 %. The highest share of young participants could be calculated for Italy (47,6 %), Spain (46 %) and Poland (44,8 %) (Figure 3.3): 19 % of the interviewed persons are between 60 and 74 years old. The highest share of people of this age group can be found in Sweden (22 %), Hungary (20,8 %) and Germany (19,6 %).

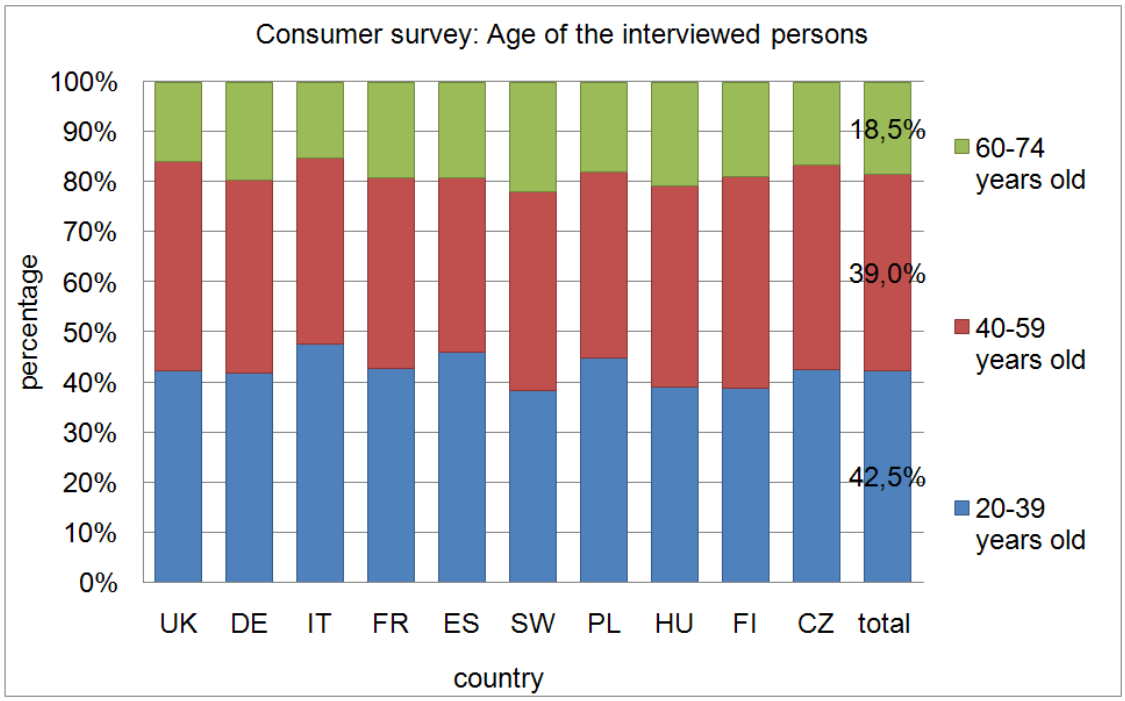


Figure 3.3: distribution: age of the interviewed persons (per country)

3.3.2 Living conditions

People were also asked to describe their dwelling type: 52 % of all interviewed households (or 2 497) said that they live in a city. Nearly 80 % of all Polish interviewed persons live in a city (Figure 3.4), which is the highest share of all European countries.

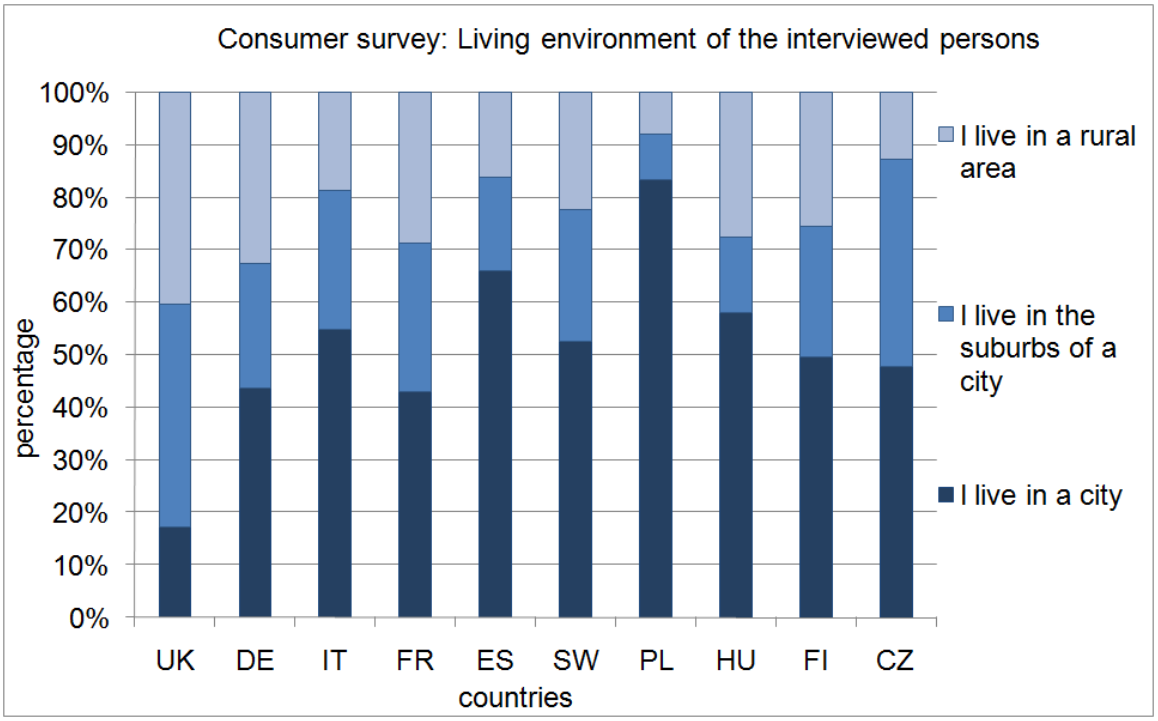


Figure 3.4: living environment of the interviewed persons (per country)

Over 60 % of all Spanish participants are city dwellers. A fourth of all households live in the suburbs of a city (25 %), of which mostly British (42 %) and Czech (39 %) interviewees, while the other countries show percentages between 14 and 28 %. The remaining interviewees (23 %) answered that they live in a rural area, especially in UK (40 %); German (33 %), French (29 %) and Hungarian (28 %) people live in the same conditions.

Nearly 60 % of all interviewed people live in a family household (Figure 3.5). This household type could be found mostly in Italy and Czech Republic with over 70 % and also in Poland and Hungary with over 66 % (Figure 3.6).

Approximately 40 % of all family households consist of 3 or 4 persons and even 10 % over 4 persons (Figure 3.7). Almost a fourth of all interviewed consumers (22 %) live in couple households, which are mostly represented by 2-person households (18 %). Especially in Finland and France this type of household is over 30 % (Figure 3.8). Over 14 % of all participants live in a single-/one-person household: particularly in Sweden 27,6 % and in Finland 18,4 % of all households are single-households. With only 3,5 % the multi-person non-family household was mentioned least frequently (Figure 3.5). With the exception of Italy in all European countries the share in this type of household is marginal, with values between 0,8 % and 5,2 % (Figure 3.6). Because of possible misunderstandings of the declaration of the different household types, it is recommended that a check with the number of the persons in the household be done.

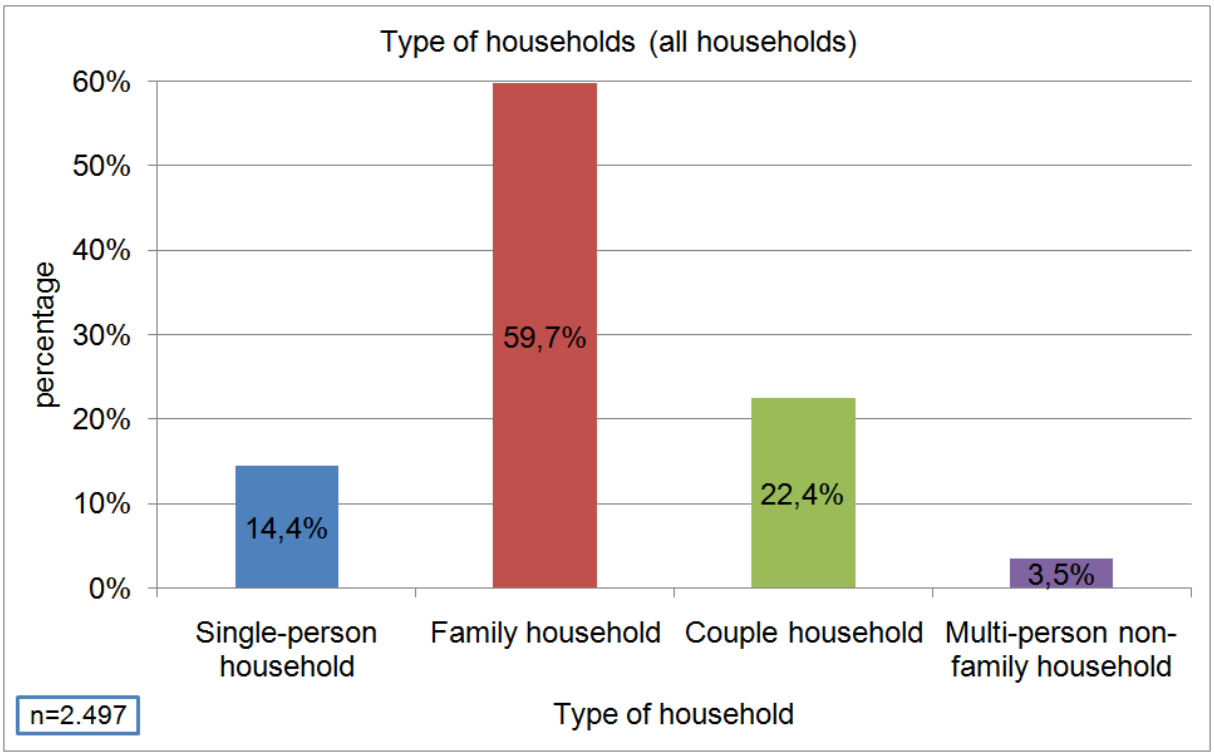
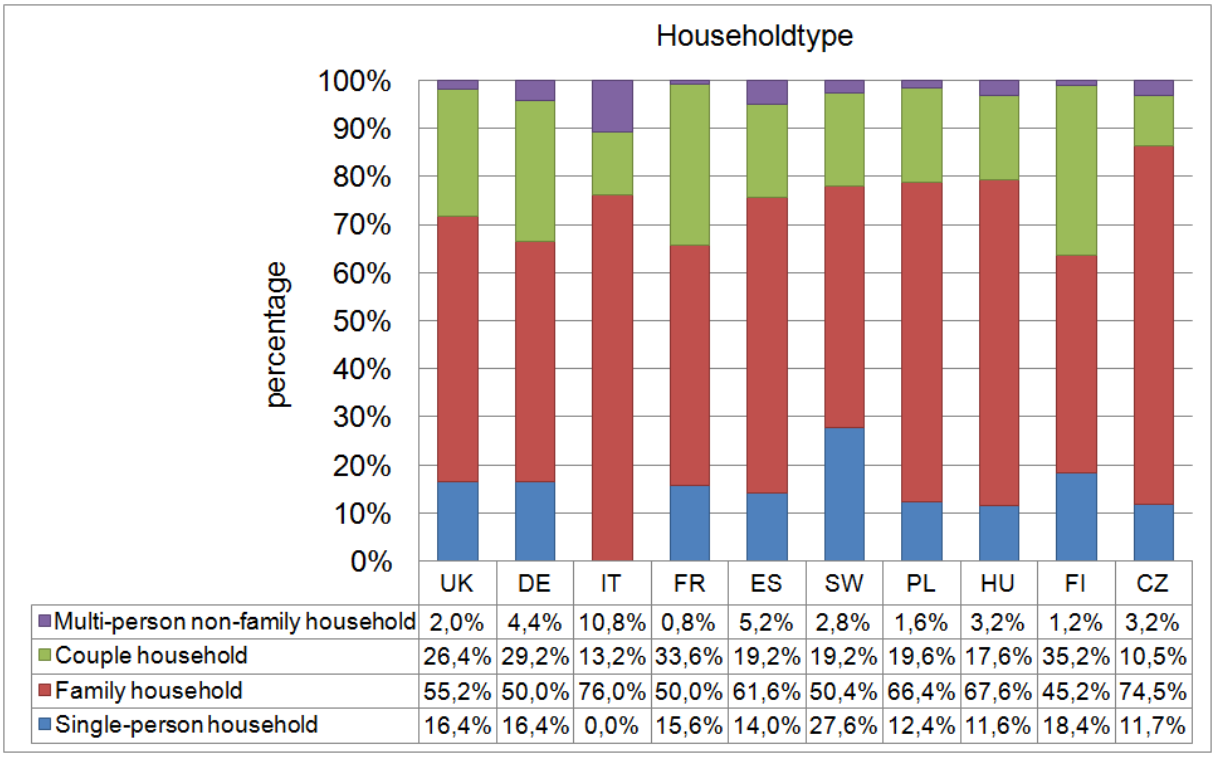
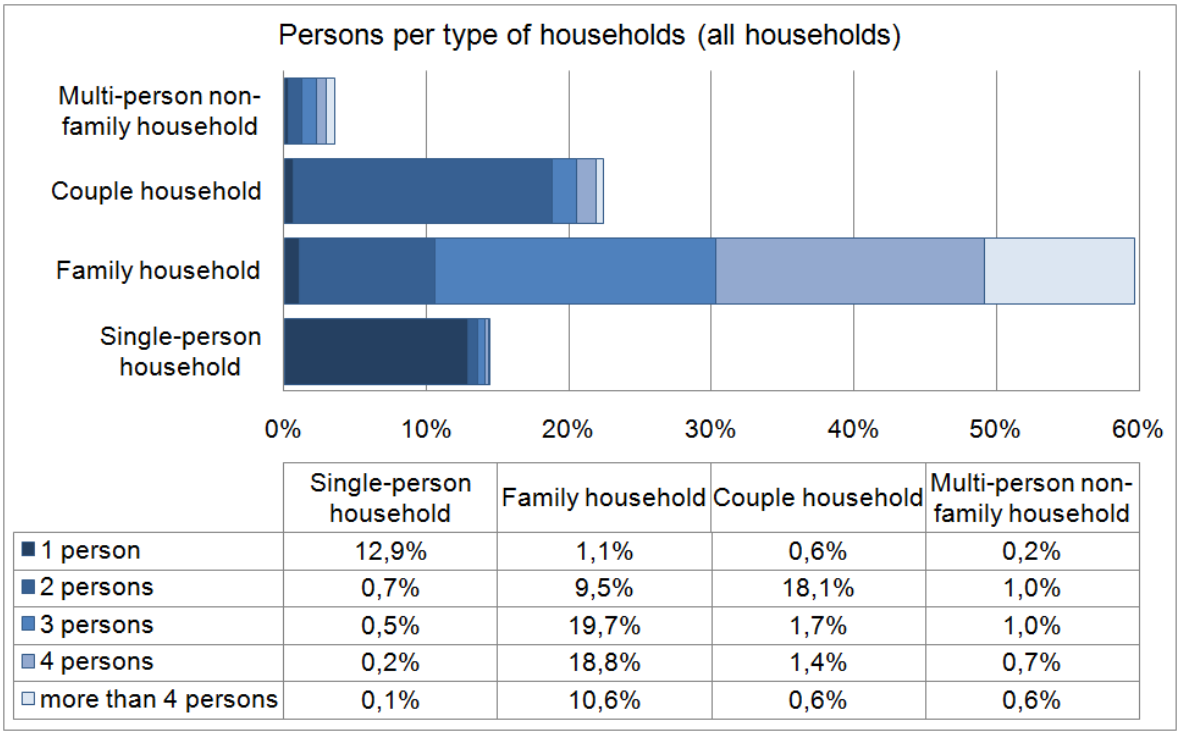


Figure 3.5: distribution: type of household (all households)



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Multi-person non-family household	2,0%	4,4%	10,8%	0,8%	5,2%	2,8%	1,6%	3,2%	1,2%	3,2%
Couple household	26,4%	29,2%	13,2%	33,6%	19,2%	19,2%	19,6%	17,6%	35,2%	10,5%
Family household	55,2%	50,0%	76,0%	50,0%	61,6%	50,4%	66,4%	67,6%	45,2%	74,5%
Single-person household	16,4%	16,4%	0,0%	15,6%	14,0%	27,6%	12,4%	11,6%	18,4%	11,7%

Figure 3.6: distribution: type of household (per country)



	Single-person household	Family household	Couple household	Multi-person non-family household
1 person	12,9%	1,1%	0,6%	0,2%
2 persons	0,7%	9,5%	18,1%	1,0%
3 persons	0,5%	19,7%	1,7%	1,0%
4 persons	0,2%	18,8%	1,4%	0,7%
more than 4 persons	0,1%	10,6%	0,6%	0,6%

Figure 3.7: distribution: by type of household and person per household (all households)

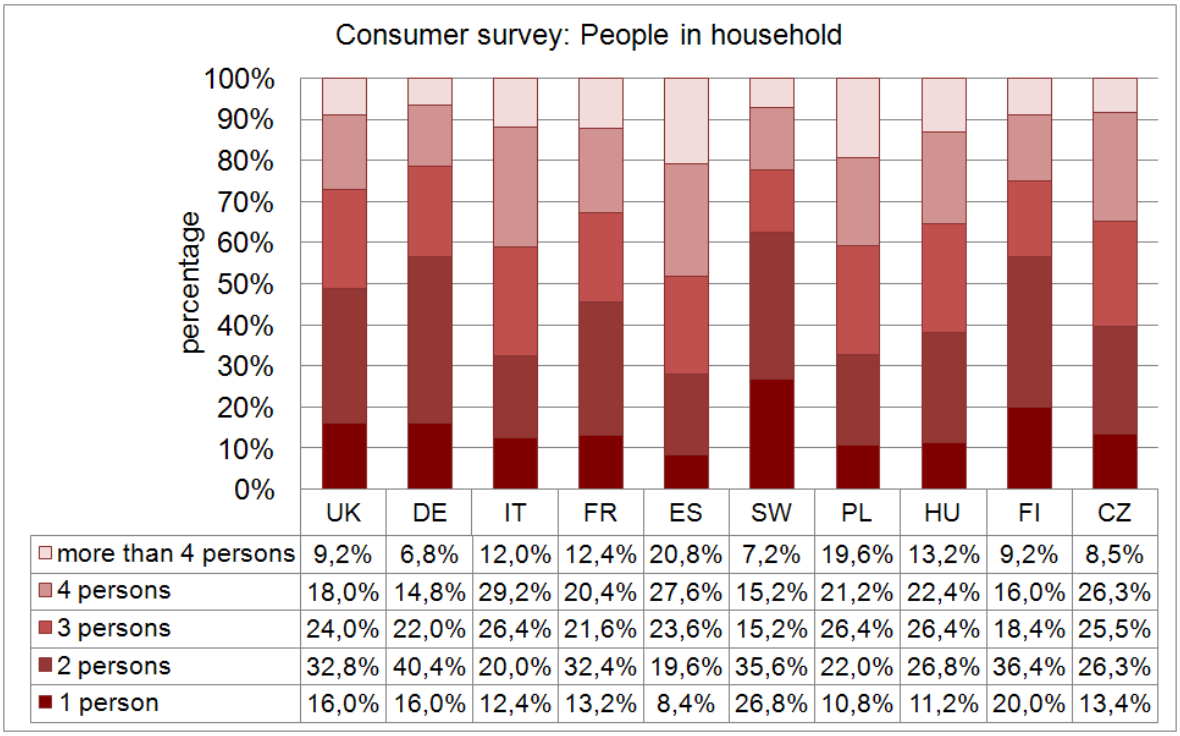


Figure 3.8: number of people in households (per country)

The detailed analysis of the answers to the question how many people are living in the household results an average of 2,9 people per household. In comparison with the average household size published by UNECE[12], for those countries investigated here, an average difference of -0,3 people per household could be calculated (Table 3.3).

Table 3.3: average household (countries of this survey) source: UNECE (2004)

Countries	EUROSTAT		Consumer survey		Δ Average household size (EUROSTAT – Consumer survey)
	Average household size	Year	Average household size	Year	
Czech Republic	2,7	1998	2,9	2006	-0,2
Finland	2,1	2001	2,6		-0,5
France	2,4	2001	2,9		-0,5
Germany	2,2	2001	2,6		-0,4
Hungary	2,6	2001	3,0		-0,4
Italy	2,6	2001	3,1		-0,5
Poland	3,1	1995	3,2		-0,1
Spain	2,9	2001	3,3		-0,4
Sweden	2,9	2001	2,4		0,5
United Kingdom	2,3	2001	2,7		-0,4

[12] The Statistical Yearbook of the Economic Commission for Europe 2003. Online: http://www.unece.org/stats/trends/ch2/2.1.xls

The highest number of persons per household, with more than four, was seen in nearly 20 % of the Spanish and Polish households in our survey (Figure 3.8). Also nearly 30 % of all Italian, Spanish, Czech and Polish interviewees stated that there are four persons in their households. Following the consumer survey analysis the most single member households could be calculated with nearly 30 % for Sweden and with 20 % for Finnish households. For the other analysed European countries, single member households represented between 8 and 16 % (Figure 3.8).

In nearly 38 % of all European households of our survey at least one person is younger than 18 years. Figure 3.9 shows that in 17 % of all households live one and in nearly 14% live two persons under this age, mostly in France (46 %), Hungary (44 %), Poland (42 %) and Italy (41 %). Households with the least share of people under 18 years were found in Czech Republic (29,6 %), Sweden (33,6 %) and Spain (32,4 %).

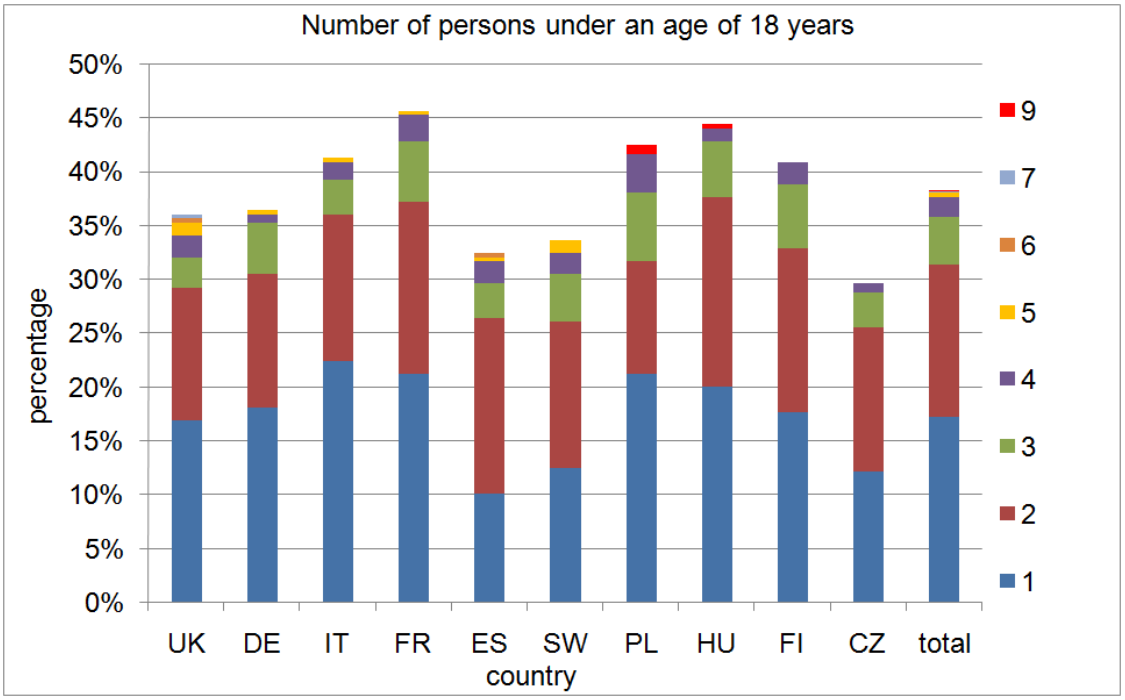


Figure 3.9: number of people under an age of 18 years (per country) living in household

The comparison of the results of our survey and published European data about the proportion of households with children aged between 0 and 17 years[13] shows differences between -4,4 % and + 15,1 % (Annex 1-3).

All these differences between the 'official' average country data and data of this survey may be explained by the setting of quotas on the age of the participants, as this eliminated quite some elderly households and properly also some very young (student) households. Following the intention of this survey to cover the average European behaviour of using household appliances this procedure is justified.

[13] http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1073,46870091&_dad=portal&_schema=PORTAL&p_product_code=FBA10512

3.3.3 The installed household appliances

A total of 10 044 household appliances are installed in the interviewed households (2 497). Refrigerators and washing machines were reported with an ownership of 100 %, because of the predefined questionnaire criteria; 69 % (n = 1 722) of all households possess a dishwasher and over 35 % (n = 893) a tumble dryer (Figure 3.10). As far as the cold appliances (e.g. refrigerators and freezers) are concerned, approximately 75 % (n = 1 871) of households own an upright freezer and nearly a fourth a chest freezer (22,6 %; n = 564); 14.2 % (n = 355) of all interviewees have both.

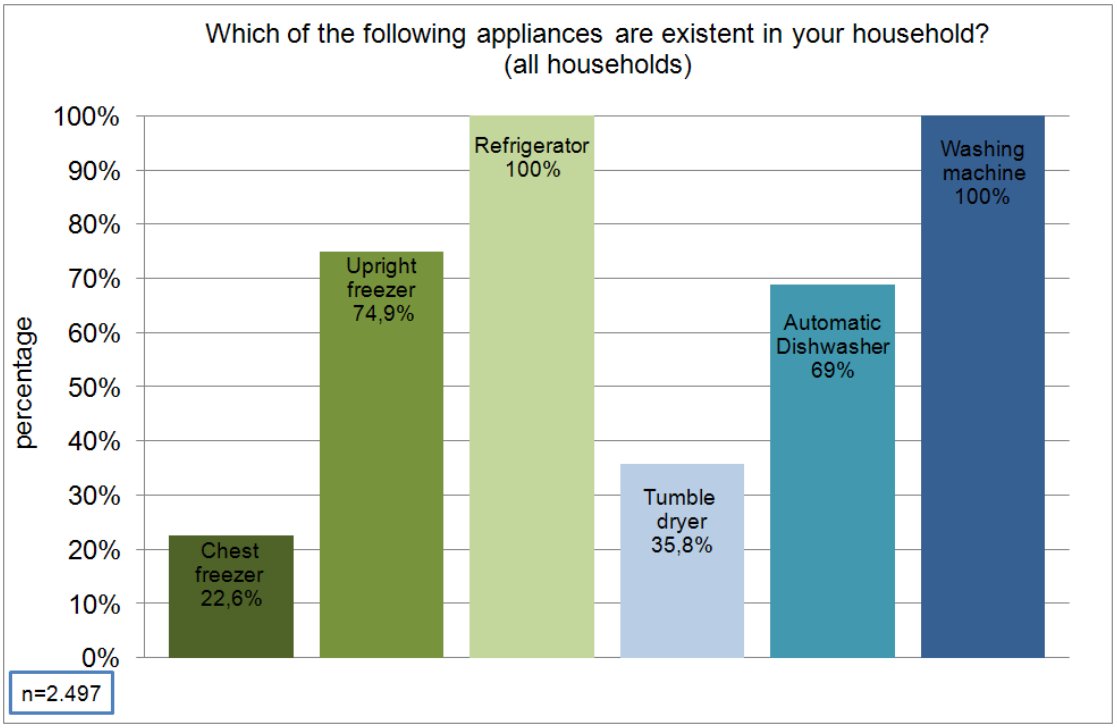


Figure 3.10: equipment of household appliances in % (all households)

The highest share of dishwashers was found in French households with 88 % and in Germany with about 77 % (Figure 3.11); less than 50 % of Polish households possess a dishwasher; 57 % of Czech interviewees mentioned that they have a dishwasher. The highest ownership of tumble dryers could be found in British households, with nearly 70 %, followed by more than 50 % in German, French and Swedish household. On the other side, in only 8 % and 9 % of Czech and Italian households a dryer do exist.

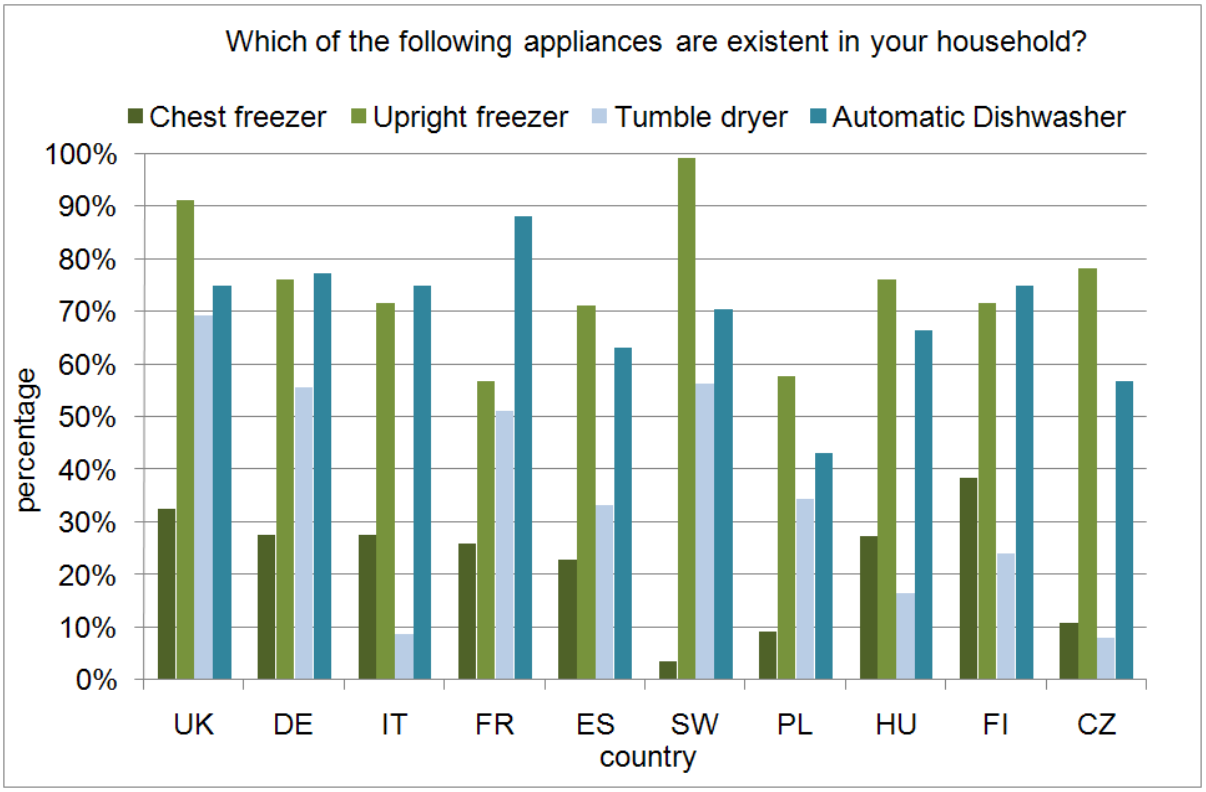


Figure 3.11: equipment of household appliances in % (per country)

Couple- and family-households show the same distribution of household appliances: over 70 % possess a dishwasher and nearly 40 % a tumble dryer (Figure 3.13). Only 49 % of single households possess a dishwasher, while 80 % of more than 4 person households have one (Figure 3.12 and Figure 3.13). The reason could be the space availability or the dwelling type.

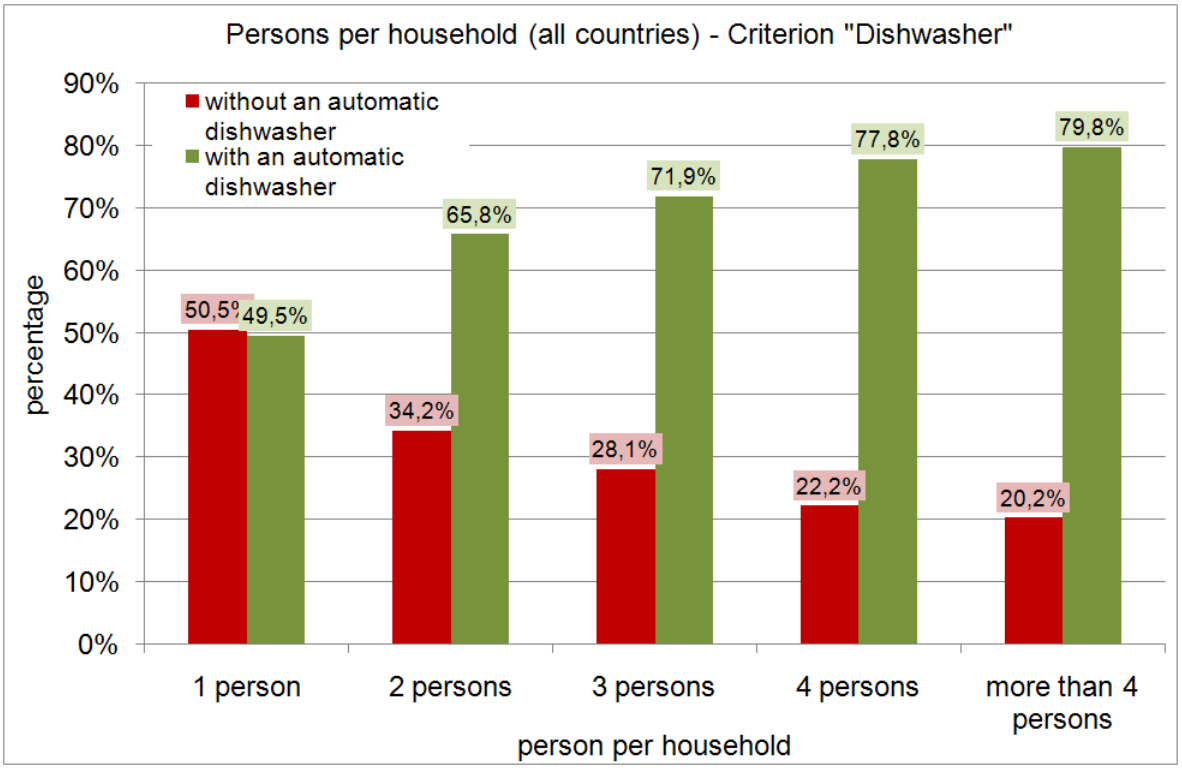


Figure 3.12: persons per household – criterion: „ dishwasher“

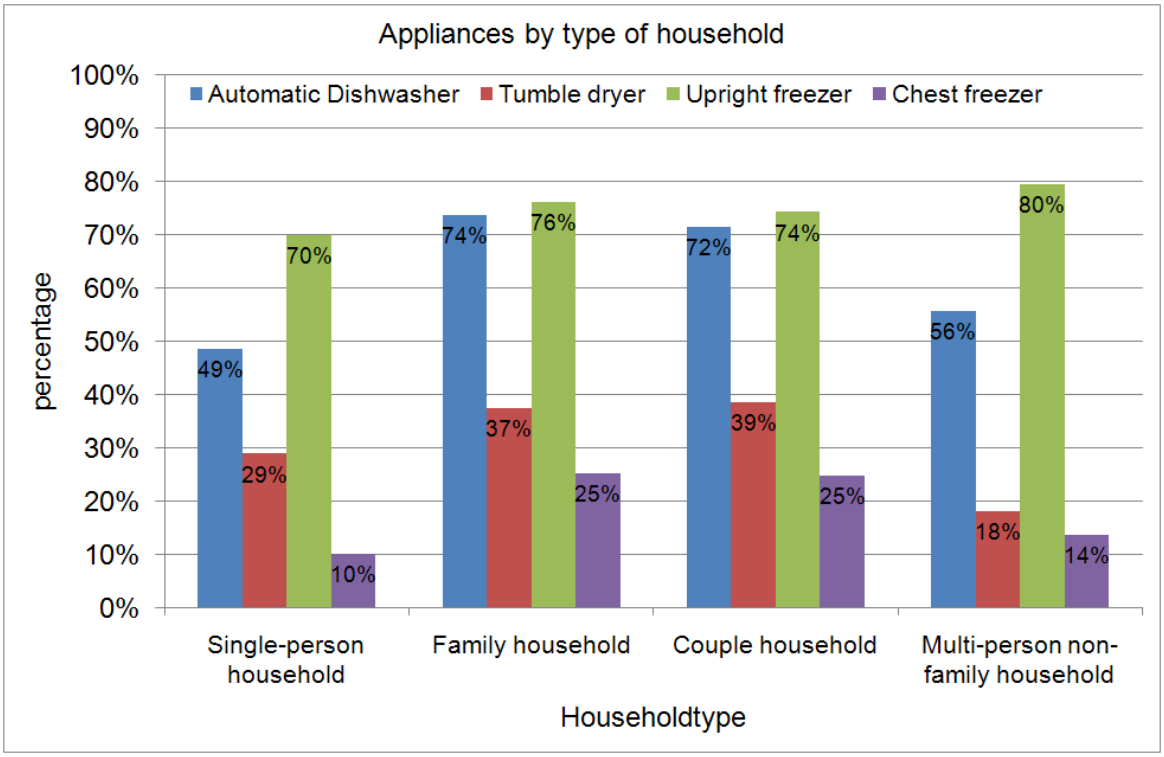


Figure 3.13: equipment of household appliances by type of household

3.3.4 The consumer opinion about "household appliances"

Consumers were asked their opinion about a list of general statements concerning their behaviour when using household appliances and the consequent environmental impact.

Nearly all interviewees stated that appliances should *just do a perfect job* (Figure 3.14) so that the consumer does not need to worry about it (53,9 %). Ecological aspects are very important for the consumers too: most of them know that their *behaviour plays a role for the environmental impact*; consequently nearly 90% of the interviewed persons mentioned that it's very important *to be able to protect the environment with their behaviour* and they also agreed with the statement that *a correct use of their machines would save energy* (94,7 %) (Figure 3.15). It is also a high priority for the interviewees that household *appliances show very good economical consumptions* (39,7 %) and *work economically* too (38,3 %).

Aspects like the aesthetics or the price seem to play a minor role for the consumers: approximately 40 % of all consumers disagree, and 7,9 % strongly disagree, with the statement that an *appliance should reflect their lifestyle or match the interior of their home* (Figure 3.14). Also nearly 30 % disagree that they primarily pay attention to an *attractive price of the appliances* (Figure 3.15), which on the other side means that 70 % of the interviewees consider the price as important or very important (more than 20 % of the answers).

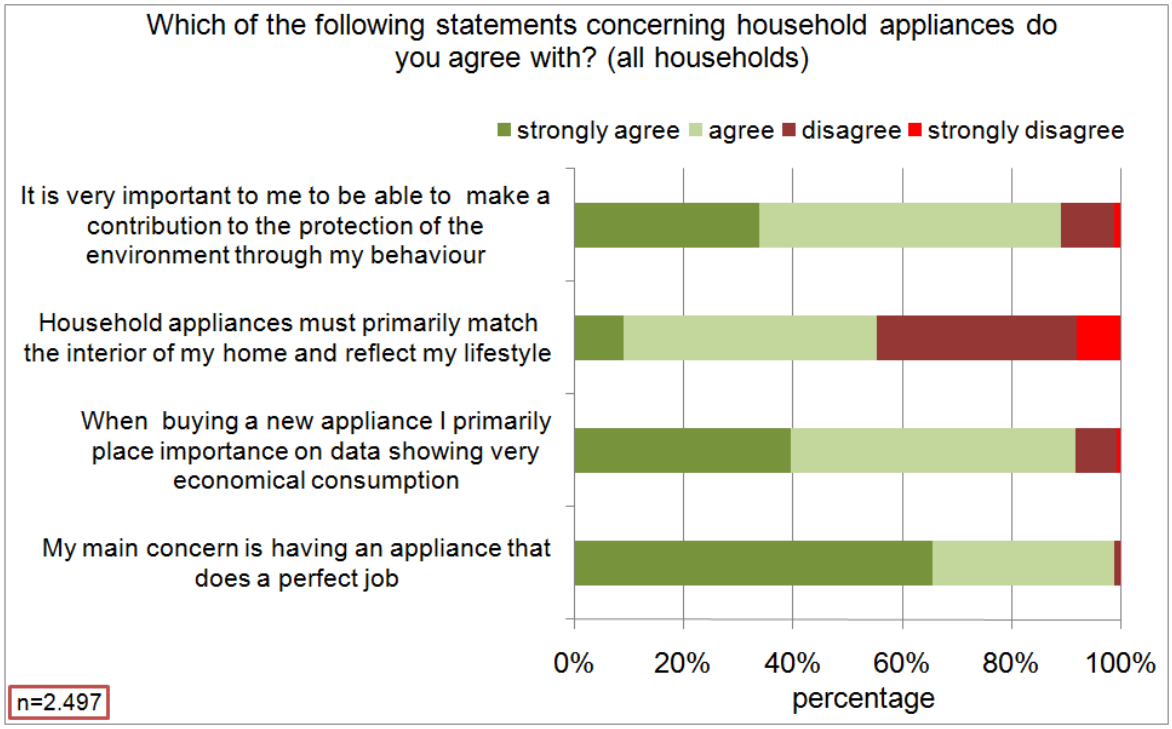


Figure 3.14: consumer statements – part I

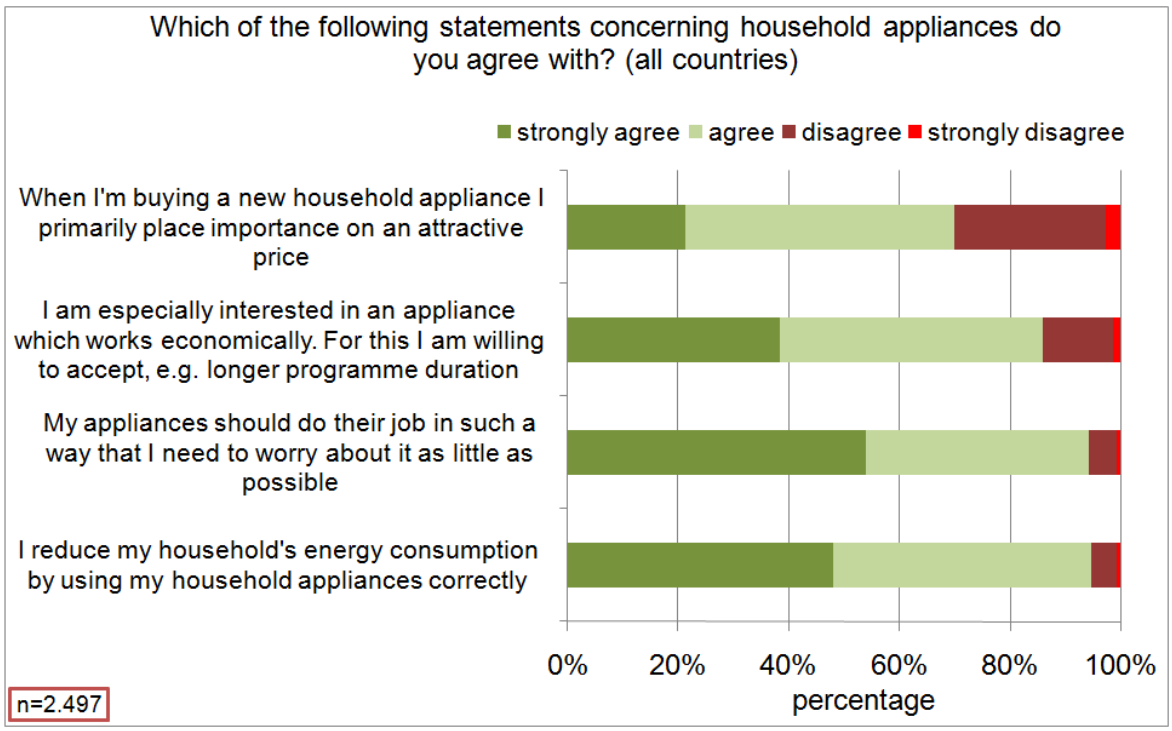


Figure 3.15: consumer statements – part II

The consumers were also asked which sources of information they would consult when they plan to buy a new appliance (multiple answers allowed). The main source of information resulted to be consumer's own *experience* (55,7 %) (Figure 3.16). The second main source of information is *Internet sites of the manufacturers* (52,2 %). *Information on the energy label* is important for nearly 52 % of all interviewed consumers. Approximately equally quoted are *advices and experiences of friends* and *test reports from consumer organizations* (50,5 % and 50,8 %).

When compared with the results of a study of a German magazine (STERN) (Figure 3.17) concerning information when purchasing an electrical domestic appliance, the importance of *information in trade* is considered less important. The *advice from sales representatives in a shop* (46,4 %) are less important for the interviewees (Figure 3.16), and a similar answer is given for "information *by manufacturers' brochures"* with nearly 30 %, which is in good agreement with the STERN[14] survey.

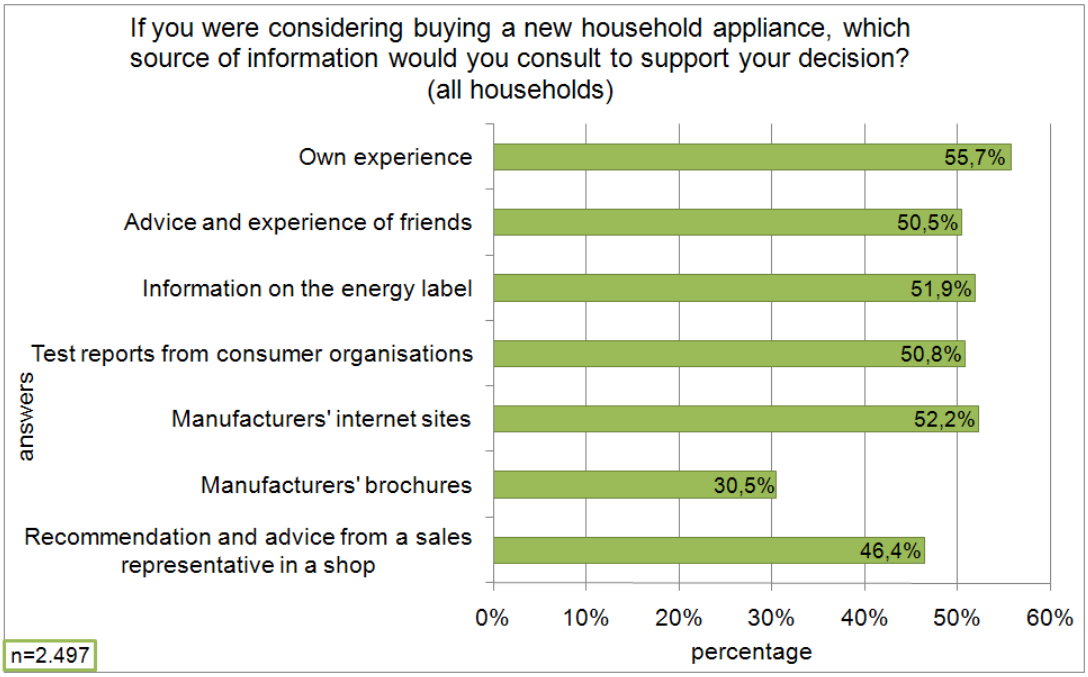


Figure 3.16: sources of information when purchasing a new appliance

[14] STERN (2005): TrendProfil "Elektronische Haushaltsgeräte". Online: http://www.gujmedia.de/_content/20/50/205011/TP_0505_Elektr_HHG.pdf?PHPSESSID=3d884f1d5fee754e7b0e5320766a6ab2

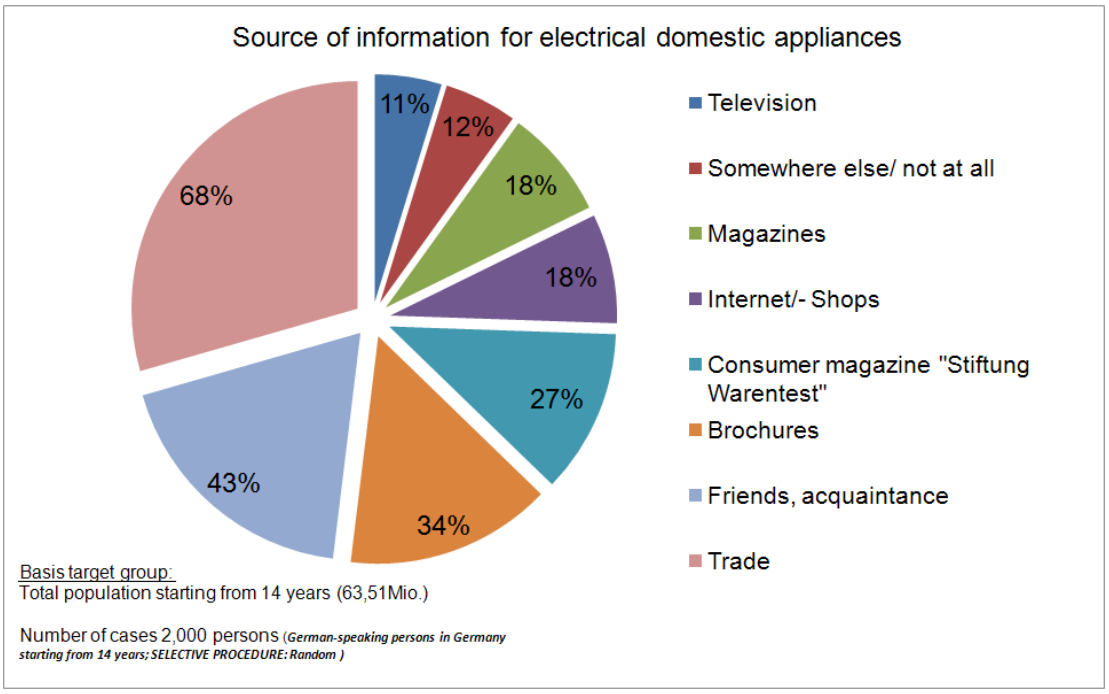


Figure 3.17: results study STERN: sources of information when purchasing an electrical domestic appliance (STERN 2005)

For approximately 52 % of the interviewees the *information on the energy label* is important for their buying decision (Figure 3.16).

The consumers were then asked in detail which information they would expect on the energy label and list of options was provided: for over 80 % the *energy efficiency class* and information about the *water consumption* are considered very important (Figure 3.18); more than about 50 and 60 % of all interviewees mentioned and chose elements which are already included in the energy label, such as for example the *cleaning/washing performance* (58,1 %), the load *capacity* (57,5 %), the *noise emission* (55,4 %) or the *spin/drying performance* (50,5 %); the information on the *programme duration* is are expected only by 45,2 % of the consumers.

As far as the *energy consumption* is concerned, the consumer expects more information on the consumption *per cycle per day* (56,4 %) than on the *annual consumption* (34,1 %); other detailed information on all *programmes or features of the appliance* or on *programme and temperature used for the assessmen*t are only desired by about 28 % of the consumers. Financial aspects like *yearly* or *running cost (per cycle)* are also requested by only about 32 % to 34 %.

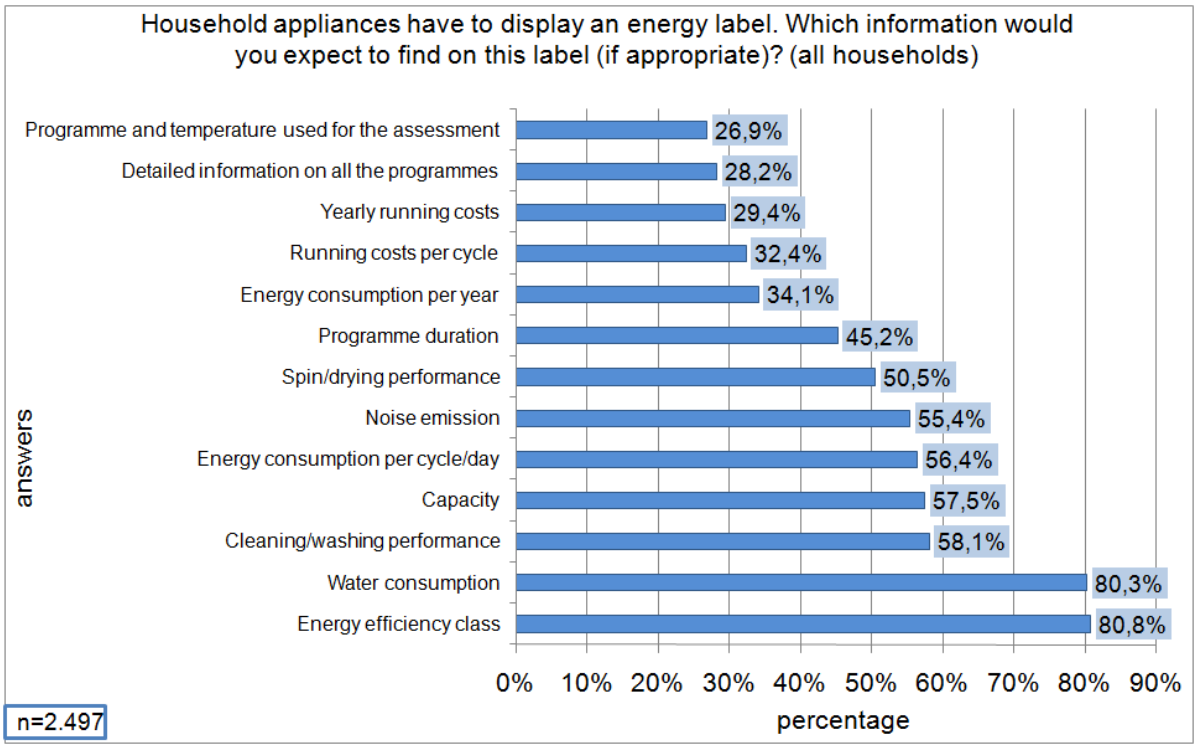


Figure 3.18: energy label – expected information

A very *low consumption of resources like water and/or energy* is the most important aspect for the consumers when they plan on buying a new appliance (83,9 %) (Figure 3.19).

Also for over 70 % of the interviewed persons a *very good cleaning/washing performance* has a high priority and more than half pay attention to a *low operating noise emission* of the appliance. Accordingly, consumers not only look at the *purchase price of the machine* (38,2 %) but also for a very *good result on the energy label* (36 %). More than one fourth of the consumers expect a *good dishes-/textile protection* too. Other criteria like *shorter programme duration*, *low detergent consumption* or a *large number of different programmes* are only mentioned by 15-18,5 % of the consumers. The lowest values are reached by a *higher capacity* (10,2 %) and an *innovative aesthetic design* (7,2 %).

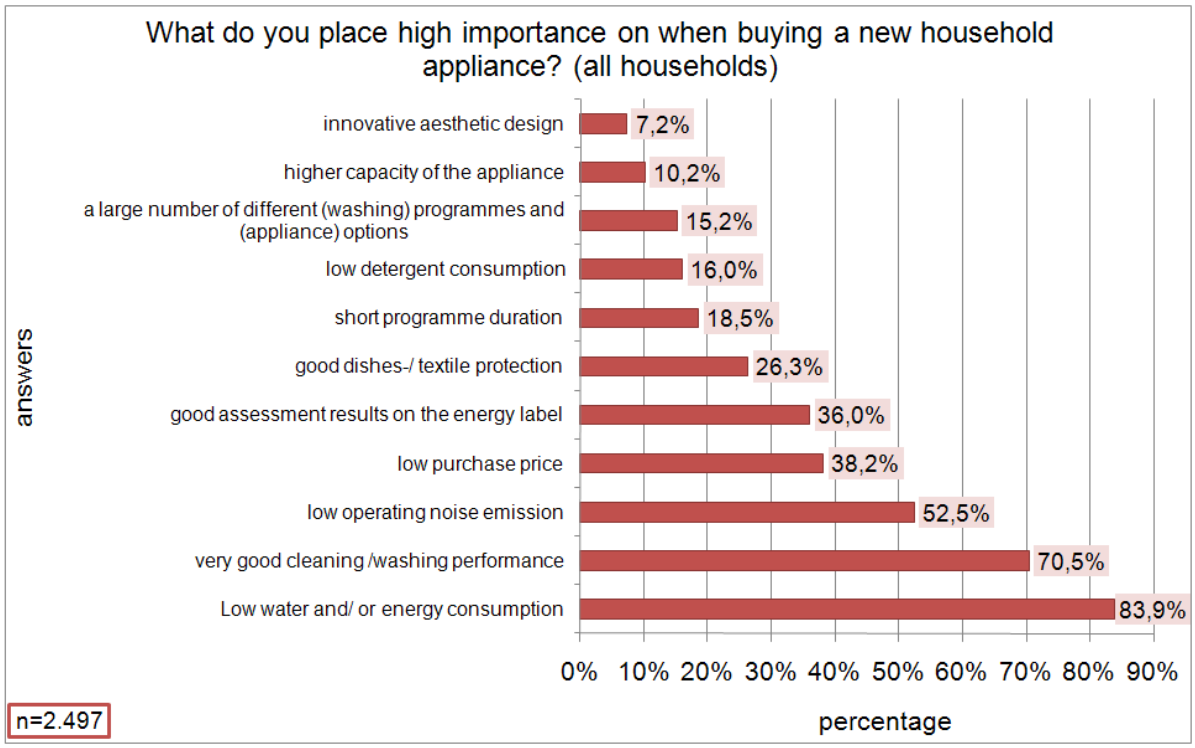


Figure 3.19: criteria when purchasing a new appliance

3.3.5 Identification of Possible Barriers to Eco-design Innovation

3.3.5.1 Appliance lifetime

Unnecessary energy consumption in households is influenced by over-aged appliances among other things.

The energy efficiency of **washing machines** has been improved considerably over the last decade. Running old washing machines is therefore far less efficient than replacing them by new models. The average lifetime of a washing machine is over ten years[15]. According to data from a CECED study nearly 25 % of all washing machines were older than ten years in 2004[16].

The consumer survey results show that nearly 50 % of all washing machines are younger than four years with 90 % younger than ten years (Figure 3.20). The analysis of the households per country shows that nearly 50 % of all washing machines are younger than 3-4 years with 90 % younger than 8-11 years (Figure 3.21). The calculated average age of washing machines in the interviewed households is 5,5 years (Figure 3.22). The lower average age was found the UK and Spanish households with 4,5 and 5,2 years respectively (Figure 3.22), the higher average age was found in Italian and Polish households with 5,7 years and in Sweden with 5,6 years.

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[15] http://www.freescale.com/webapp/sps/site/overview.jsp?nodeId=02M0zpbnQXGM10G4KwF8; http://mail.mtprog.com/CD_Layout/Day_1_21.06.06/1400-1545/ID76_Stamminger_final.pdf

[16] CECED (2006): WHITE PAPER: ENERGY EFFICIENCY A SHORTCUT TO KYOTO TARGETS. THE VISION OF EUROPEAN HOME APPLIANCE MANUFACTURERS, S.18 ONLINE: HTTP://WWW.CECED.ORG/IFEDE//EASNET.DLL/GETDOC?APPL=1&DAT_IM=20429D&DWNLD=WHITE PAPER_ENERGY EFFICIENCY_FEB 2006_FINAL.PDF

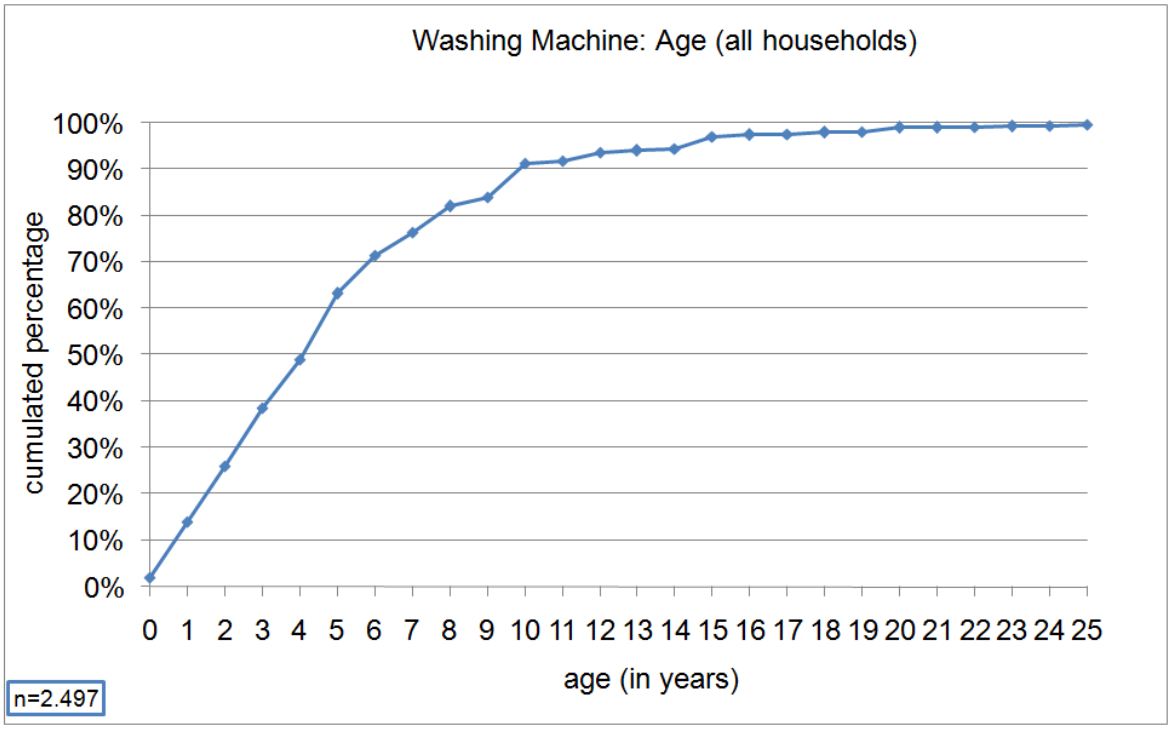


Figure 3.20: age of washing machines (all households)

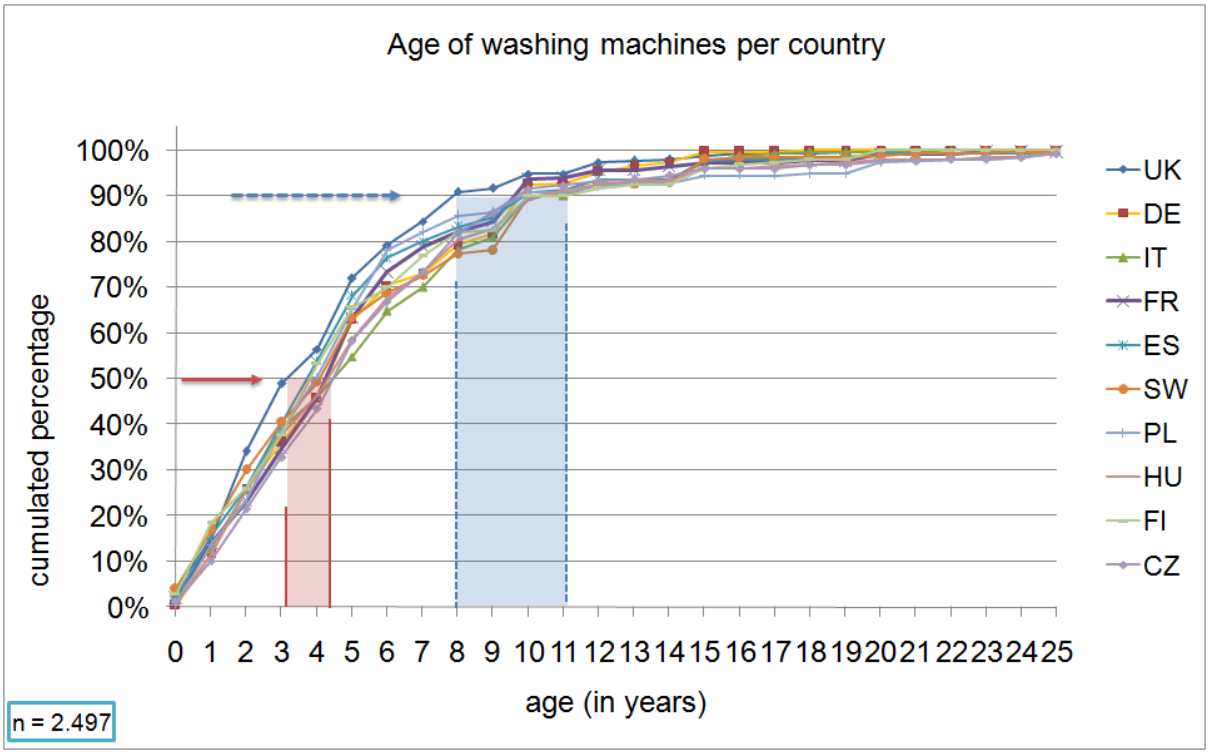


Figure 3.21: age of washing machines per country

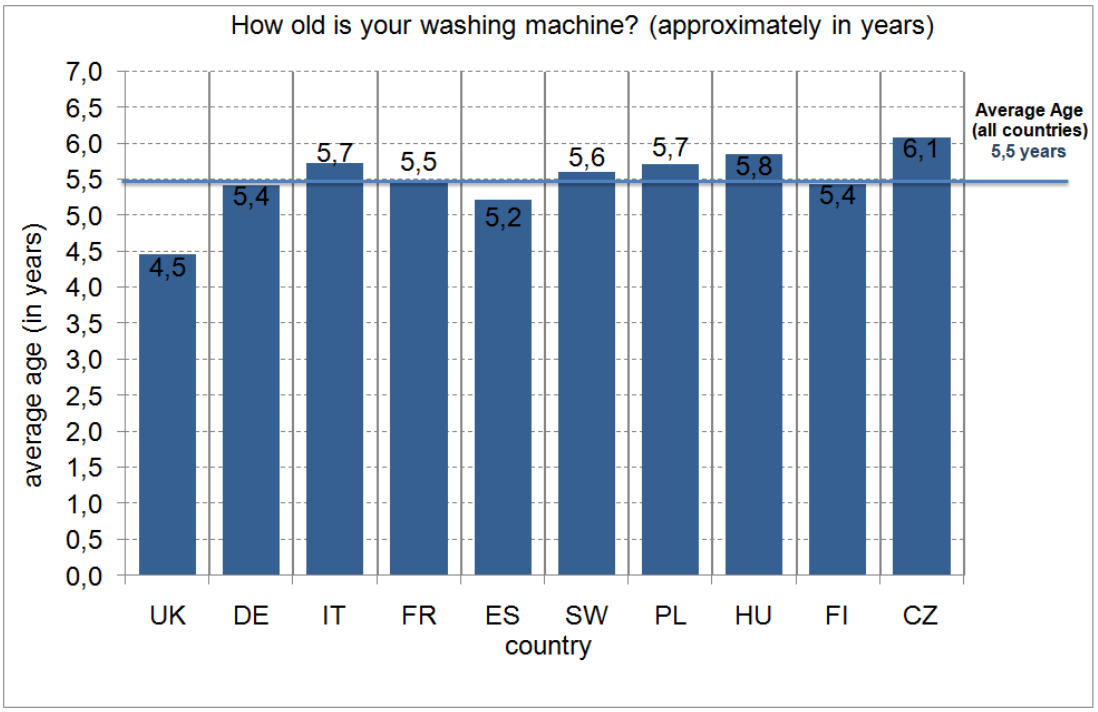


Figure 3.22: average age of washing machines per country

According to published sources the average economic lifetime of **dishwashers** is 10-12 years[17]. The difference between the energy consumption per cycle of an over 10 years old 12 place settings dishwasher and a similar appliance of today is nearly 0,5 kWh[18].The average age of dishwashers (n = 1 722) in all interviewed households is 4,7 years.

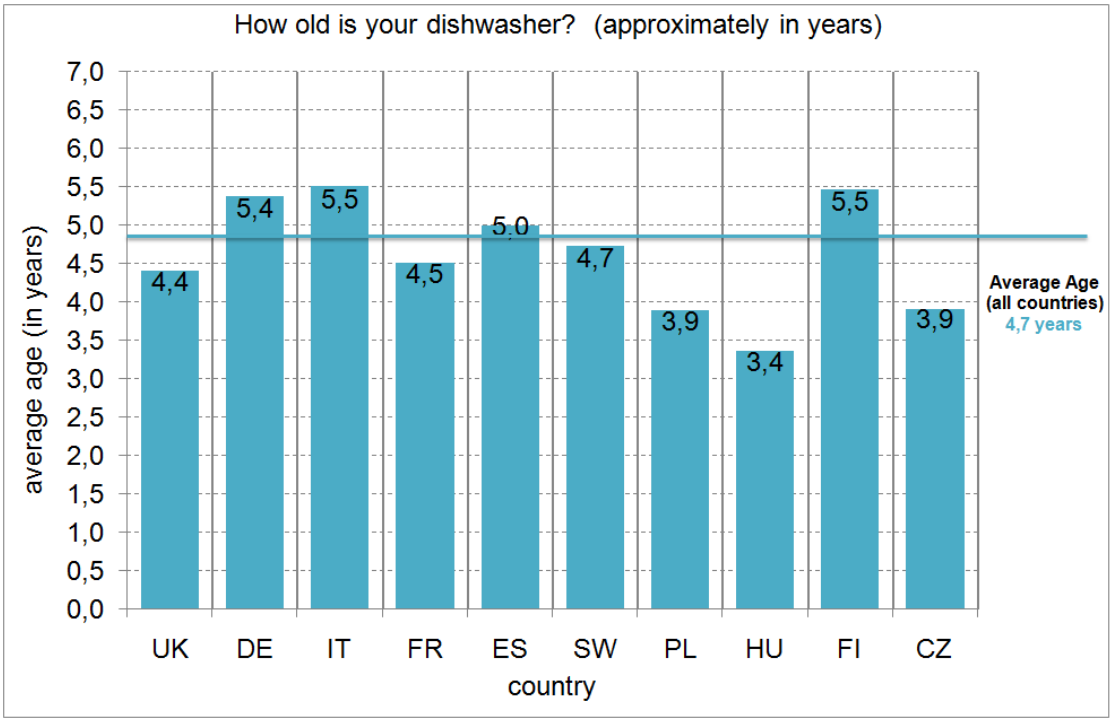


Figure 3.23: average age of dishwashers per country

[17] Öko-Institut. (2006): http://www.ecotopten.de/download/EcoTopTen_Kriterien_Spuelen.pdf
[18] Stamminger, R. (2006): http://www.haushaltstechnik.uni-bonn.de/waschtag/pdfMulitplikatoren/VortagMultseminar_Stamminger.pdf

Half of all dishwashers are younger than three years with 90 % younger than 9,5 years (Figure 3.24). Also the analysis of the age distribution per country (Figure 3.25) shows that 50 % of the dishwashers are between 2,2 and 4,3 years old or younger; 90 % of all appliances have an age younger than between 6 and 11,5 years. Dishwashers with the highest average age can be found in Italy and Finland with 5,5 years, followed by Germany (5,4 years). The youngest machines with an average age < 4 years are found in Polish (3,9 years), Hungarian (3,4 years) and Czech households (3,4 years). Dishwashers in the other countries have and age between 4,4 and 5 years on average.

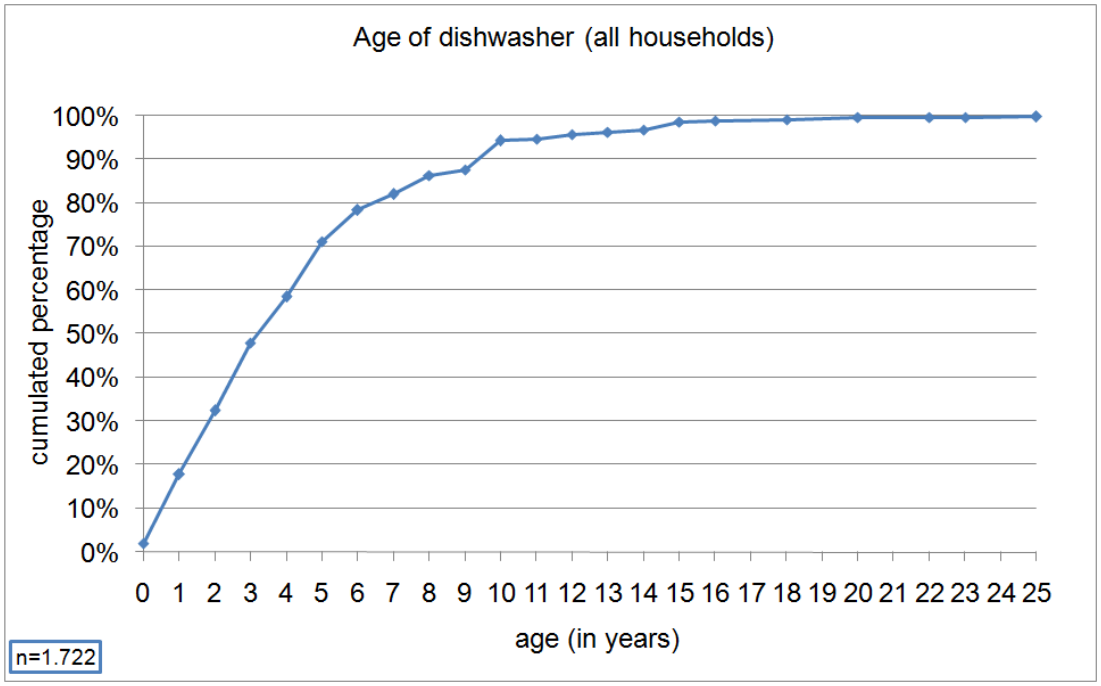


Figure 3.24: age of dishwasher (all households)

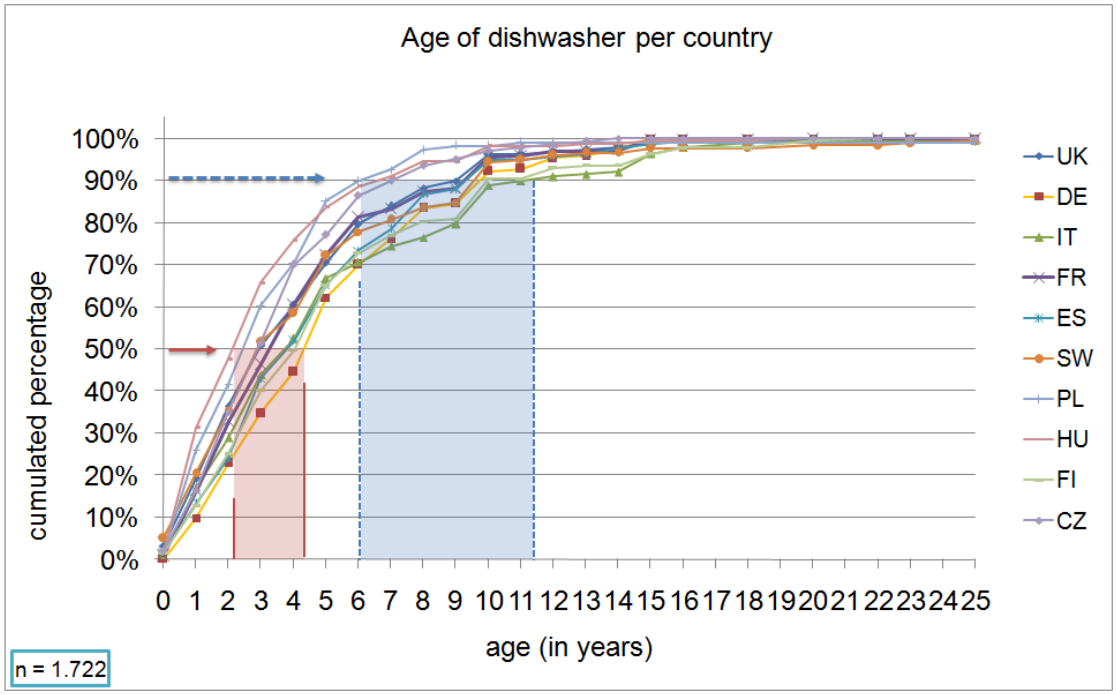


Figure 3.25: age of dishwasher per country

3.3.5.2 Maintenance and repairs

Sixteen percent (n = 1 611) of all household appliances covered by the survey were repaired or serviced (Table 3.4). Washing machines are reported to be the mostly repaired/serviced appliance with a share of 30 % (Figure 3.26), followed by dishwashers with nearly 18 %.

Table 3.4: overview: distribution of repaired/serviced appliances

	total	repaired/ serviced
Dishwasher	1.722	309
Washing machine	**2.497**	**750**
Tumble-dryer	893	133
Refrigerator	2.497	306
Freezer	1.871	78
Chest freezer	564	35
Sum (repaired/serviced)		**1.611**
all appliances		10.044
% of all appliances		**16,0**

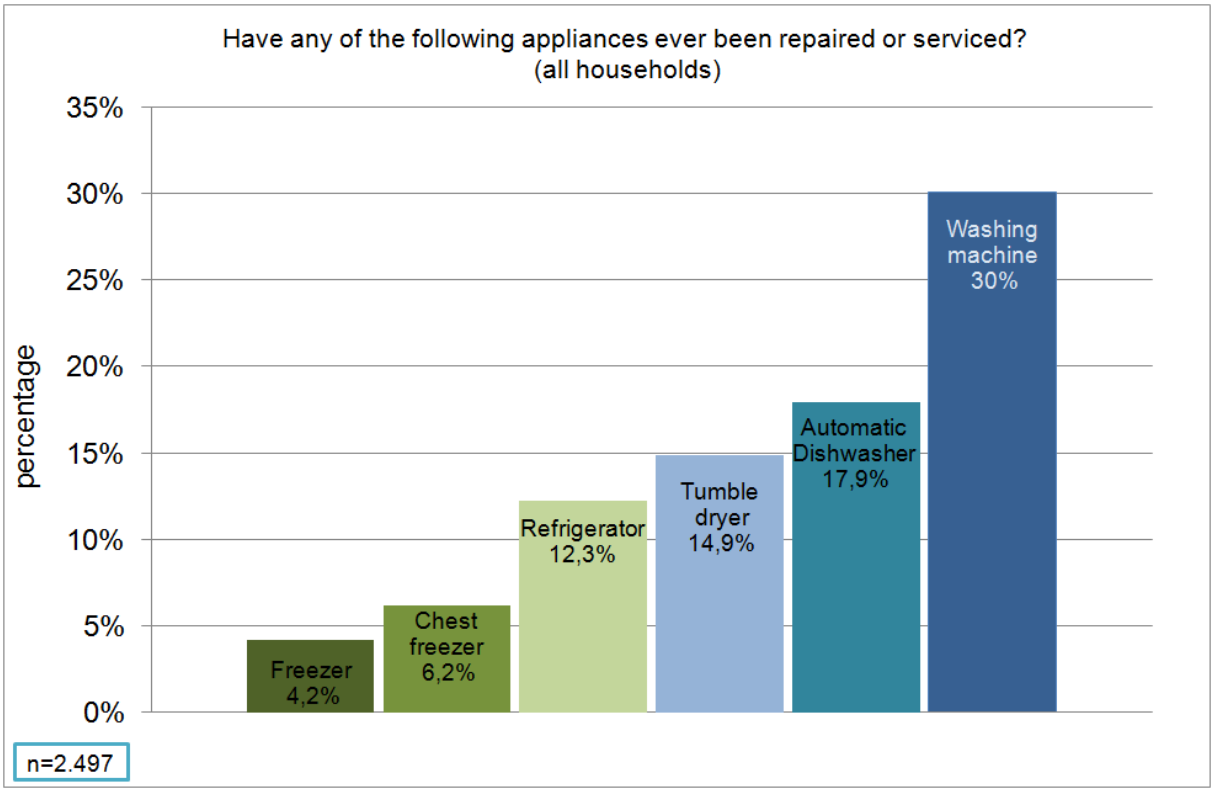


Figure 3.26: appliances – repaired or serviced

The highest share of repaired/serviced **washing machines** (48 %) was found in Spain and the lowest (7 %) in Swedish households, followed by the French ones (16 %) (Figure 3.27). In the other countries values vary between 24 % and 38 %.

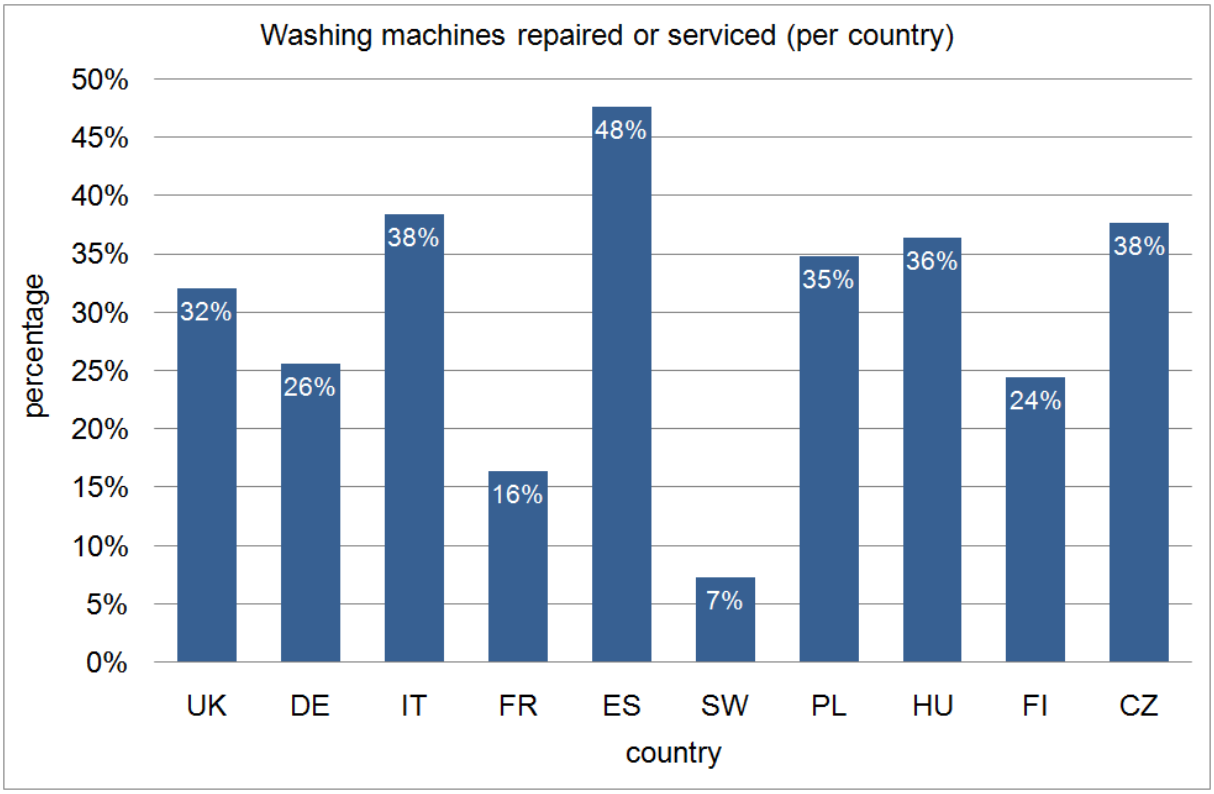


Figure 3.27: washing machines repaired or serviced per country

In comparison with the 5,5 years average age of all washing machines, machines, which have been serviced, were on average 1,3 years older (average 6,8 years) (Figure 3.28), therefore the servicing/repairing resulted in an extension of the lifetime.

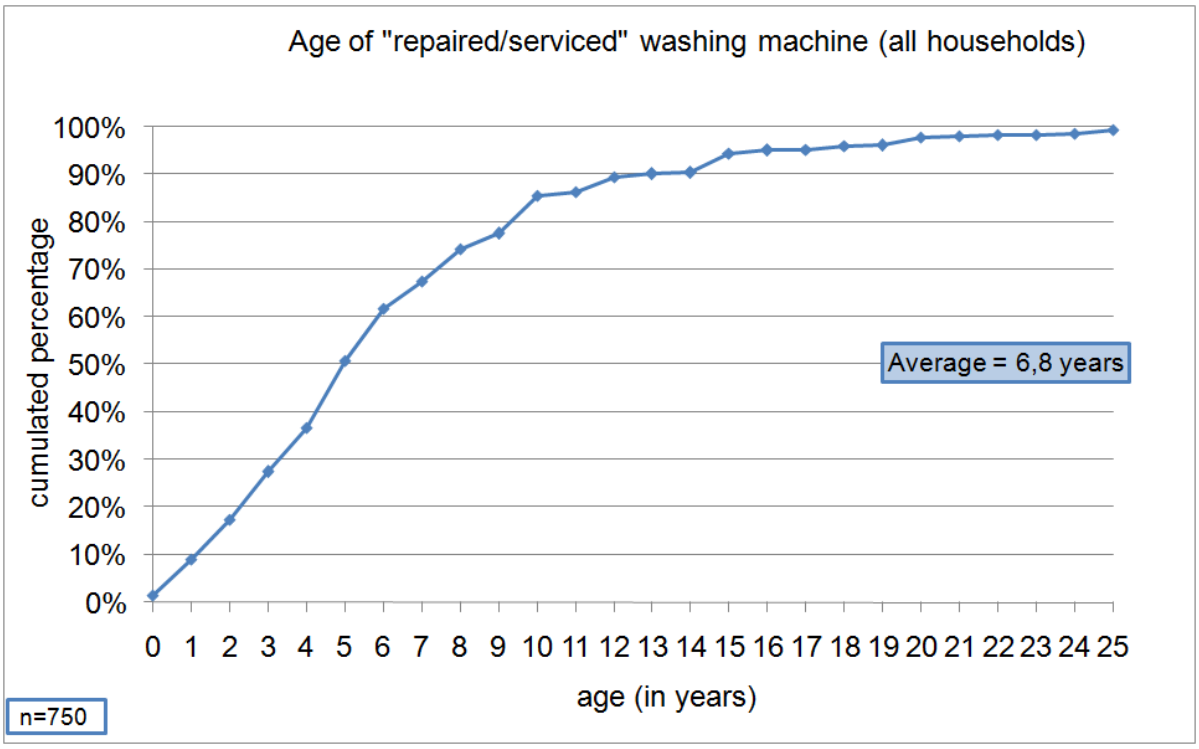


Figure 3.28: age of „repaired/serviced“ washing machines

One third of **dishwashers** (35 %) in Italy have been repaired or serviced. United Kingdom, Spain and Czech Republic followed with a percentage between 19 to 24 % (Figure 3.29). The lowest percentage of repaired/serviced dishwashers can be found in Sweden with only 6 %.

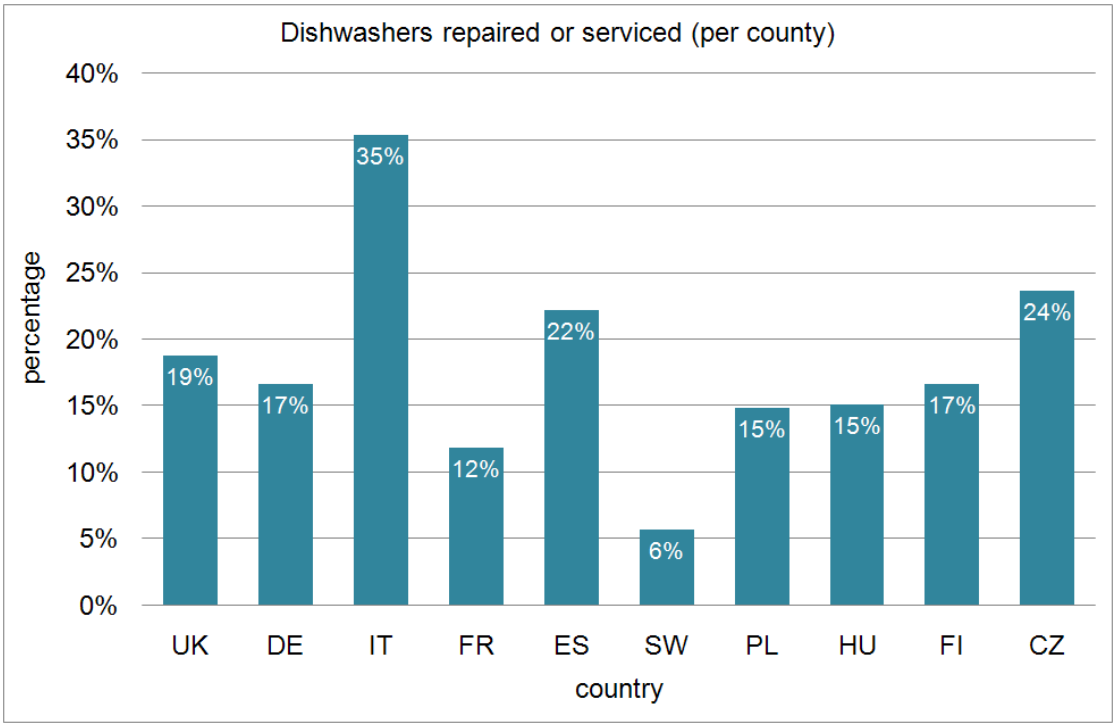


Figure 3.29: dishwashers repaired or serviced per country

The average age of repaired or serviced dishwashers is 6,4 years: 50 % are younger than 4,5 years and 90 % are younger than 13 years. (Figure 3.30). In comparison with non-repaired dishwashers they are between 1,7 and 3,5 years older.

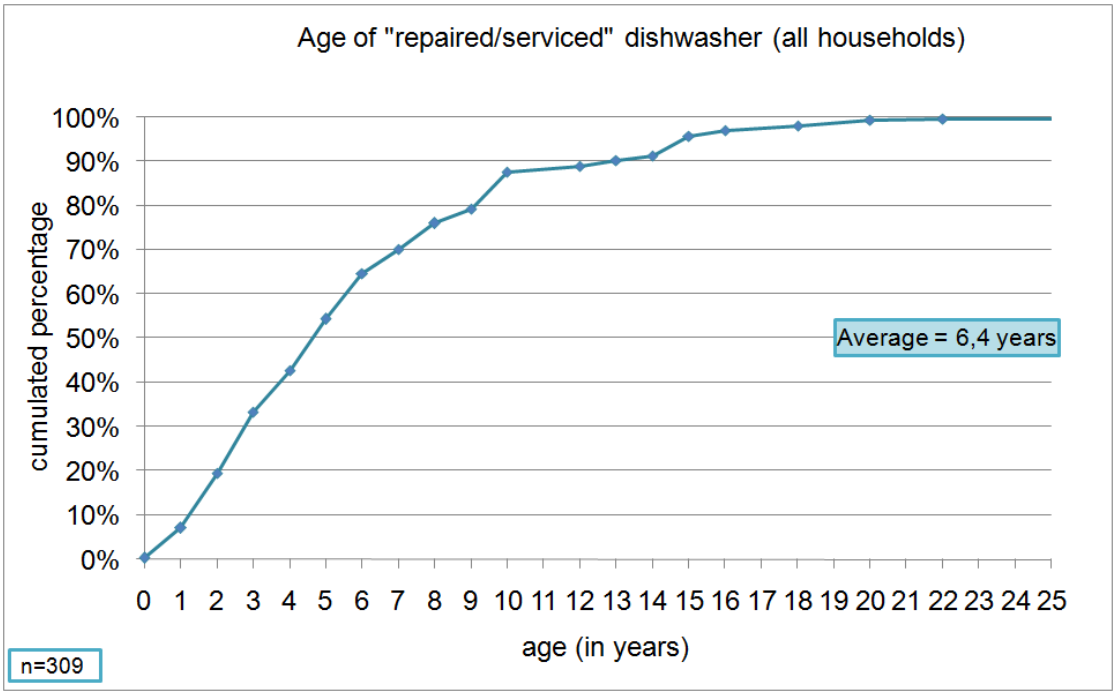


Figure 3.30: age of „repaired/serviced“ dishwashers

3.3.5.3 Second hand market

Another possible barrier for the implementation of eco-design innovations is the stock of second-hand purchased appliances in households. Consumers may choose to replace broken or missing appliances by second-hand machines, which have lower performance than the new models on the market.

The consumers were asked which appliances they purchased second-hand. In general, 6,3 % (n = 633) of all appliances were purchased this way (Table 3.5). Washing machines only show a share of 5,6 % of second-hand purchases, dishwashers a 6,6 % share. (Figure 3.31).

Table 3.5: overview: distribution of second hand appliances

	total	second hand
Dishwasher	1.722	114
Washing machine	**2.497**	**140**
Tumble-dryer	893	59
Refrigerator	2.497	122
Freezer	1.871	118
Chest freezer	564	80
Sum (second hand)		**633**
all appliances		10.044
% of all appliances		**6,3**

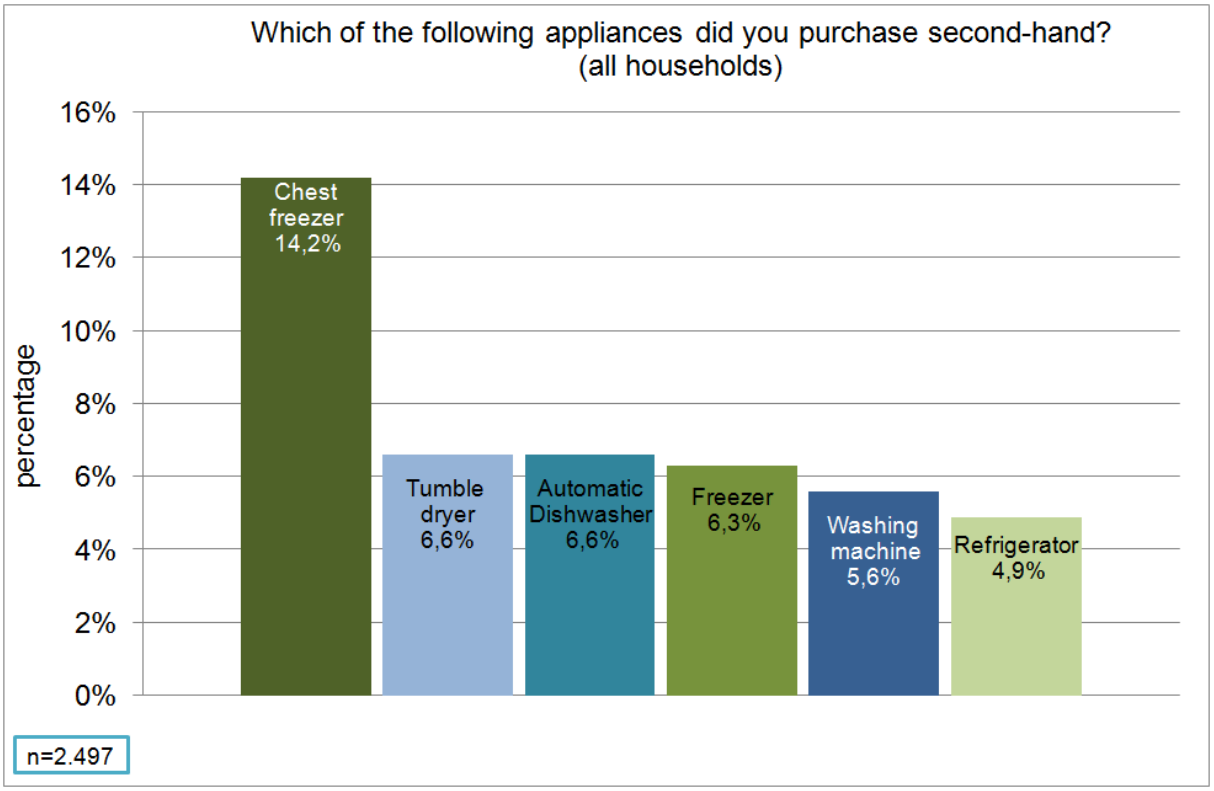


Figure 3.31: appliances – purchased second-hand

Most of second-hand **washing machines** could be found in Finland (10 %), Sweden (8,8 %) and the Czech Republic (8,1 %) (Figure 3.32). The lowest percentage of second-hand washing machines was found for Italian households with only 1,2% and for Spanish households with 2 %. On average

second-hand washing machines are 7,3 years old or 1,8 years older in comparison to all washing machines (average age 5,5 years); 10 % are older than 13 years and 50 % are older than 5,5 years. (Figure 3.33).

Comparing these results with the energy efficiency improvements achieved in the last decade, second-hand appliances are in general less efficient: therefore, the re-selling of washing machines older then 10 years through the second-hand market is not an energy saving behaviour.

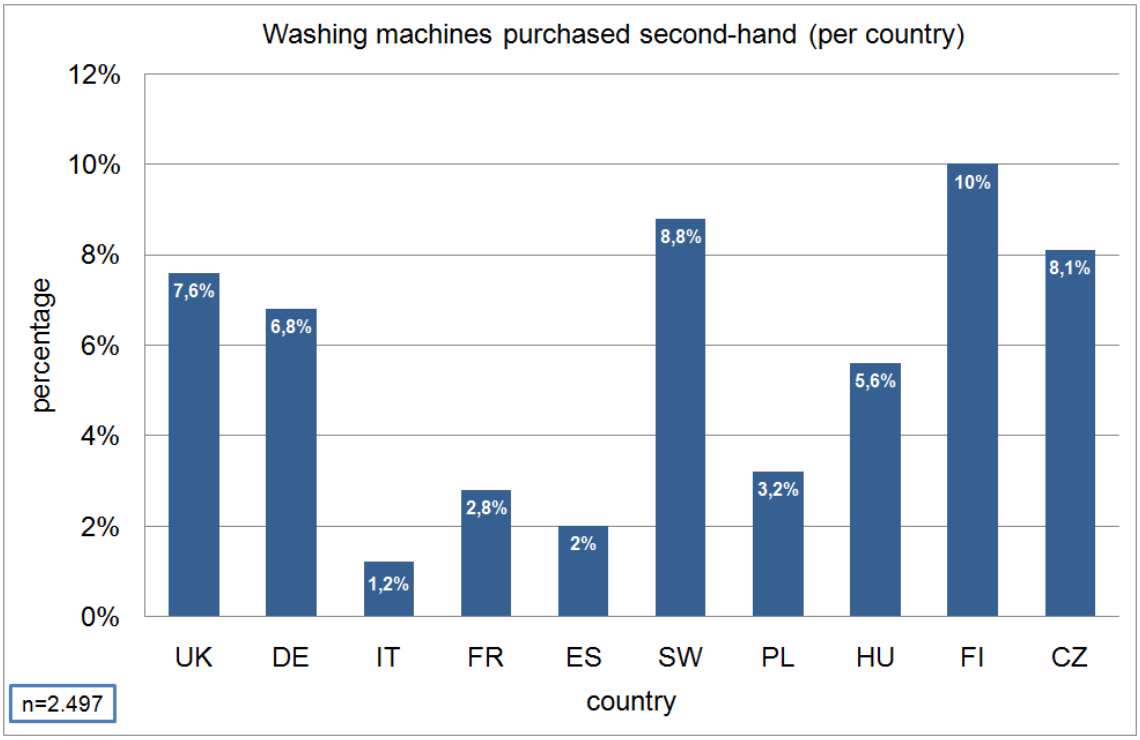


Figure 3.32 washing machines purchased second-hand per country

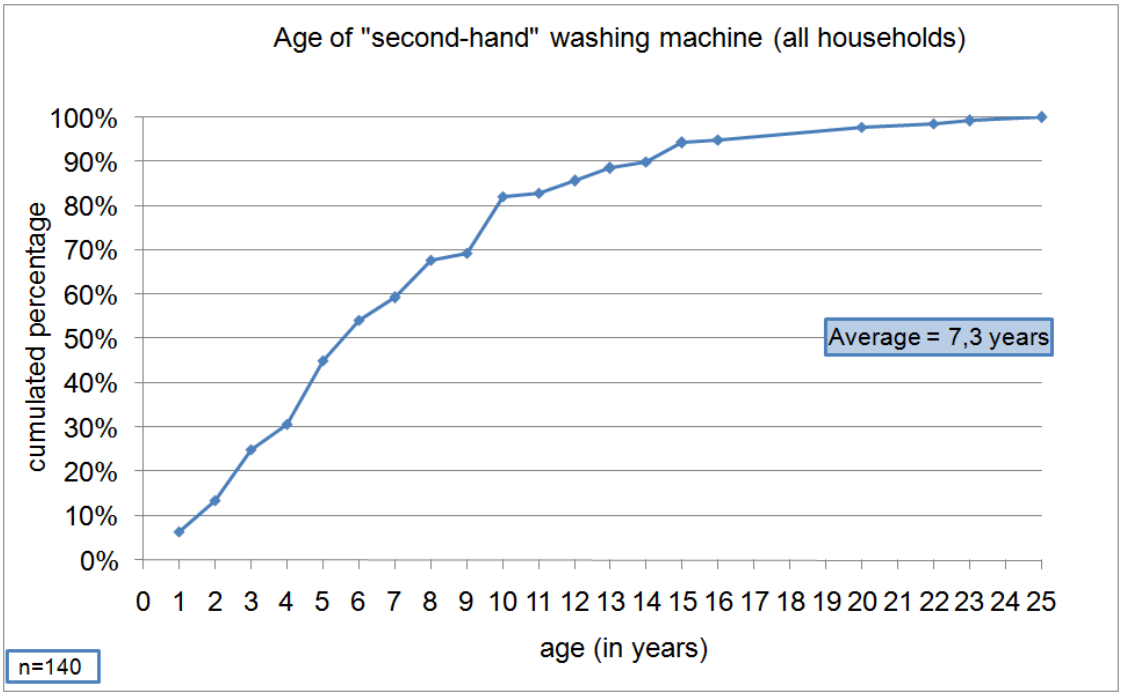


Figure 3.33: age of „second hand“ washing machines

The highest share of second-hand **dishwashers** can be found in Finnish households with 10,7 % and in Sweden and the Czech Republic with 8,5 % and 8,6 %, respectively (Figure 3.34). The results for Italy show the smallest share of second-hand dishwashers with a percentage of only 2,7.

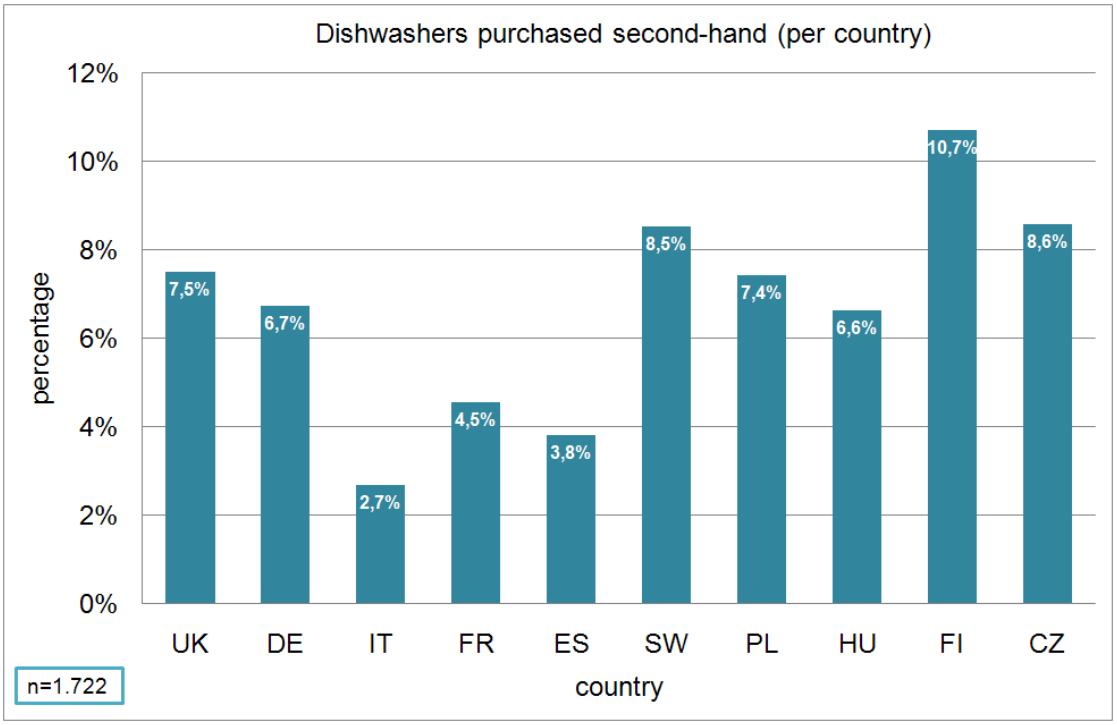


Figure 3.34: dishwashers purchased second-hand per country

The average age of second-hand dishwashers is 6,1 years, with 50 % younger than 4,5 years and nearly 90 % younger than 10 years (Figure 3.35).

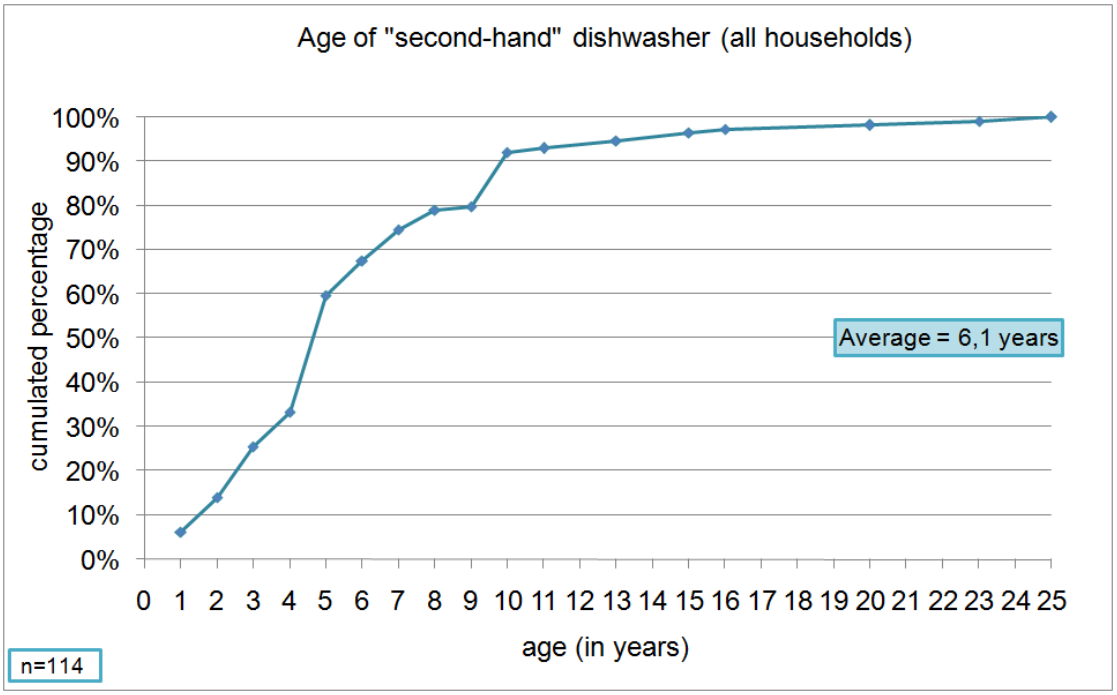


Figure 3.35: age of „second hand“ dishwasher

3.3.6 Consumer attitude towards energy saving options

Over 60 % of the interviewed consumers estimate the influence of a washing machine on the overall energy consumption of a household as "great" or even more, "massive" (Figure 3.36). In addition, the consumers consider the washing machines as the most energy consuming appliance of the listed products. The results for dishwashers show that nearly 70 % of all consumers think that the influence is "moderate" (35,2 %) or "great"(32,6 %).

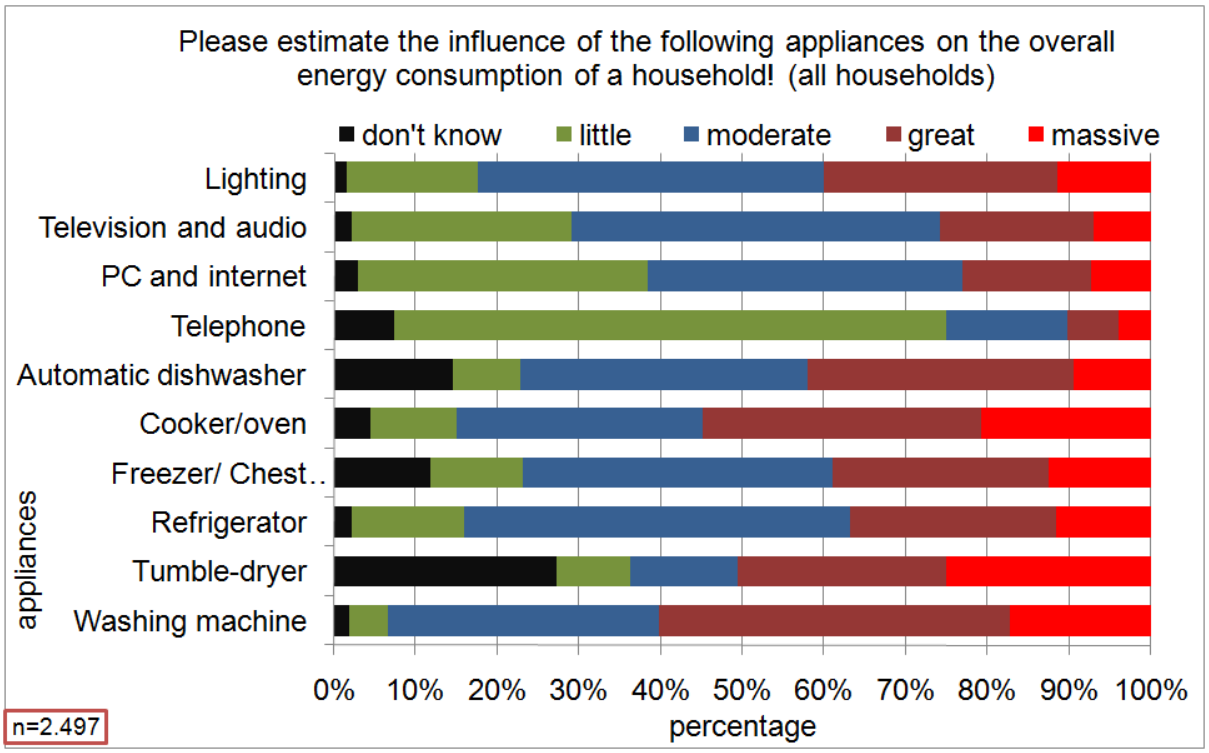


Figure 3.36: estimation: influences of appliances on the energy consumption of a household

To identify possible barriers to eco-design innovation and effective ways for their implementation, the consumer opinion about energy saving options was analysed.

Consumers were asked to select the preferred options to save energy or money.

The analysis of the answers for **washing machines** shows that most of the consumers (73,8 %) would definitely use *economic programmes* or would perhaps choose this option (22,5 %) more frequently than the other listed options (Figure 3.37). The options "*longer programme duration*" and "*delay start*" achieved similar values: in both cases 80 % of the consumers would "use" or "perhaps use" them. The lowest consideration was give to the use of "*hot water supply*" with 28,3 % of consumer not willing to use and only slightly more than 30 % clearly accepting it.

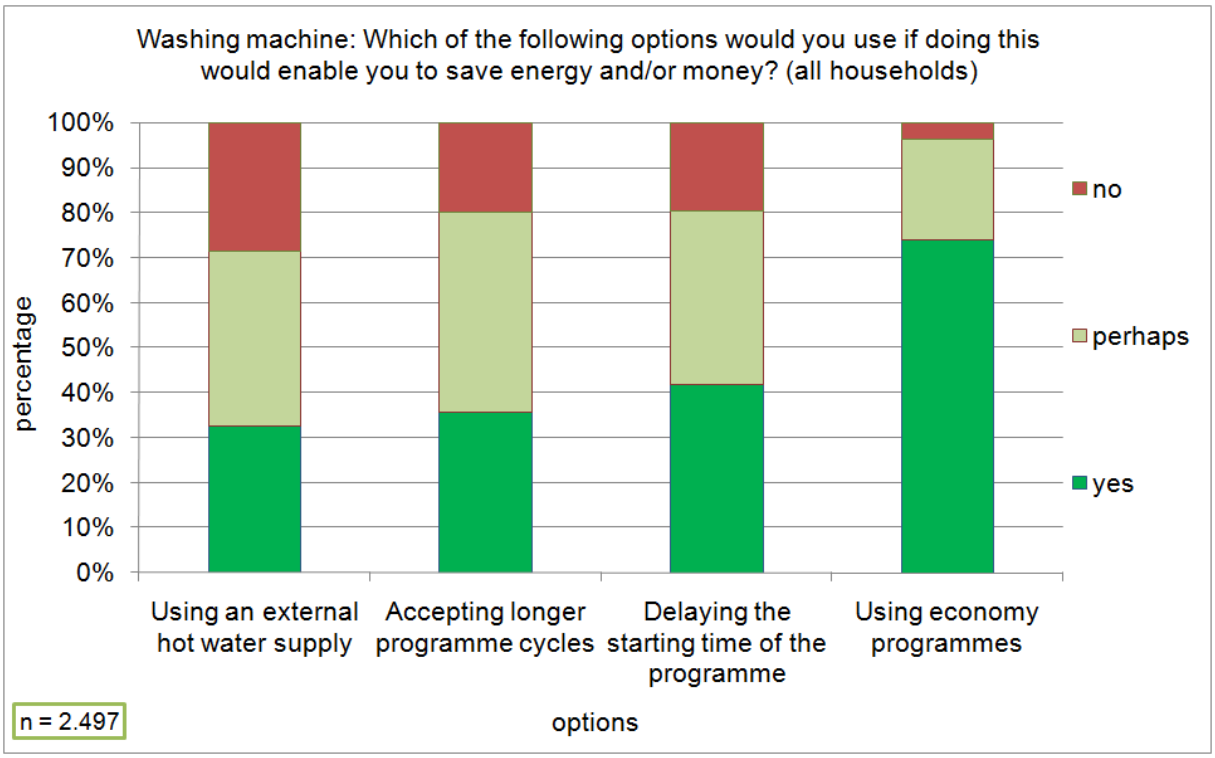


Figure 3.37: washing machines: consumer attitudes – energy saving options

For **dishwashers**, most of the consumers (72,1 %) would choose the *eco-programme* (Figure 3.38). Nearly 80 % of all consumers would use or consider using the *start-delay option* or *longer programme cycles* if this would save energy and/or money. The results concerning the use of an external *hot water supply* are ambiguous: 30,4 % of consumers would choose this option and 28,7 % would refuse it; the remaining consumers will perhaps choose the option.

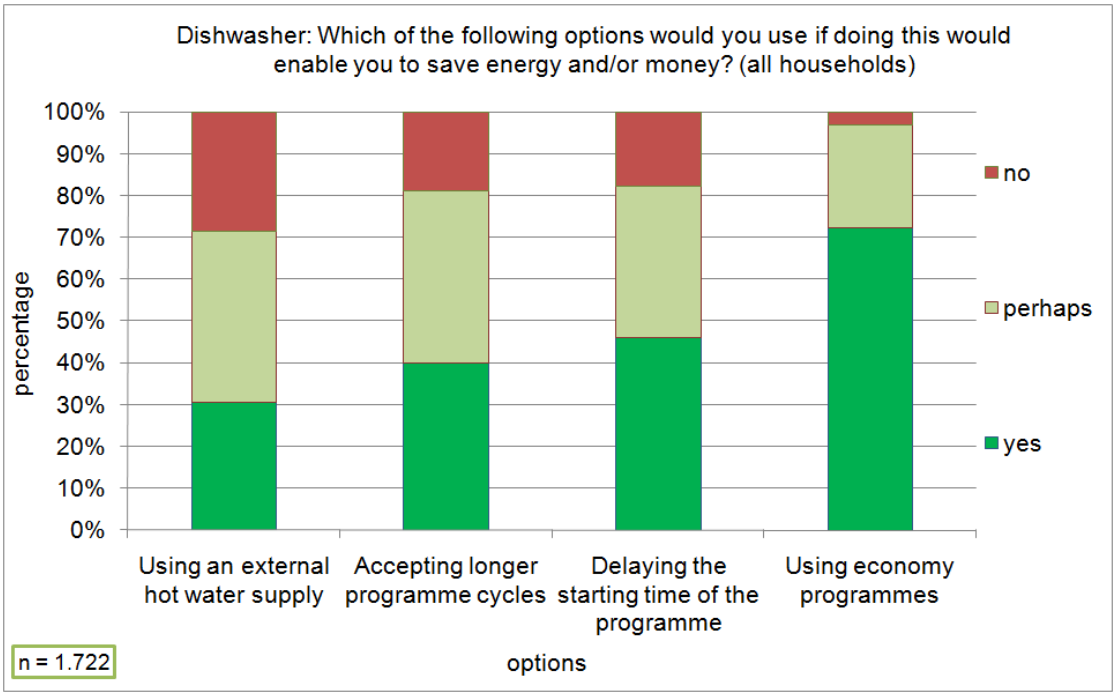


Figure 3.38: dishwasher: consumer attitudes – energy saving options

3.3.7 *The purchasing of a dishwasher*

All interviewed consumers without a dishwasher were asked for the reasons for not having a dishwasher. The most named reason is *shortage of space in the kitchen* (56,8 %) (Figure 3.39), frequently mentioned by consumers in United Kingdom, Germany, Italy, Sweden and Poland (Figure 3.40). Another frequent reason is that there are *not enough dishes* to justify the purchase (49,3 %), which is the main justification for French, Spanish, Hungarian and Czech consumers (with answers between 57 % and 70 %). The reason that consumers are *just happy without a dishwasher* is mentioned with an average percentage of about 39 %, in particular for the Finnish consumers (57,1 %); the initial cost is too high for 23,5 %. For nearly 15 % of the consumers the *high energy and water consumption* is the reason against the purchasing of the dishwasher: for consumers in Poland, Hungary, Czech Republic and United Kingdom this is an important point (17,6-22,2 %).

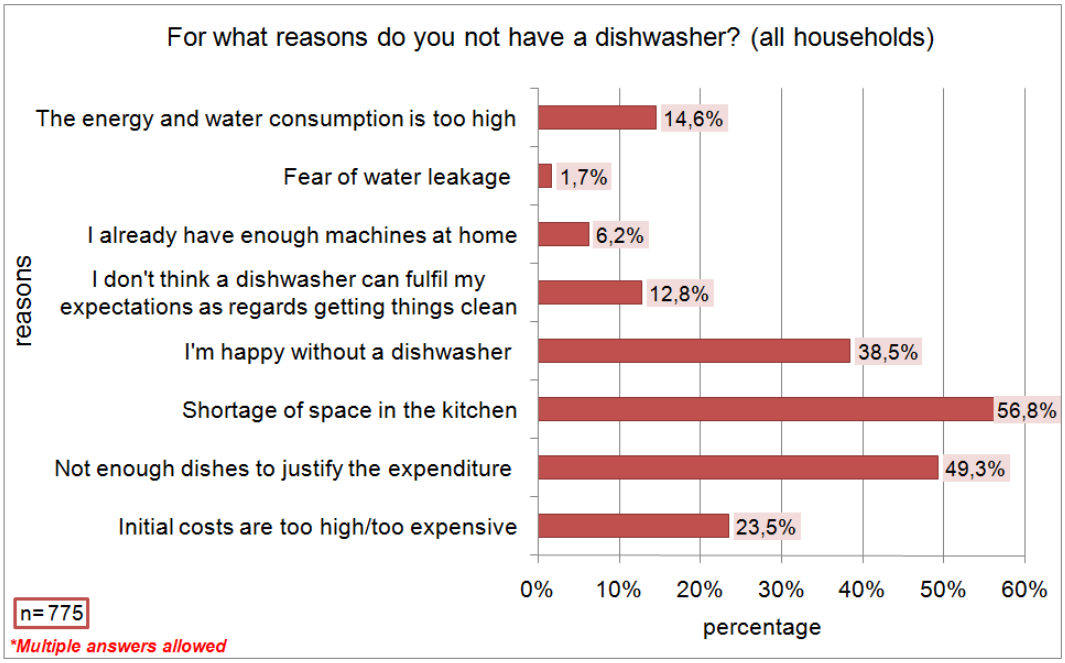
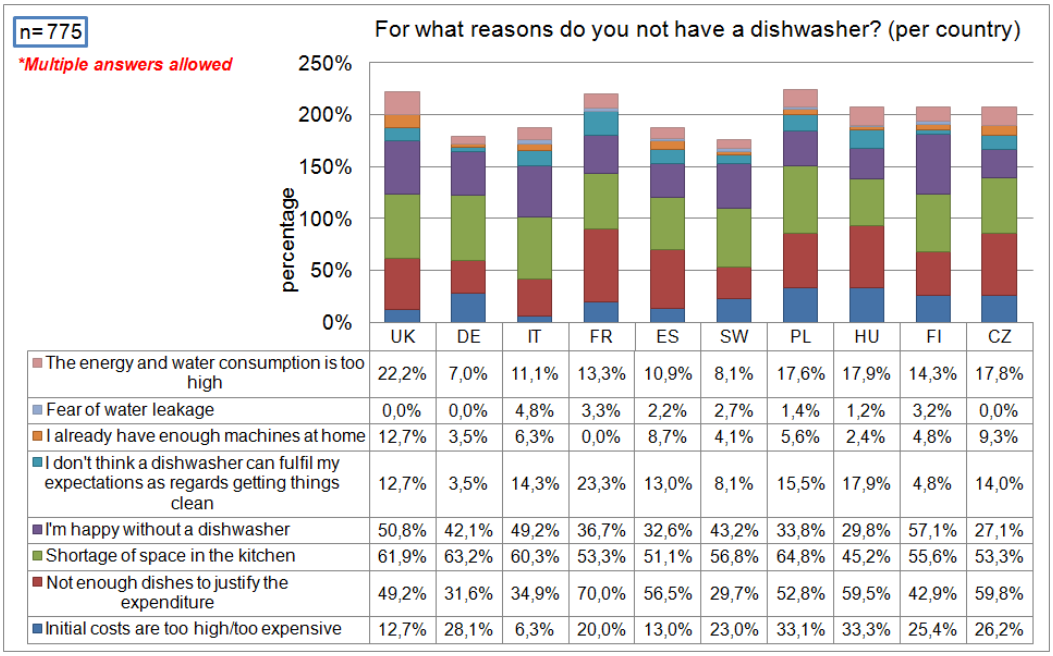


Figure 3.39: reasons for not having a dishwasher



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
The energy and water consumption is too high	22,2%	7,0%	11,1%	13,3%	10,9%	8,1%	17,6%	17,9%	14,3%	17,8%
Fear of water leakage	0,0%	0,0%	4,8%	3,3%	2,2%	2,7%	1,4%	1,2%	3,2%	0,0%
I already have enough machines at home	12,7%	3,5%	6,3%	0,0%	8,7%	4,1%	5,6%	2,4%	4,8%	9,3%
I don't think a dishwasher can fulfil my expectations as regards getting things clean	12,7%	3,5%	14,3%	23,3%	13,0%	8,1%	15,5%	17,9%	4,8%	14,0%
I'm happy without a dishwasher	50,8%	42,1%	49,2%	36,7%	32,6%	43,2%	33,8%	29,8%	57,1%	27,1%
Shortage of space in the kitchen	61,9%	63,2%	60,3%	53,3%	51,1%	56,8%	64,8%	45,2%	55,6%	53,3%
Not enough dishes to justify the expenditure	49,2%	31,6%	34,9%	70,0%	56,5%	29,7%	52,8%	59,5%	42,9%	59,8%
Initial costs are too high/too expensive	12,7%	28,1%	6,3%	20,0%	13,0%	23,0%	33,1%	33,3%	25,4%	26,2%

Figure 3.40: reasons for not having a dishwasher per country

If, as previously mentioned, most of the consumers consider the dishwashers as having a moderate or great influence on the overall household energy consumption, in detail over 40% of all households without dishwashers "don't know" the energy consumption of a dishwasher, in comparison with households with a dishwasher (2,3 % "don't know") (Figure 3.41). Especially Polish, Spanish and Czech consumers can hardly estimate the influence of the dishwasher (57 %; 64,1 %; and 65,4 %) on the household energy consumption (Figure 3.42). A higher number of the Spanish consumers without a dishwasher estimate the influence of a dishwasher as "little" compared with the average results of the other European countries. A "great" or "massive" influence of the dishwasher on the energy consumption is mostly mentioned by French (13,3 %) and Italian (23,8 %) consumers (Figure 3.43). This opinion was given also by French and Italian consumers with a dishwasher (21,4 % and 19,8 %).

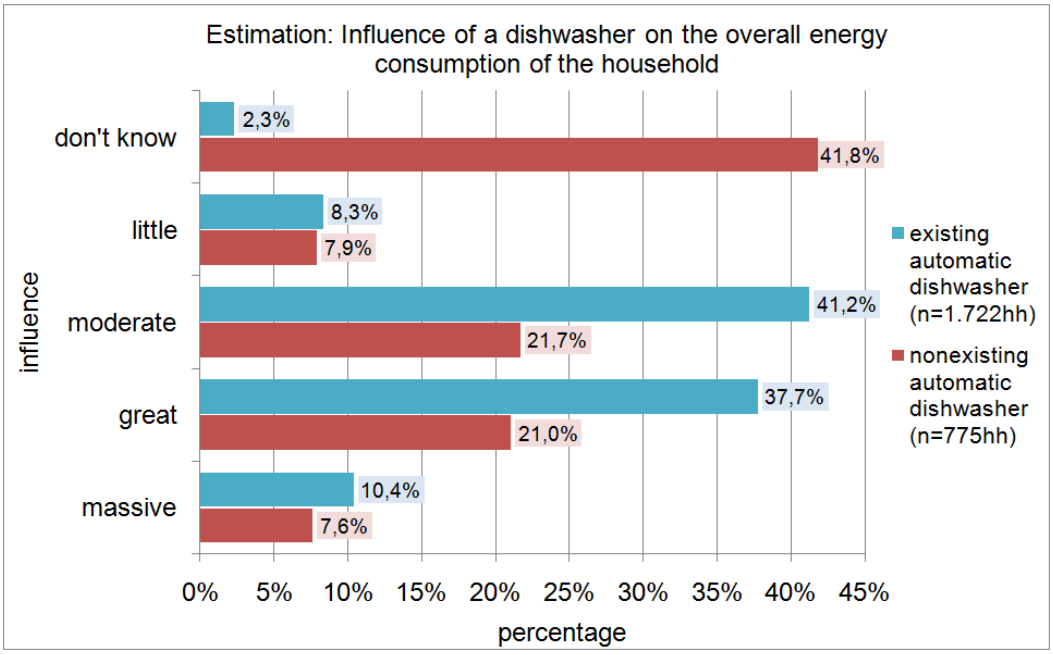


Figure 3.41: estimation – influence dishwasher on the energy consumption (households with vs. without a dishwasher)

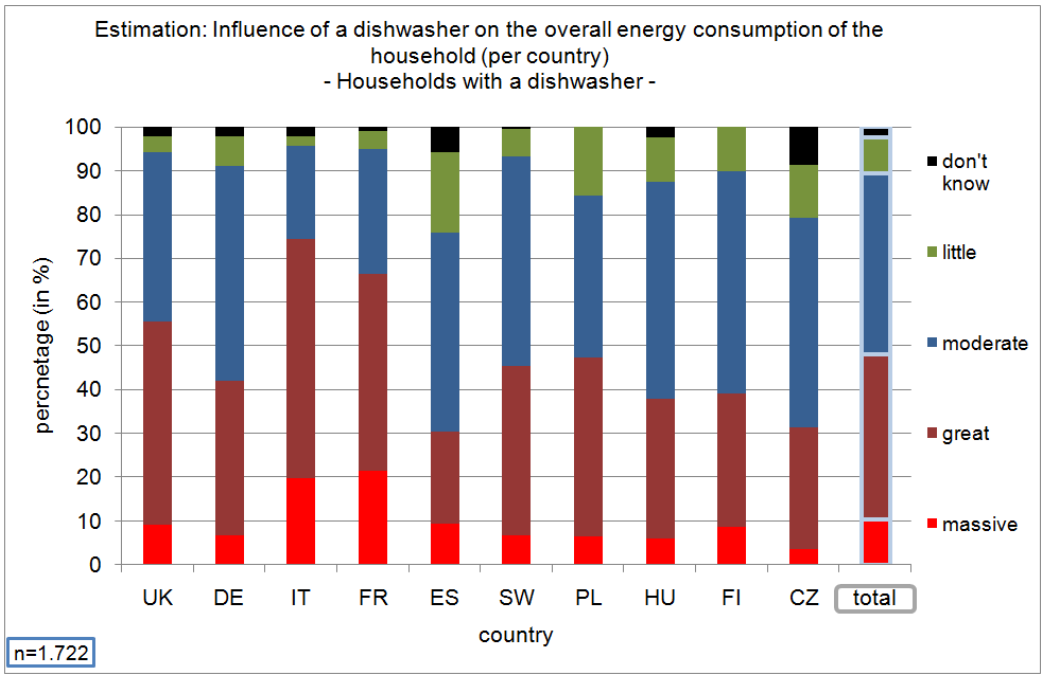


Figure 3.42: estimation: influence of a dishwasher on the energy consumption of a household (households with a dishwasher per country)

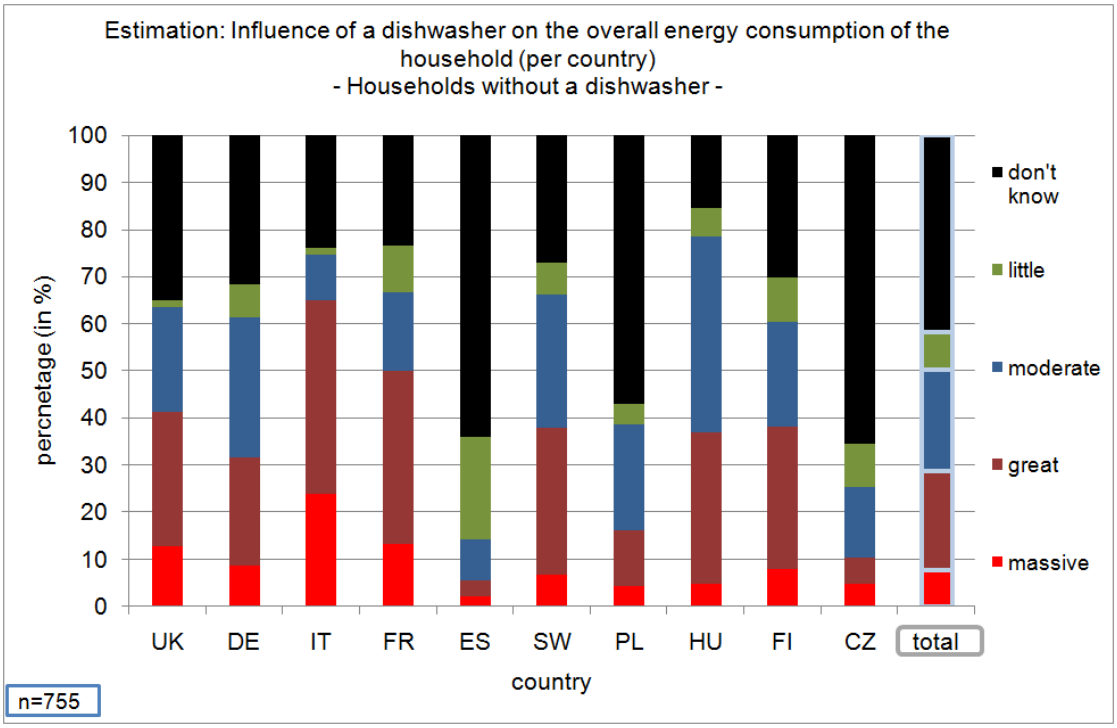


Figure 3.43: estimation: influence of a dishwasher on the energy consumption of a household (Households without a dishwasher (per country))

For 23,5 % of all consumers, the *high initial costs* are deterring, especially for Polish and Hungarian consumers (nearly 33 %); with the exception of German and Finnish consumers the rest of the interviewed European households also indicated that a dishwasher *wouldn't fulfil their expectations in cleaning performance*. On average nearly 13 % mentioned this point as a reason for not having a dishwasher. The less important reasons are *fear of water leakage* (1,7 %) and *high equipment level* (6,2 %).

3.4 USER DEFINED PARAMETERS: WASHING MACHINES

3.4.1 Consumer behaviour and appliance energy consumption & saving

Washing machines are operated on consumer demand only. Therefore their energy consumption in the use phase is due by the listed, mainly consumer driven, factors:

- Ambient conditions
- Frequency of operation
- Selected programme and its consumption
- Programme temperature in combination with amount (and type) of detergent
- Option/feature chosen
- Machine efficiency under real use conditions
- Load size
- Low power mode (delay start, left-on, off, etc.)

The ambient where the washing machine is located and the resources that are used may have some influence on the actual consumption of these resources. While it may be calculated that the influence of the ambient temperature is relatively small, the temperature of the supply water may have some more significant influence, if the temperature of the selected wash programme is higher that the inlet water temperature.

The use of pre-heated water (by other sources than electricity) was used extensively in UK in the past. Due to the tendency to wash at lower temperatures and due to the need for additional installations (double piping for installation and the washing machine) this option is less and less attractive[19] (see Task 4 for a more detailed discussion of this infrastructural option).

A metering study[20] developed in Germany has shown the need to correct the ”theoretical energy consumption” based on 15 °C water inlet temperature by a constant value of 180 Wh, which may be explained by a lower water inlet temperature. No statistical data on the average annual temperature of the cold water supply in European households could be found.

The frequency of operation mainly depends on the household size, as this defines the amount of load to be treated. For washing machines consumer research of the real washing practice in 100 households in Germany for one month has roughly shown a linear increase of the number of washing cycles with the number of persons living in the household (Figure 3.44). The same study has measured the weight of the laundry washed and concluded, that per person per week an almost constant load of 4,0 kg of laundry was washed.

In this study also the programme used was recorded. The analysis (Figure 3.45) shows that the most frequently used programme/temperature combination in Germany is still the cotton 60°C programme, while the most frequently selected temperature is 40 °C, due to the variety of different programmes available at this temperature (e.g. cotton, easy-care, silk, wool). The same study also measured the real wash load of washing machines (Figure 3.46). The weight of the load is different

[19] http://www.mtprog.com/ApprovedBriefingNotes/PDF/MTP_BNW15_2007April10.pdf

[20] Berkholz P., et al.: Verbraucherverhalten und verhaltensabhängige Einsparpotentiale beim Betrieb von Waschmaschinen, Shaker-Verlag, 2007

for the various types of garments/programme types and shows a frequent under-loading for the cotton programmes and over-loading for the other types of programmes, compared to what is recommended by the manufacturer as maximum load. For cotton programmes alone (Figure 3.47) the average load used is 3,2 kg, but goes up to more than 5 kg for some loads.

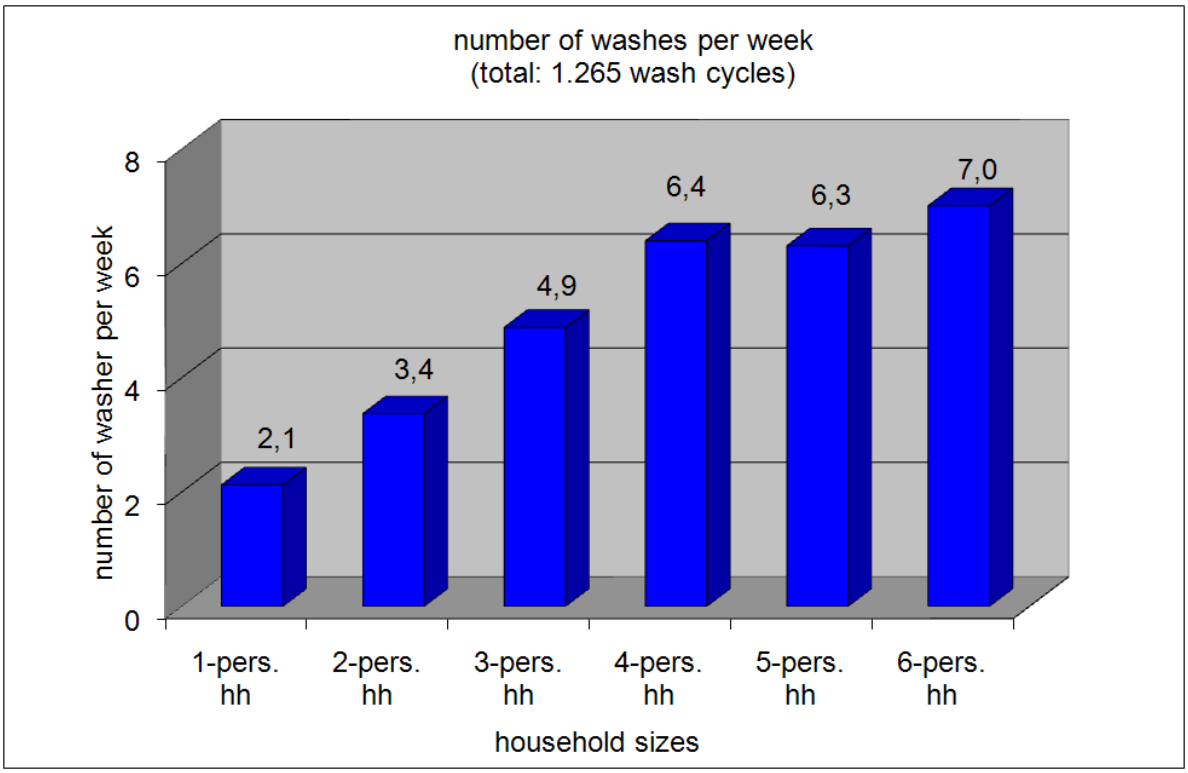


Figure 3.44: number of washes per week in relation to household size (source: Berkholz P., et al. [20])

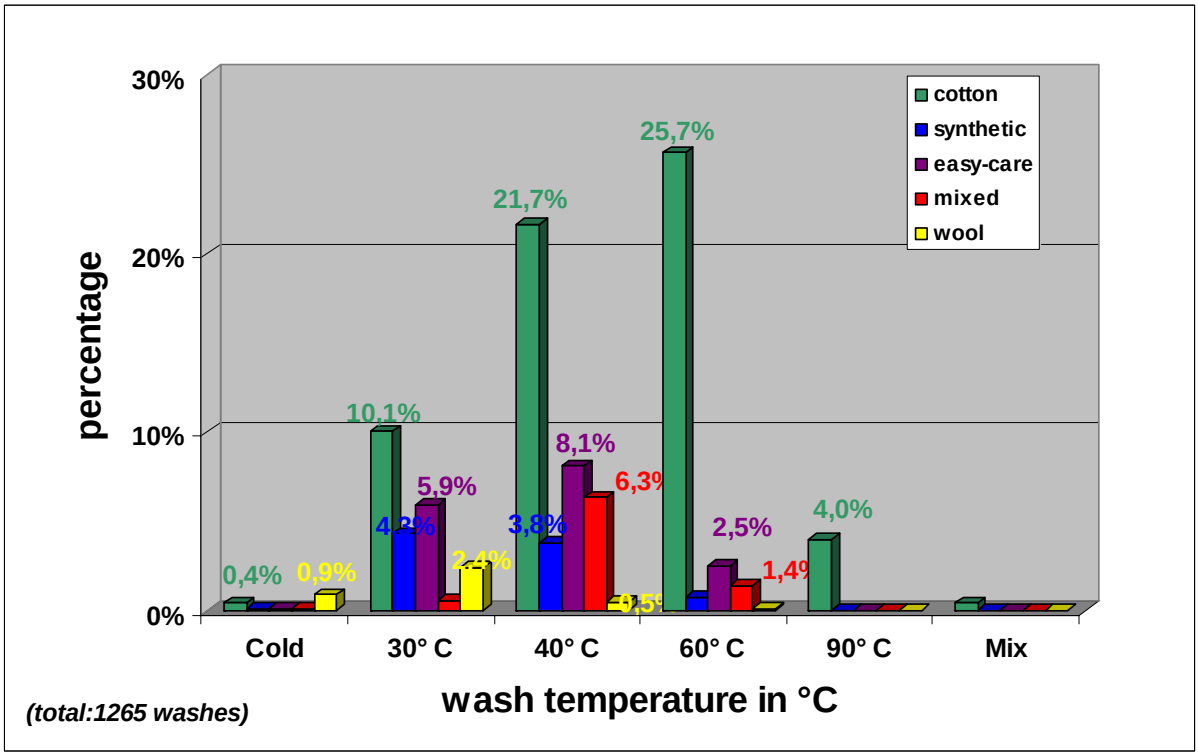


Figure 3.45: distribution of wash programmes and temperature (source: Berkholz P., et al. [20])

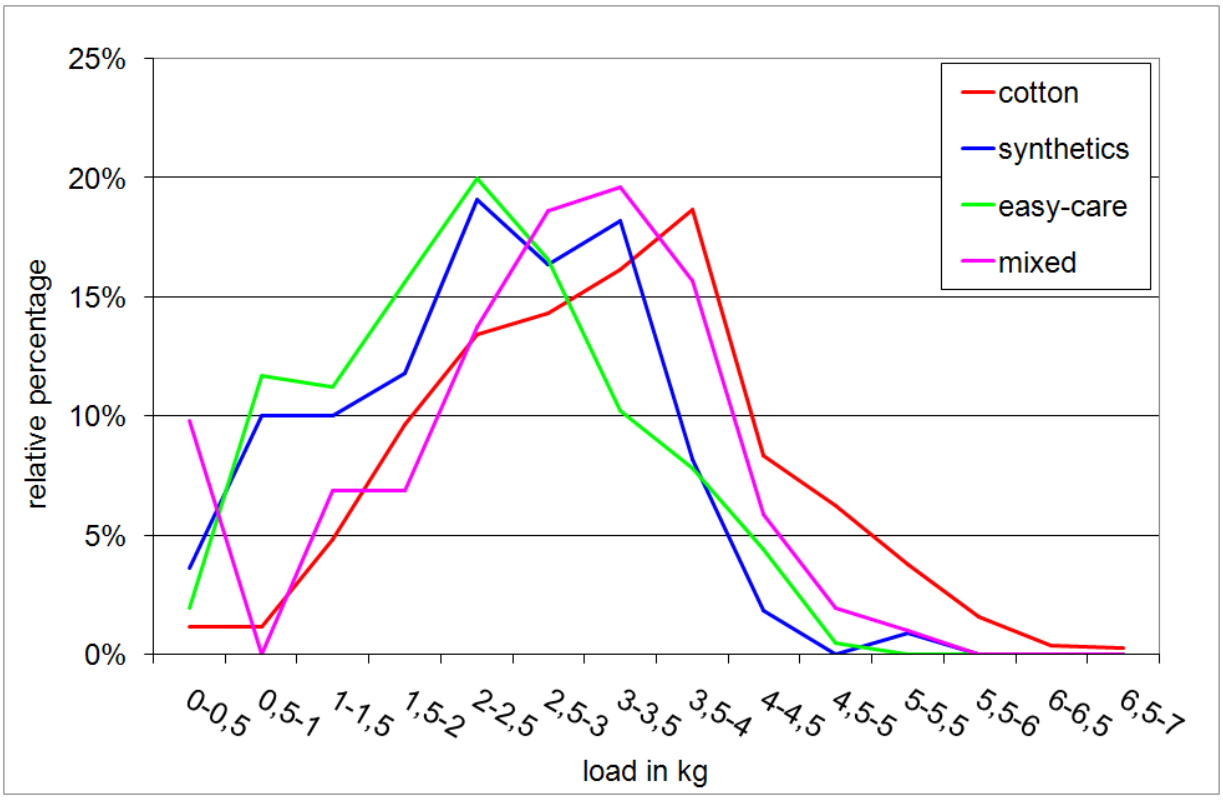


Figure 3.46: distribution of the load size for various programme types (source: Berkholz P., et al. [20])

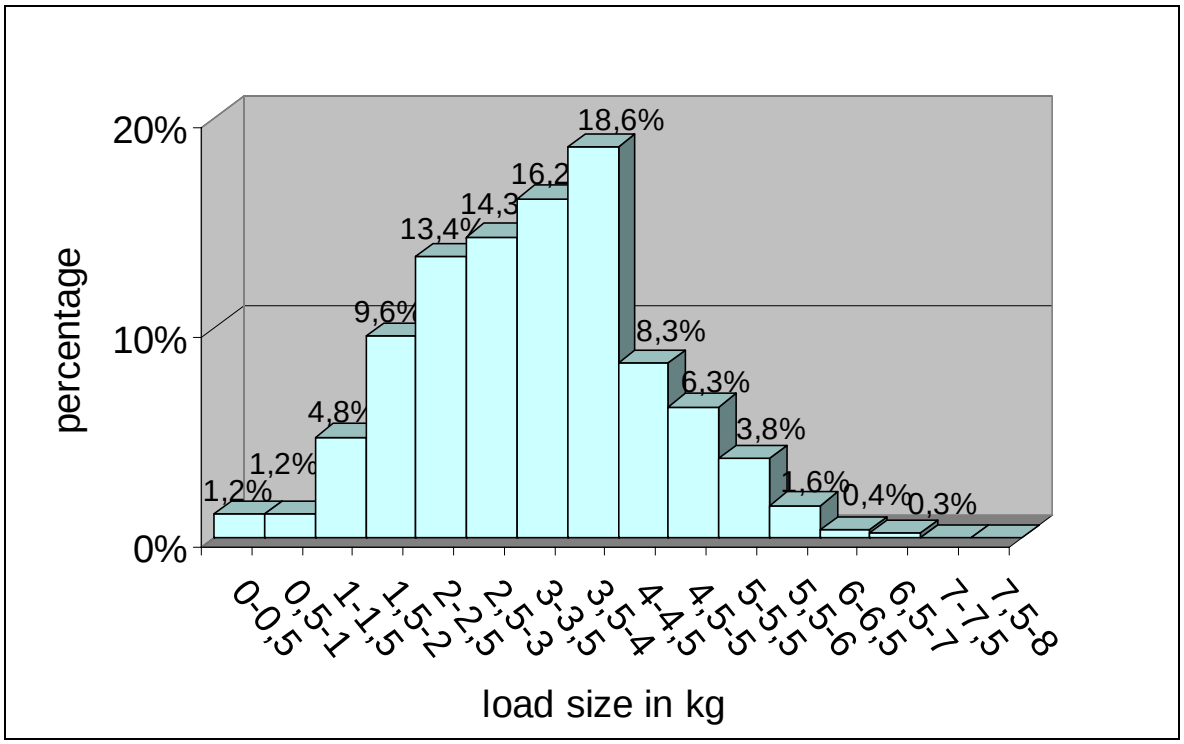


Figure 3.47: relative frequency of load sizes washed in cotton programmes (source: Berkholz P., et al. [20])

The measured real energy consumption in the studied 100 households (Figure 3.48) shows for cotton load an average of 1,02 kWh/cycle, averaging all the different temperatures, load sizes and machines used in the households. For other programmes the average consumption is even lower than for cotton, due to the lower washing temperature for these programmes. The programme temperature has the highest influence on the machine energy consumption (Figure 3.49), although the distribution is broad due to the various load sizes and machine efficiency levels found in the households.

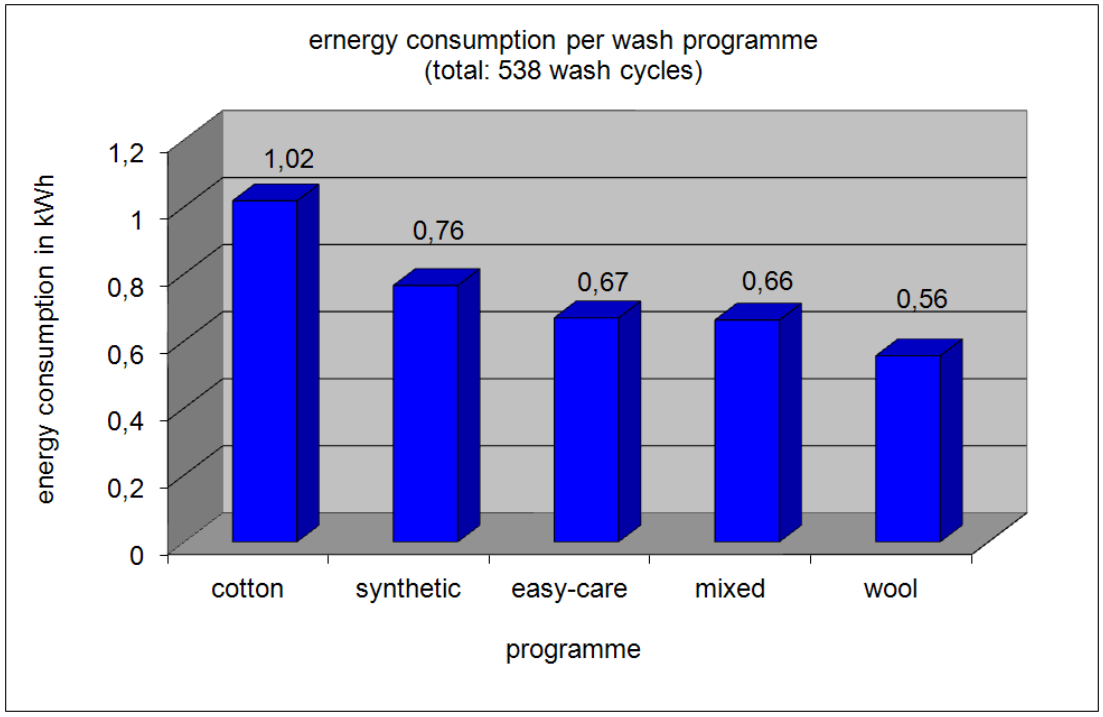


Figure 3.48: average measured energy consumption for various programme types selected (source: Berkholz P., et al. [20])

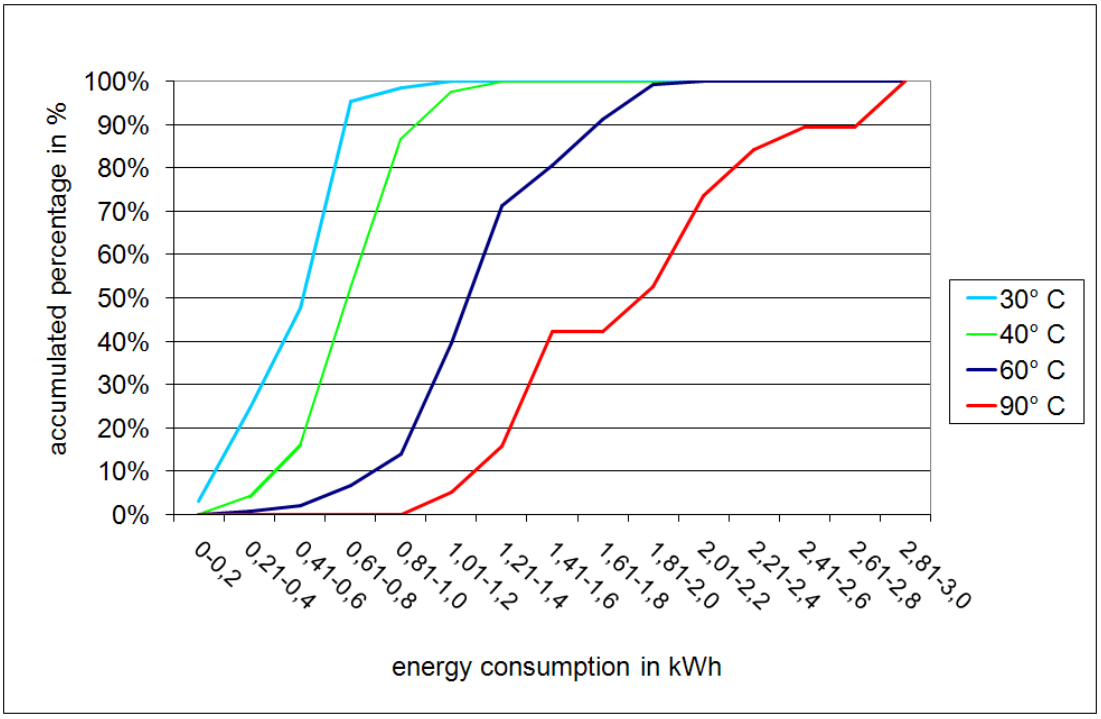


Figure 3.49: cumulated distribution of energies consumed at different temperatures selected (source: Berkholz P., et al. [20])

The average measured energy consumptions found in the German study may be compared to values previously calculated using the AISE stock model[21] for EU15: some significantly lower values for the boil wash programme and somewhat higher values for low temperature programmes at 30 °C are found (Figure 3.50). This increase in the energy consumption at low wash temperatures may be explained with an increased washing performance at lower temperatures, which in turn allows the use of these programmes for everyday washing, while some year ago these programmes where more considered as refreshing programmes only. The calculated energy consumption increase per degree Celsius between 40 and 60 °C nominal wash temperature for both studies is 0,031 kWh/K or 0,027 kWh/K.

These changes in programme efficiency are possible for all programme types and temperatures and are closely linked to the type and amount of detergent used. Temperature and amount of detergent are balanced in such a way, that one may be substituted by the other to a large extend without decreasing the washing performance. This was experimentally shown[22] in tests using the nominal (100 %) amount of detergent for 40, 60 and 90 °C cotton programmes. In addition, the washing machines were operated with reduced (50 %) and increased (150 %) detergent dosage for the 60 °C cotton programme. The tests were developed to take into account the flexibility of the users in adjusting the performance of their washing machines by choosing different temperatures or by varying the amount of detergent.

[21] AISE Code of Good Environmental Practice: Final report to the European Commission 1996-2001, Annex 5 (www.aise.com)

[22] Stamminger, R., Barth, A., Dörr, S.; Old Washing Machines Wash Less Efficiently and Consume More Resources. In: Hauswirtschaft und Wissenschaft 3/2005, p. 124-131

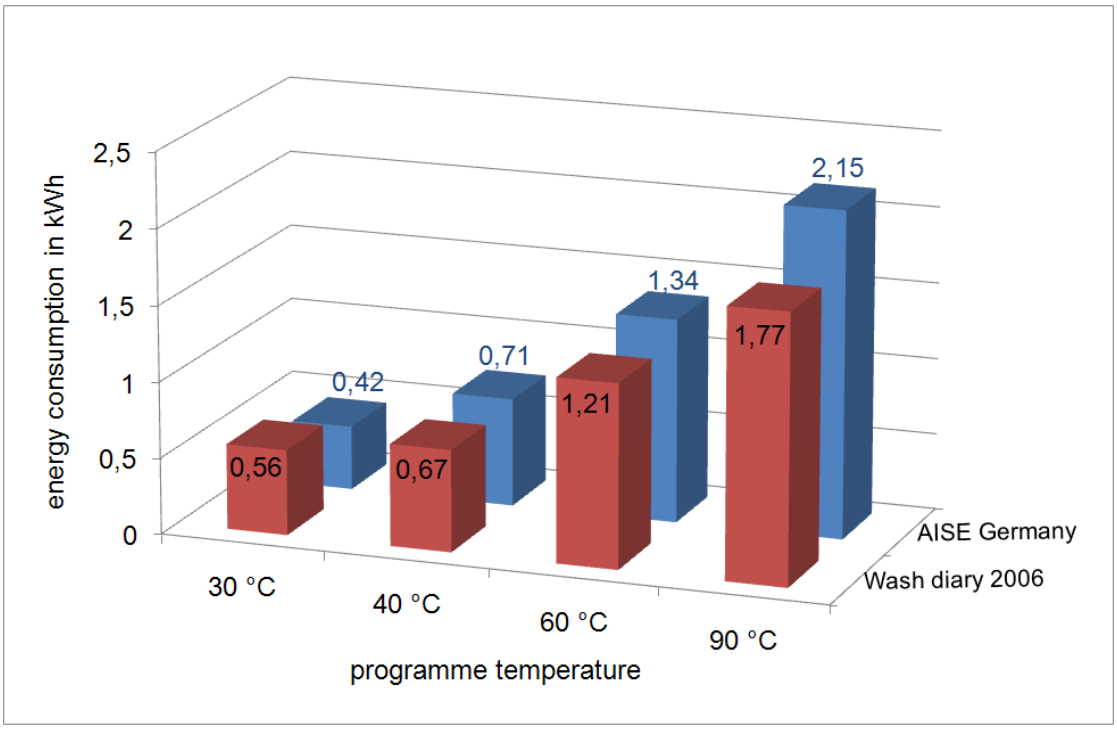


Figure 3.50: average energy consumption at the different wash temperatures observed, compared to a stock model prediction (picture: Univ. Bonn)

The results are presented in terms of the index and washing efficiency class as defined in the European energy labelling scheme, although the test conditions were not fully complying with the standard measurement method.

A three-dimensional plot of the performance fields[23] which washing machines can achieve depending on the amount of detergent used and on the temperature selected, provides the best overview of the results (Figure 3.51 a). The same level of performance can be achieved in a 90 °C programme with only 50 % of the nominal detergent dose, in a 60 °C programme with the nominal detergent dosage, or in a 40 °C programme with 150 % of the nominal detergent dose. Thus, consumers are basically free to select any combination to achieve a specific level of cleaning performance, the only limitation being the temperature stability of the fabrics to be washed.

[23] Stamminger, R. et al.: Old Washing Machines Wash Less Efficiently and Consume More Resources. In: Hauswirtschaft und Wissenschaft 3/2005, p. 124-131

a: new washing machine

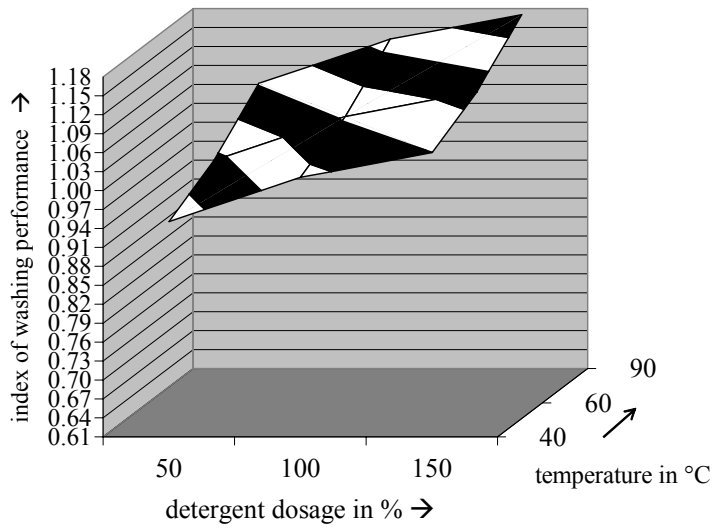


Figure 3.51: washing performance index of a new and an old washing machine respectively under varying conditions. Shaded areas represent classes of washing performance according to the European Energy Label system and are for visualisation only. The machines' performance with reduced and increased doses of detergent at 40 and 90 °C was calculated by linear extrapolation (source: Stamminger, R. et al.[23]).

Figure 3.51

Other washing machines, particularly older ones, have similar performance, but their absolute values are considerably lower, and their slopes show an increased influence of dosage and temperature on washing performance (Figure 3.52 b).

b: washing machine from 1975

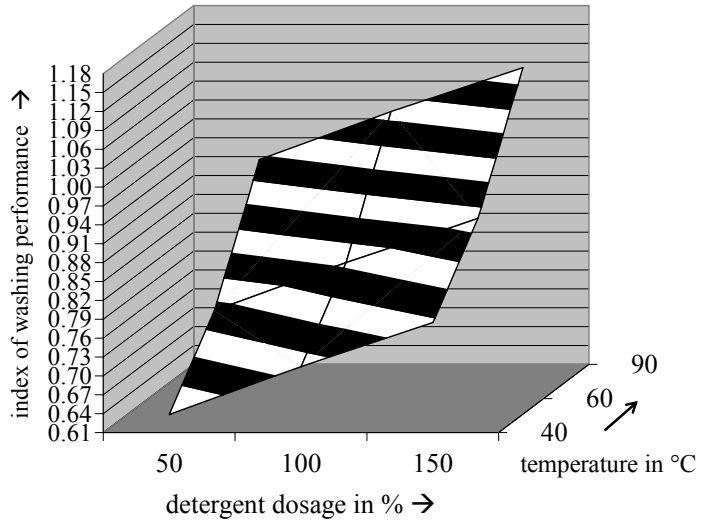


Figure 3.52: index of washing performance of a new and an old washing machine respectively under varying conditions. Shaded areas represent classes of washing performance according to the European Energy Label system and are for visualisation only. The machines' performance with reduced and increased doses of detergent at 40 and 90 °C was calculated by linear extrapolation (source: Stamminger, R. et al.[23]).

Figure 3.52

A synopsis of the 60 °C cotton cycle measurements, for the three detergent dosages (Figure 3.53), shows that performance, in addition to varying greatly between machines, can be adjusted effectively via detergent dosage. This becomes even more evident when the results are ranked according to the European energy label washing performance index, in which machines are graded

in classes of 0,03 width ranging from A (best) to G (worst). Older machines rarely achieve class A performance, which are common in new washing machines (at nominal capacity – which was not used in the shown tests), and they usually require increased doses of detergent. In addition, the slopes of older washing machines' performance differ significantly from that of newer machines: the loss in performance going from 100 % to 50 % detergent dosage being significantly greater than going from 150 % to 100 %. This may be due to detergent sump losses in older washing machines with large proportions of the loaded detergent probably being unused.

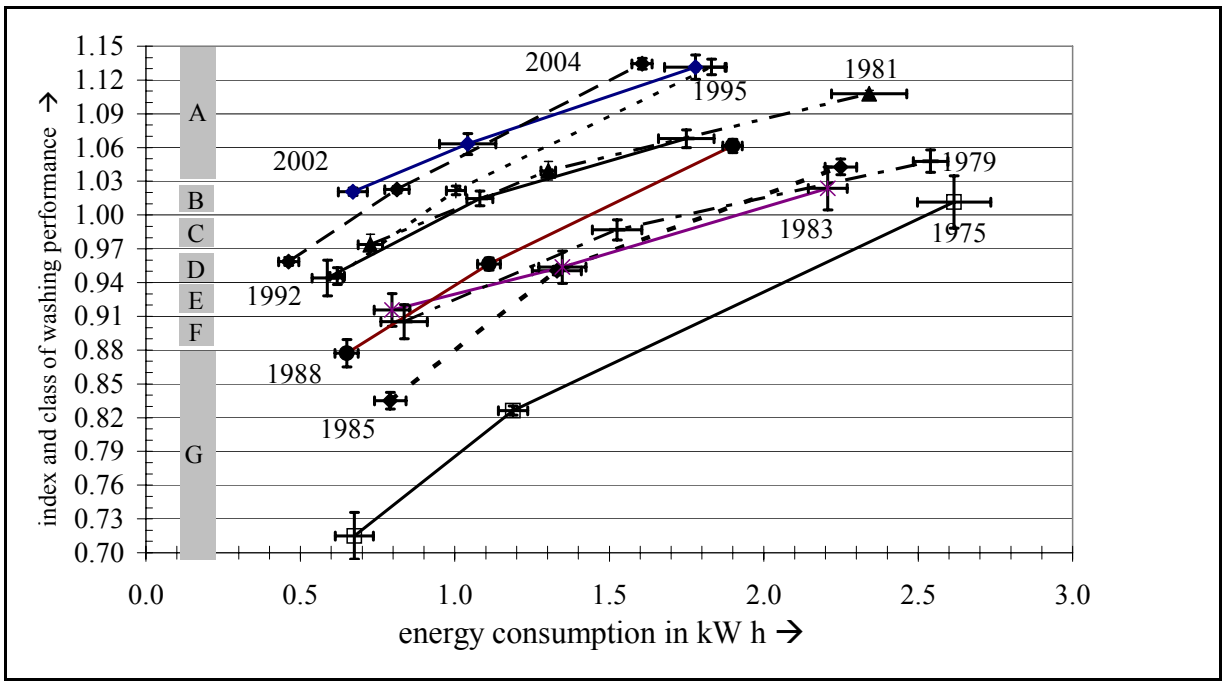


Figure 3.53: washing performance versus energy usage values for all machines under study (coded by year of production). From left to right the energy values indicate the machines' energy use for 40, 60 and 90 °C programmes; washing performance is given as index and corresponding class A to G as used by the European Energy Label. Error bars indicate standard deviation of index of washing performance and energy measured. Lines are for visualisation only. (Source: R.Stamminger et al.)

A comparison of the washing performance levels achieved at 40, 60 and 90 °C programmes with the corresponding energy use gives surprising results: the distribution of the curves is even less uniform, and it becomes clear that older washing machines need much more energy to achieve a good washing performance. Indeed, to achieve the same washing performance as new machines in a 40 °C programme, old machines must be operated at a 90 °C programme Moreover, at 40 °C (the point furthest left in the graphs) the washing performance of old washing machines is much lower than that of new ones.

Another factor influencing consumption values under real life conditions is the actual amount of textiles washed. As it previously shown the load size is variable and is often lower than the rated capacity declared by the manufacturers. Depending on the real load size and the soaking capability of the textiles the washing machine will somehow adjust the amount of water taken in for the main wash and the rinse cycles in an automatic way. Additionally, sensor systems available in some machines (e.g. the so called ‘fuzzy’ logic) may measure the weight or the soaking capacity of the load and additionally adjust both the programme and water intake to ensure a good washing and rinsing performance with a reduced amount of water and energy. How effective the adjustment is and how different is the energy/water consumption between the machines was recently investigated (Figure 3.54). The results show a very different behaviour of the machines, with load adjustment

factors between 0,12 kWh/kg and -0,02 kWh/kg for a cotton 60 °C programme. The later value means that this machine actually consumes more energy when only partly loaded, but it is not known if this machine was equipped with the partial load detection, or if it was an old or control machine without this option.

On average the load dependency is 0,08 kWh/kg. A machine consuming 1,0 kWh/cycle at 5kg load will consume 0,6 kWh/cycle when almost no laundry is put in. A similar dependency is seen for water, where the best machine was found to use 6,7 l/kg and the worst -0,04 l/kg (meaning again an increase of water consumption for lower amounts of loads put into the drum, but the same warning about this machine applies). The average found was found at 2,8 litres per kg of reduced load compared to the rated capacity.

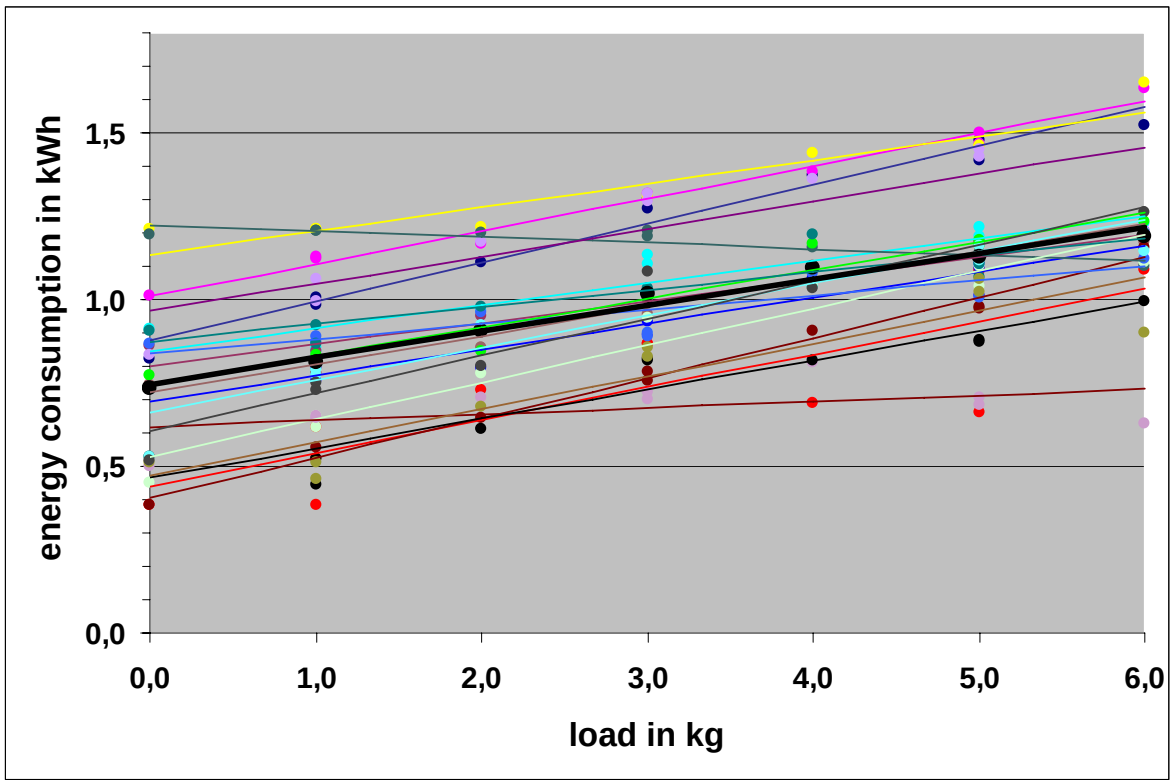


Figure 3.54: energy consumption of 20 washing machines at various load size at 60°C cotton programme. Lines are trends lines for each machine. The black line indicates the average behaviour of the 20 measured machines (source: Berkholz P., et al[20])

As energy may not only be consumed during the operation cycle, other modes like the off- or standby-mode, delay-start, programme-end or left-on-mode may be important as well. Some tests of the energy consumed in these modes have been done by Consumer Organisations and published[24] (Figure 3.55). On average, the energy consumption of the standby-mode for 1 hour was measured at 0,61 Wh, the delay-start-mode at 4,34 Wh and programme-end-mode at 3,29 Wh. As the two latter are only active for some hours, their contribution to the annual energy consumption is rather small. More relevant may be the left-on-mode[25], as this may persist indefinitely between wash cycles.

[24] Stiftung Warentest, private communication

[25] see Task 1 for the definition as given in IEC 60456 5th edition draft

The European Commission within Lot 6 of the Tender TREN/D1/40-2005 has launched a specific study on standby consumption for EuPs. The European Association of Household Appliance Manufacturers CECED has provided to Lot 6 study group an estimation of the average low power mode consumption of washing machines (Table 3.6).

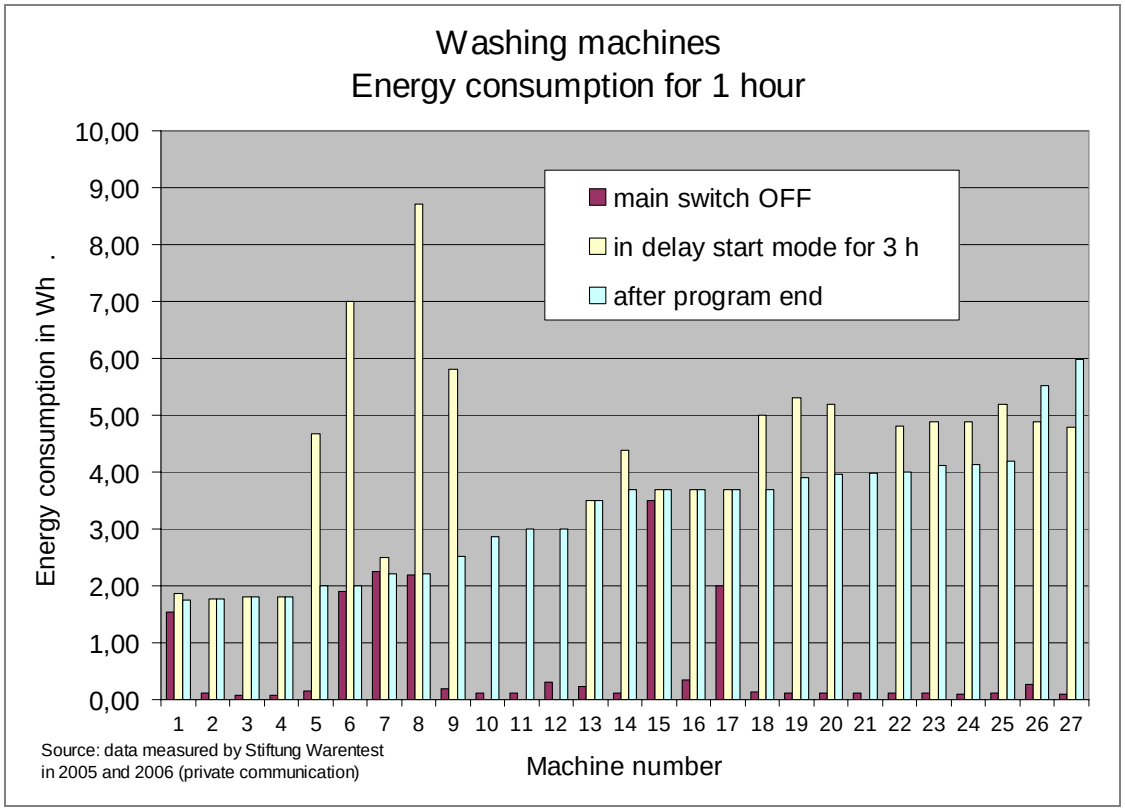


Figure 3.55: energy consumption measured in three different low-power modes of 27 washing machines (graphic: Univ. Bonn)

Table 3.6: stand-by and low-power mode consumptions of washing machines [26]

Steady state condition	**Average real life power** (W)
Delay-start	2,5
End of cycle	1,6
Off-mode*	0,5

*As defined in EuP Lot 6 study

A detailed analysis of the standby and other low power mode for washing machines, and a comparison between the definitions presented in Task 1 and the Lot 6 outcome will be run in Task 6 of this study.

[26] Document: CECED Contribution on BAT/BNAT about Lot 6 EuP Preparatory Study (GS_07-30_CECED_Contribution_for_Chap._6_of_Lot_6.pdf)

3.4.2 The results of the consumer behaviour questionnaire

The number of washing cycles is the most important element affecting the use of resources for laundry washing. Since the consumer questionnaire is representative of the household size of the covered countries, the resulting values are very likely representative of the average number of washes run per household (Figure 3.56). This figure goes from 4,1 (Czech) up to 6,0 (Italy) wash cycles per household per week, with an average at 4,86 washes per household per week.

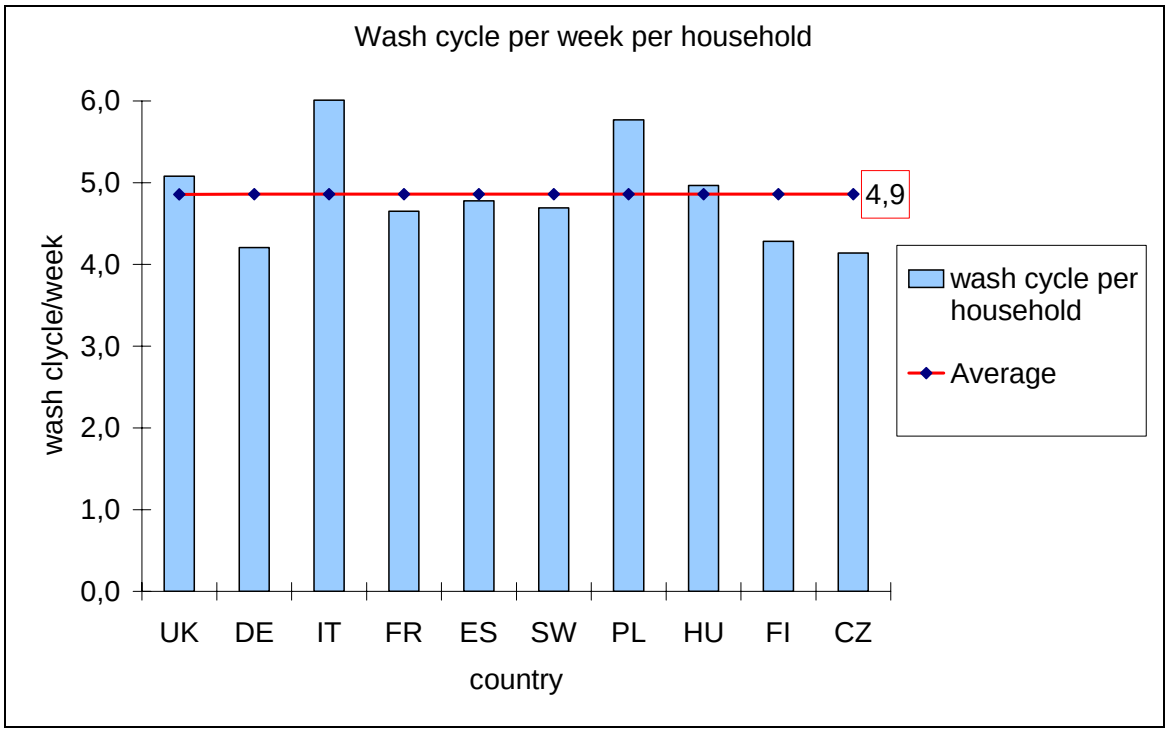


Figure 3.56: average number of wash cycles per household per week

Since the household size may be different from country to country, the number of washing cycles per week per person living in the households may be a more significant parameter for comparison among countries: this number is between 1,4 (Czech and Spain) and 2,0 (Sweden) washing cycles per person and week, with an average of 1,7 washes per person per week (Figure 3.57).

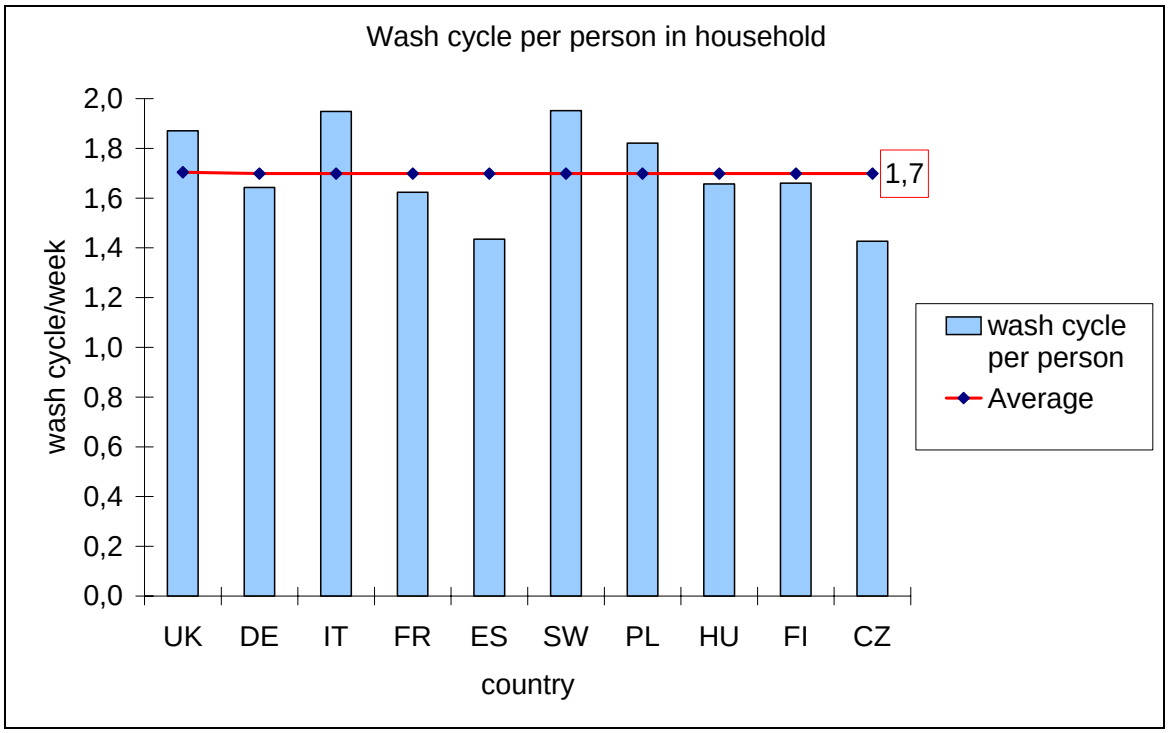


Figure 3.57: average number of wash cycles per week per person

The second most important element affecting the energy consumed in the washing process is the temperature of the selected wash programme. Averaging the answers from almost 2 500 consumers from 10 countries, a 37 % preference for the 40 °C programmes (Figure 3.58) results; the second most used temperature is 60°C with 23 % of all the washes; but also the 90 °C is declared to be used almost 7 % of the times. The calculated average of all the nominal wash temperatures is 45,8 °C.

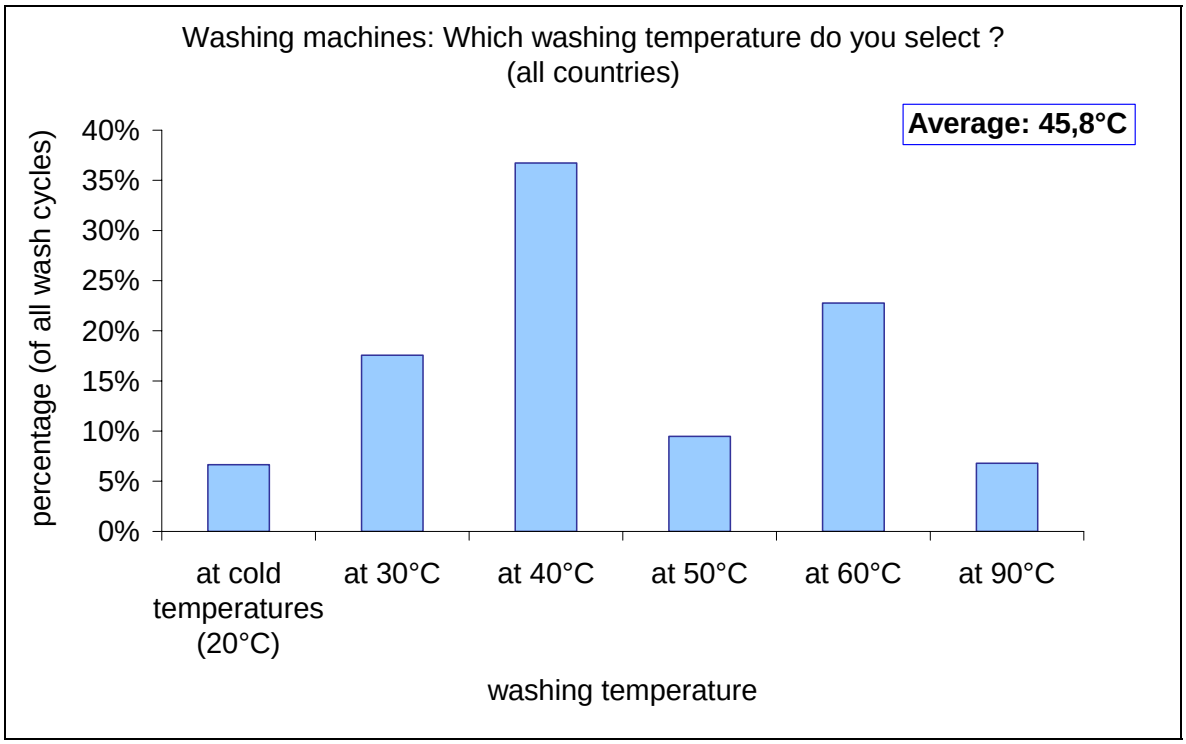


Figure 3.58: relative occurrence of wash temperatures in Europe (average of 10 countries)

The share of the temperatures (Figure 3.59) in the covered countries is quite different:

- in Spain more than 40 % of the washes are done at cold temperatures (tap water) and almost no (3 %) boil wash temperature programmes are used.
- in other countries (especially Sweden and Czech Republic) more than 50 % of the washes are at or above 50 °C and the boil wash programme is used more than 10 % of the times.

These differences are also visible when looking at the average wash temperatures for all the investigated countries (Figure 3.60), which range from 33,3 °C to 50,1 °C.

The chosen wash programme type shows (Figure 3.61) a dominance of the cotton programmes (cotton, linen, mixed) where more than 50 % of the consumers declare that these programmes are used *always or often*. Less frequently used are programmes for easy-care, delicate or synthetic laundry and even less the programmes for silk and wool articles.

Other programmes and options are available in washing machines, which once selected by the consumers, may influence the water and/or the energy consumption of the machine: 'energy saving/eco-washing' is found (Figure 3.62) to be the most frequently used option or programme, followed by 'soft wash' programmes and options, which consume more energy (stain wash or intensive wash) or water (extra rinse, additional water). The later are used only by some 15 % of the consumer *often or always*.

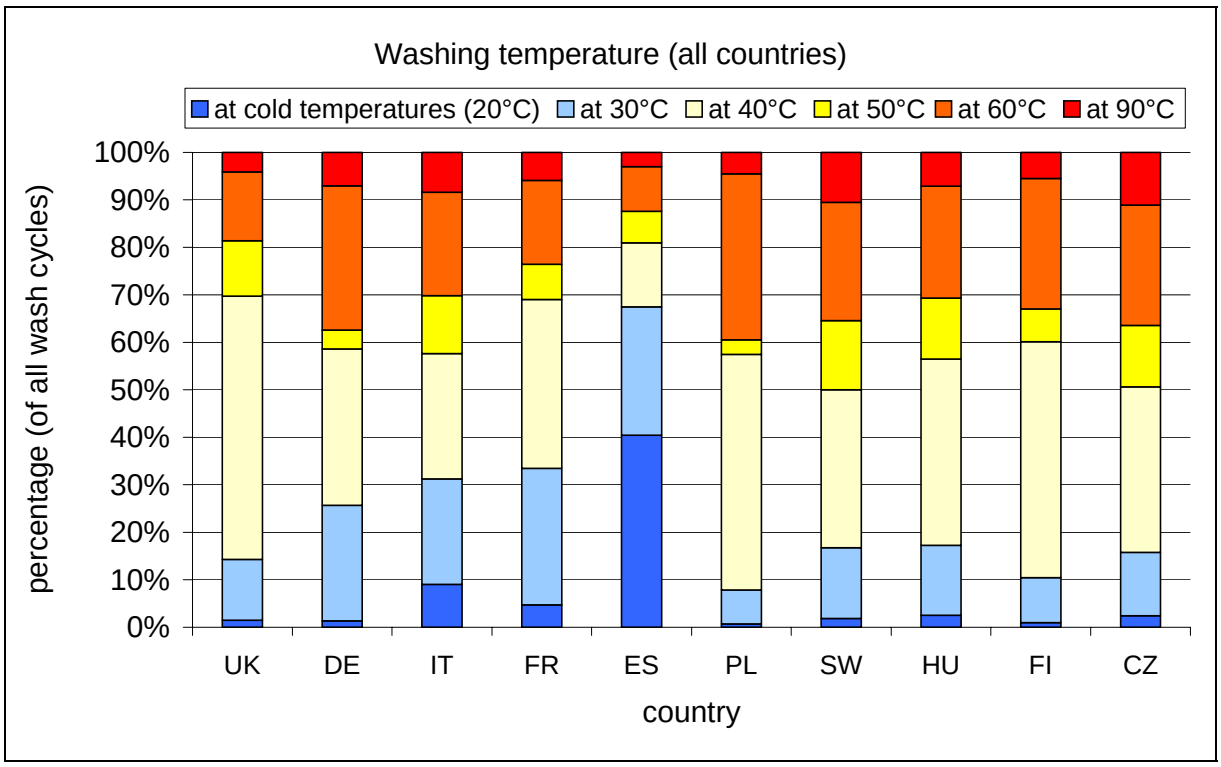


Figure 3.59: temperature distribution of wash programmes for various countries

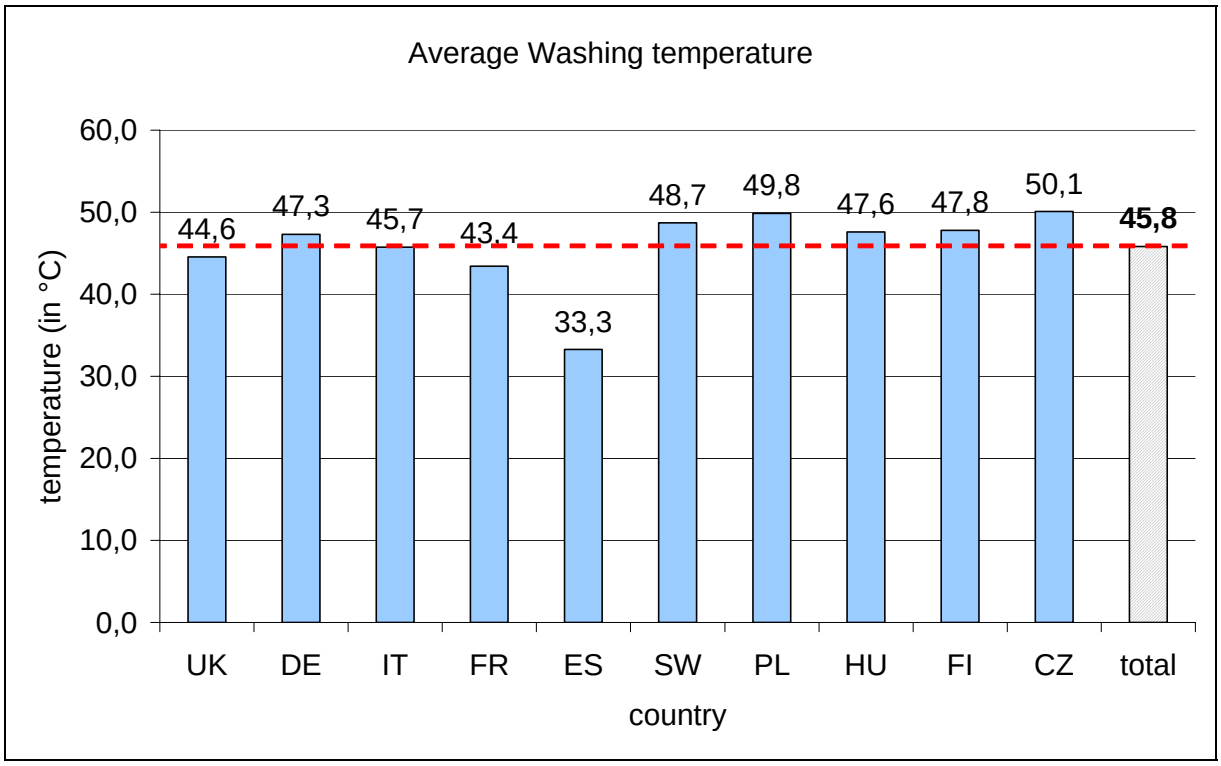


Figure 3.60: average nominal wash temperature

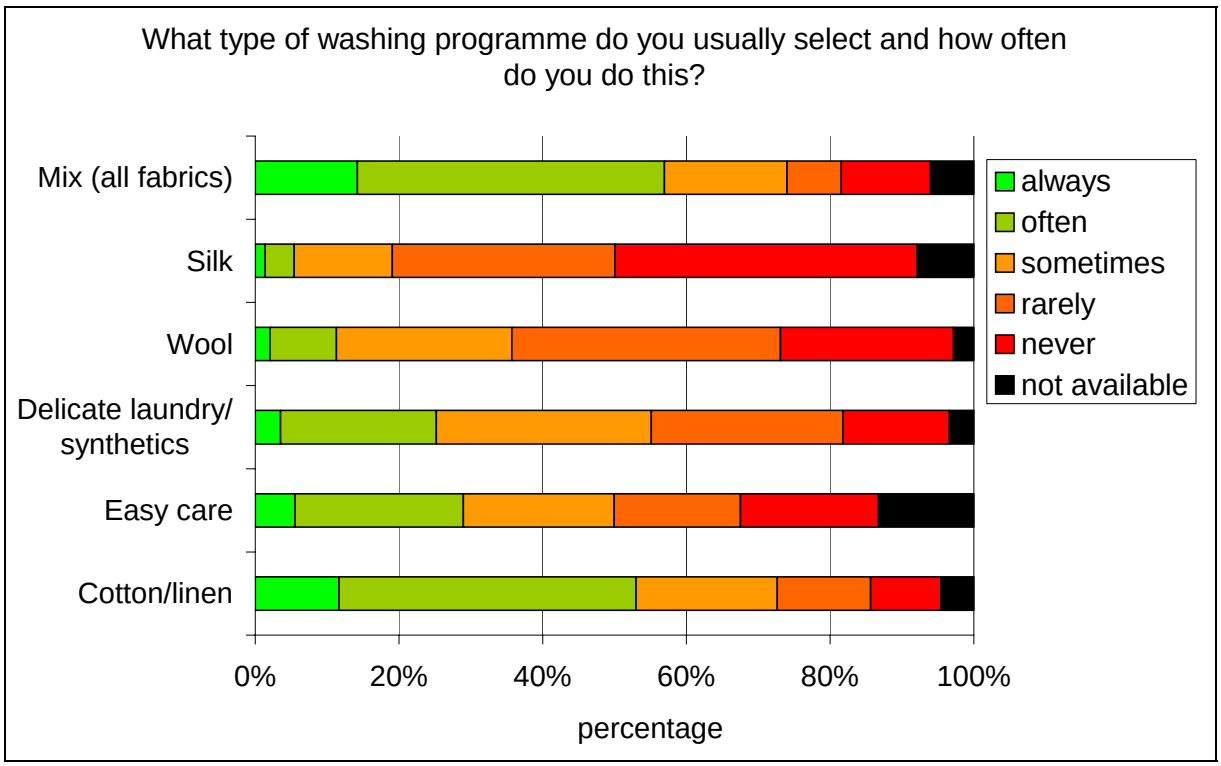


Figure 3.61: frequency of use of various programmes regarding the type of textiles washed

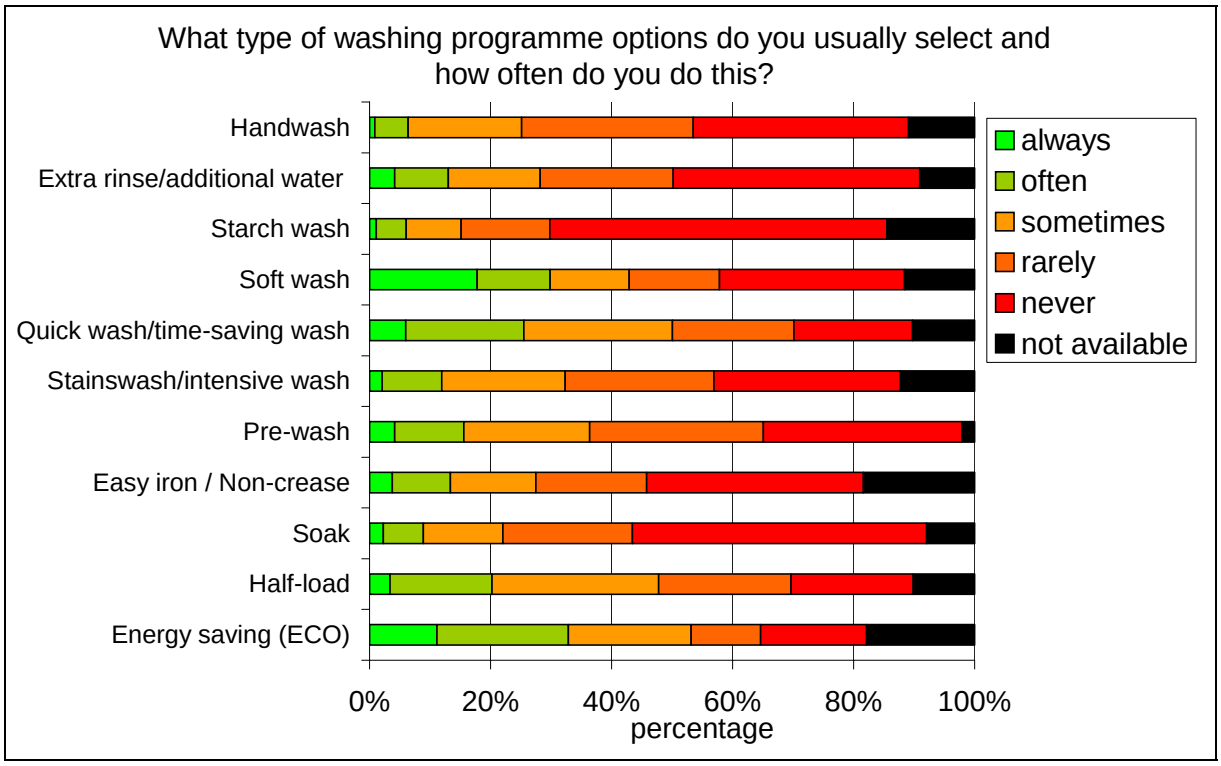


Figure 3.62: frequency of use of various other programmes or options

A higher influence on the actual energy and water consumption may be expected by the use of the machine at full capacity. Almost 3 out of 4 consumers claim (Figure 3.63) to use the full capacity of the machine, although they normally do not check it.

Assuming that those consumer answering an 'overloading' of the machine may have loaded 4,5 kg, those using 'the full capacity without overloading' may have put in 3,25 kg, those which 'don't fill the machine completely' use 2,0 kg and those which 'run the machine even with a small quantity' may have a 1,0 kg load the average load size was calculated and the answers from country were compared (Table 3.7). **Although the result calculated for Germany fits quite well with the values measured in the previously mentioned study, the underlying assumptions may be challenged**.

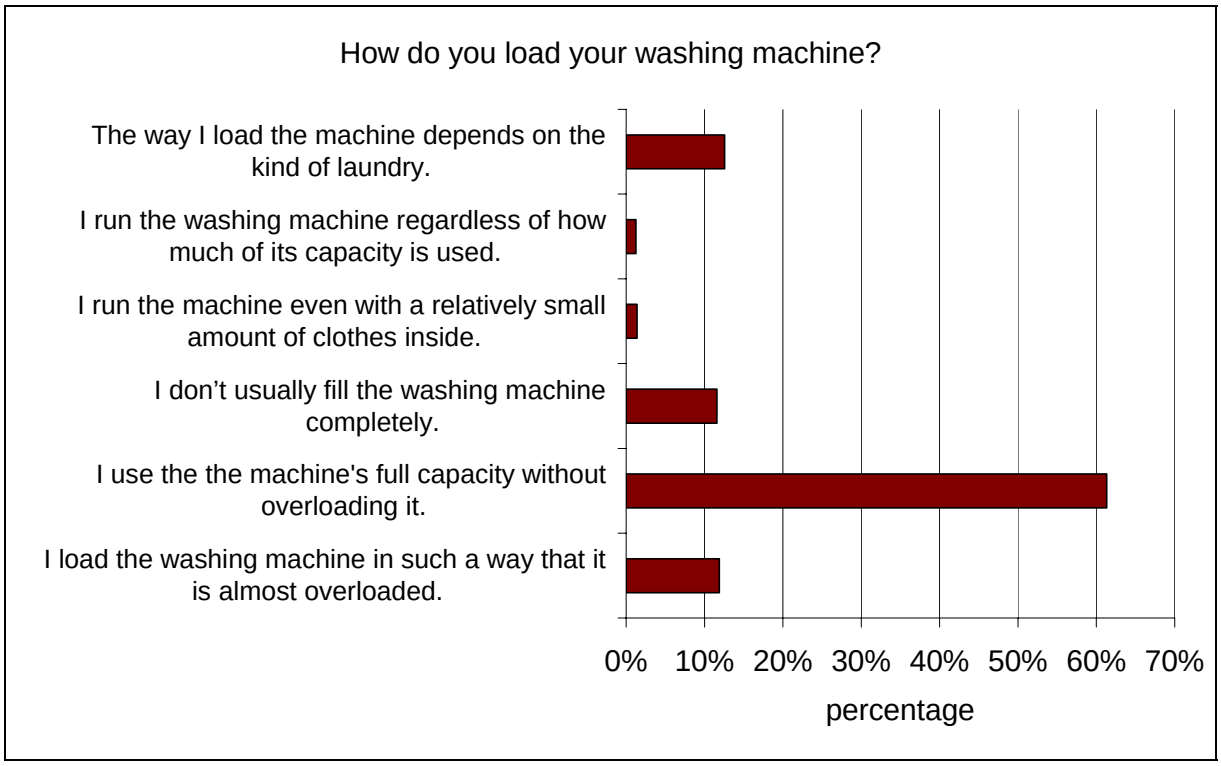


Figure 3.63: consumer answers about the load they are putting into the washing machine

Table 3.7: calculated average load size

Country	**UK**	**DE**	**IT**	**FR**	**ES**	**SW**	**PL**	**HU**	**FI**	**CZ**	All
average load in kg	3,2	3,3	3,5	3,3	3,1	3,2	3,2	3,1	3,2	3,1	3,2

Looking at the final spin speed, the distribution shows large differences (Figure 3.64) among countries: while in Italy, Spain, Poland, Hungary and Czech about 70 % of the spin cycles are at or below 900 rpm, in UK, Germany and Sweden 70 % are above 900 rpm. Taking the average of the individual range of spin speeds given from ≤ 400 up to ≥ 1 300 rpm, the average spin speed per country can be calculated (Figure 3.65) which confirms the same differentiation between the low-spin and high-spin countries. The average of all investigated country is 914 rpm.

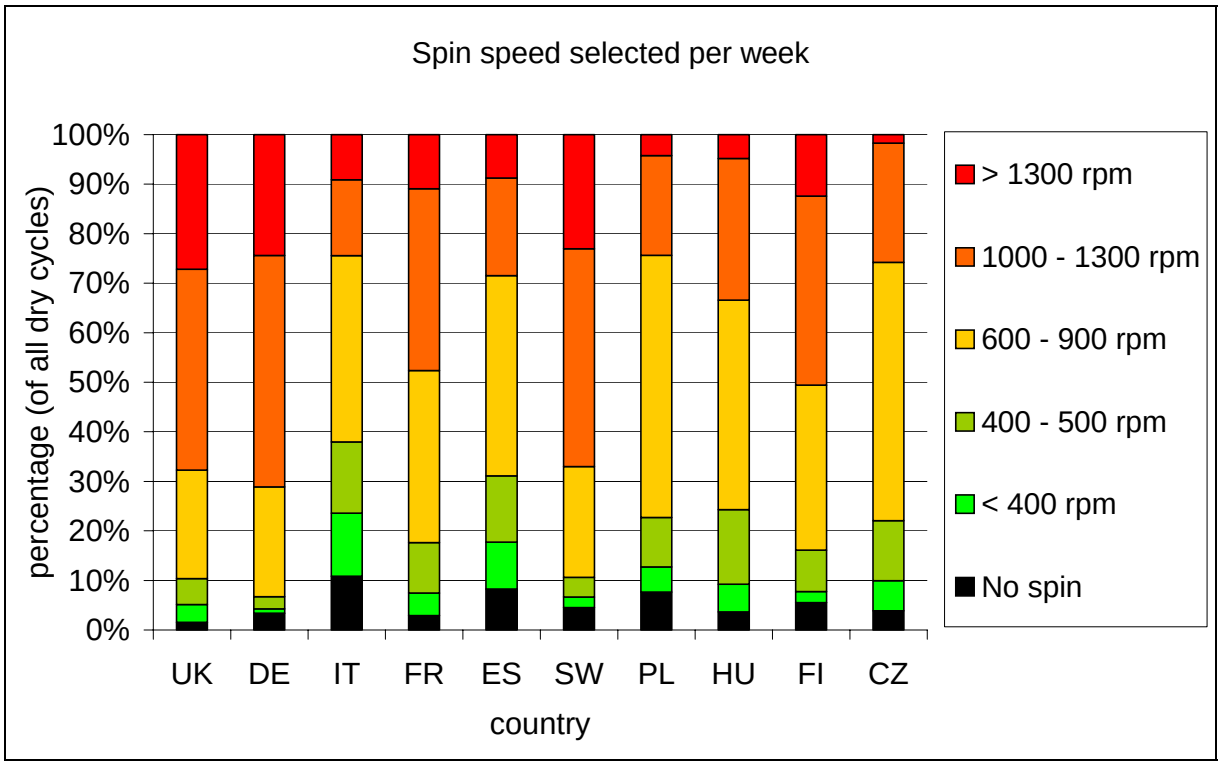


Figure 3.64: distribution of spin speeds

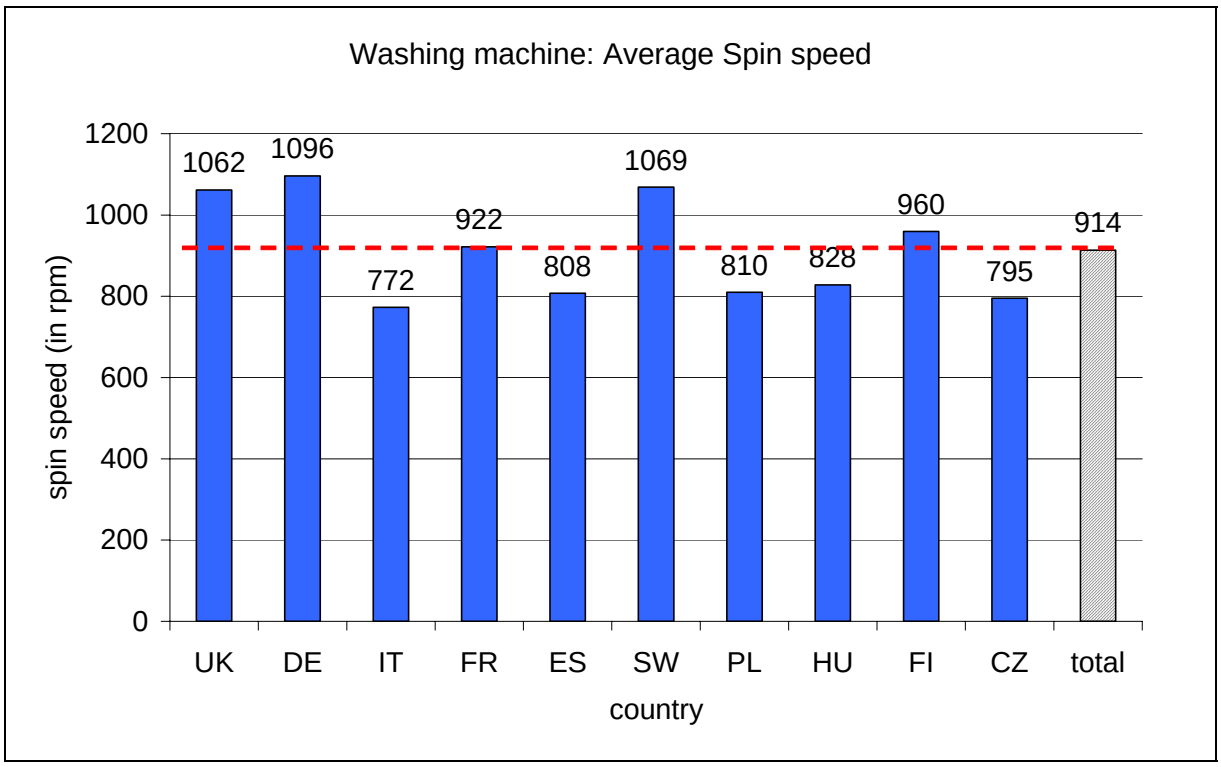


Figure 3.65: calculated average spin speed per country and in total

As a delay of the start of the washing process may be used to postpone the energy (and water) consumption when - during the day or the night - cheaper (off-peak) tariffs may be offered, the selection and the frequency of use of this option have been investigated.

Consumers were asked if their washing machine was equipped with a delay-start time pre-selection function: over 32 % of the washing machines have this option but with some differences among countries (Figure 3.66).

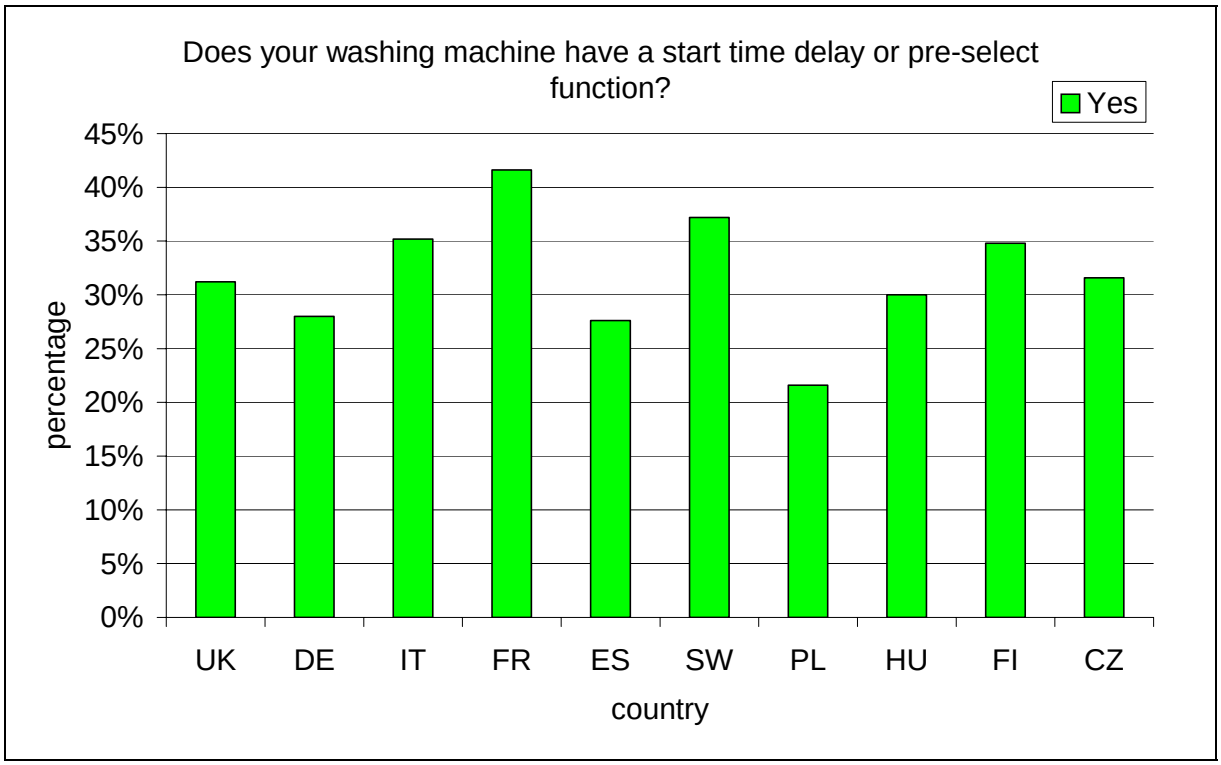


Figure 3.66: availability of start-time pre-select function

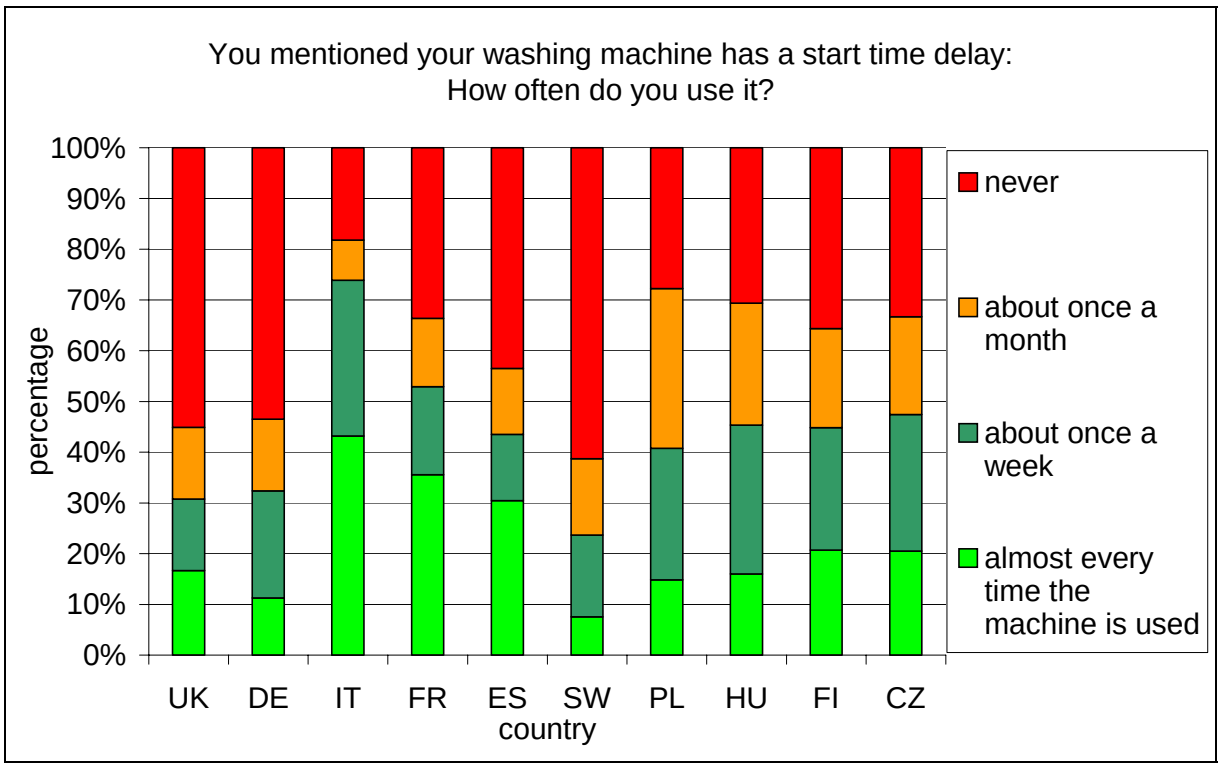


Figure 3.67: usage frequency of the delay start function

When asked about the frequency of use of this delay start option, most consumers confess (Figure 3.67) to 'never' use them (on average 40 %); only 22 % say they always use this function and another 22 % use it about once per week. It would have been interesting to know also the reason why consumer selects this option: if to match off-peak tariffs or for their personal convenience (laundry ready when needed), but this aspect was not included in the questionnaire.

This function also has a possible negative impact on the energy consumption on one side because the consumer convenience may - at least potentially - lead to start the washing cycle during peak hours, and on the other side because the machine consumes some energy when waiting for the start time. Asking those consumers having and using a delay start function in their washing machine, on average 56 % declared to choose a time between 0 and 3 hours (Figure 3.68), while 28 % use it to delay the start time between 4 and 6 hours and 16 % to delay it for more than 7 hours.

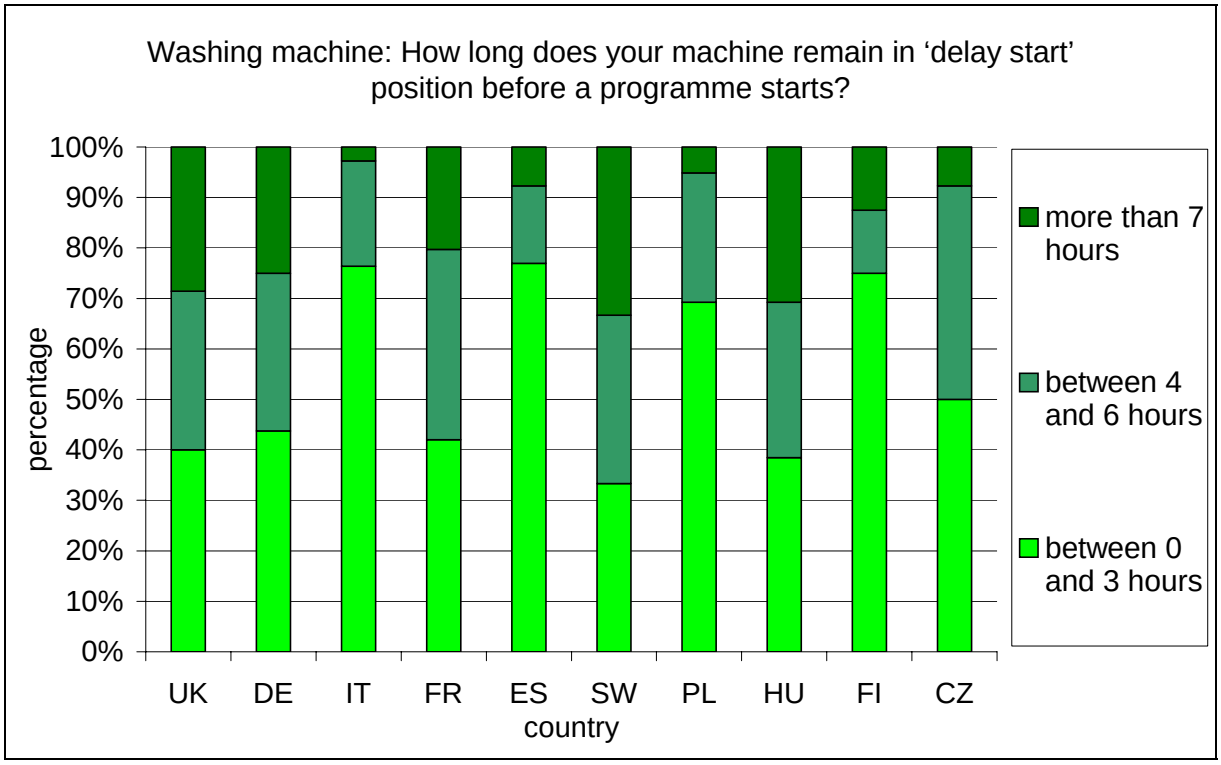


Figure 3.68: frequency of delay start time in hours

Additional energy may be consumed when the machine is entering the programme-end-mode, which may be tentatively defined as the time between finishing the washing programme (including a final spin) and unloading. During this time the machine may run for example some de-wrinkling actions with the drum turning time to time. Asked how long this time normally is, on average 37 % of the consumers (Figure 3.69) open the door immediately after the programme has ended and 57 % do this within a maximum of three hours; only 6 % admit to wait for more than 3 hours.

But also after the washing machine is unloaded, there may be an additional amount of energy being consumed, when the machine is "left on" and not switched off completely. On average 48 % of the consumers declared (Figure 3.70) to switch off the appliance immediately and an additional 22 % to do this after unloading; only 10 % of the consumers claim not to switch off the appliance always or most of the time. Most of the remaining consumers have a machine, which turns automatically to 'off', and a minority do not know.

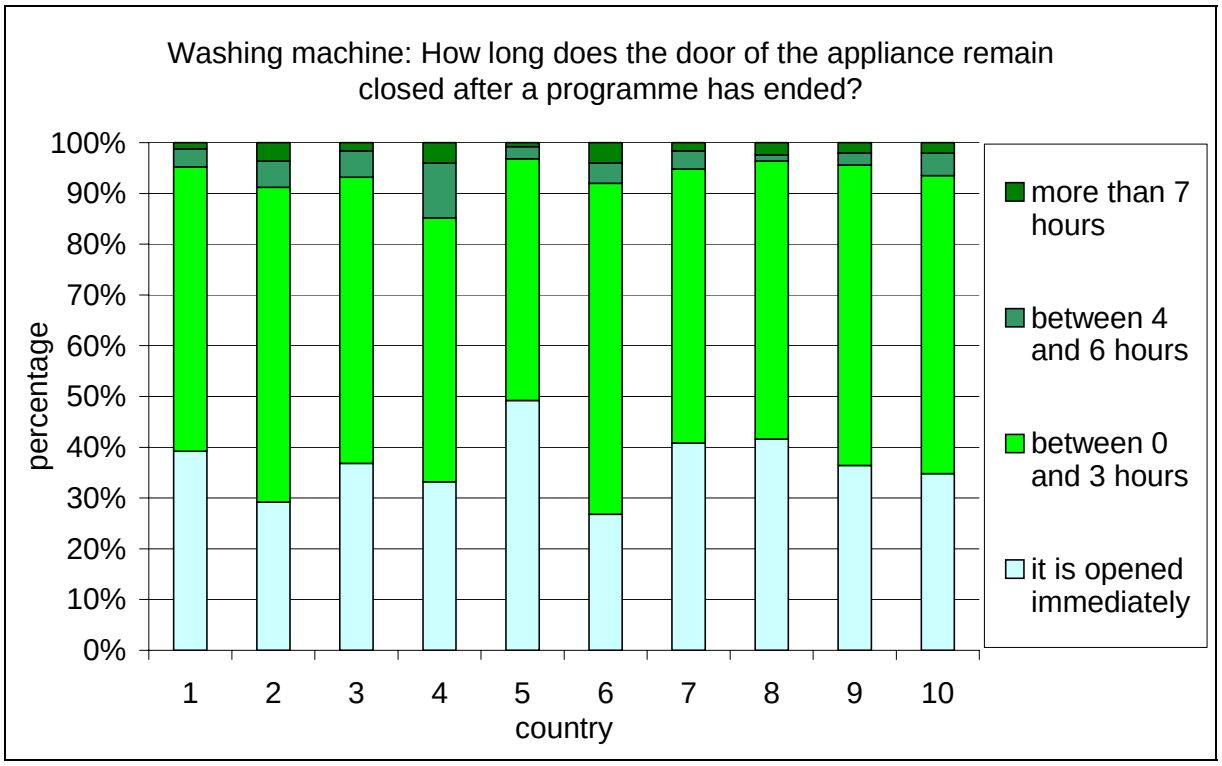


Figure 3.69: time of keeping the door closed after programme end

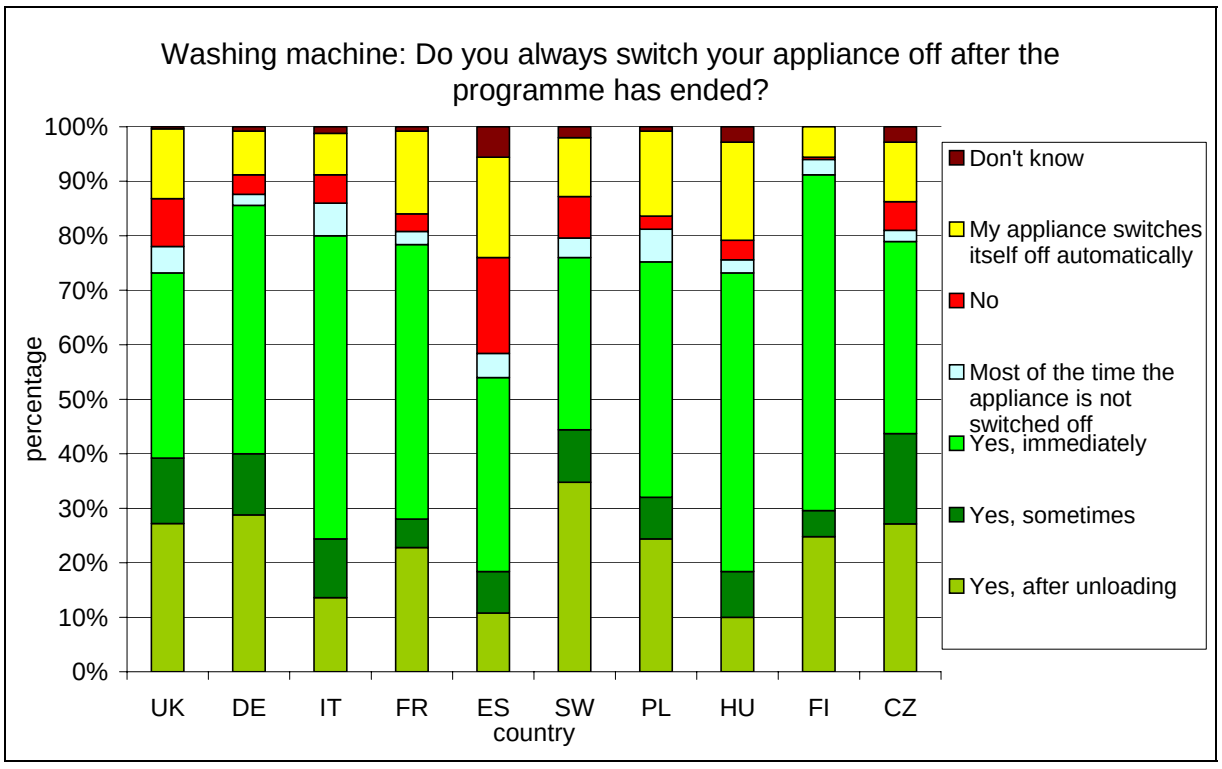


Figure 3.70: action after programme has ended regarding off-switching

Regarding drying of the clothes, large differences can be found between summer and winter time: while in summer time, about 40 % of the consumer always dry the clothes outside on a cloth line and another 28 % do it often (Figure 3.71), these figures reduce in winter time to just 7 and 10 %, respectively (Figure 3.72). The preferred way of drying clothes in winter is to dry them in the house in a heated room: this is always done by 28 % and often by 33 % of the consumers.

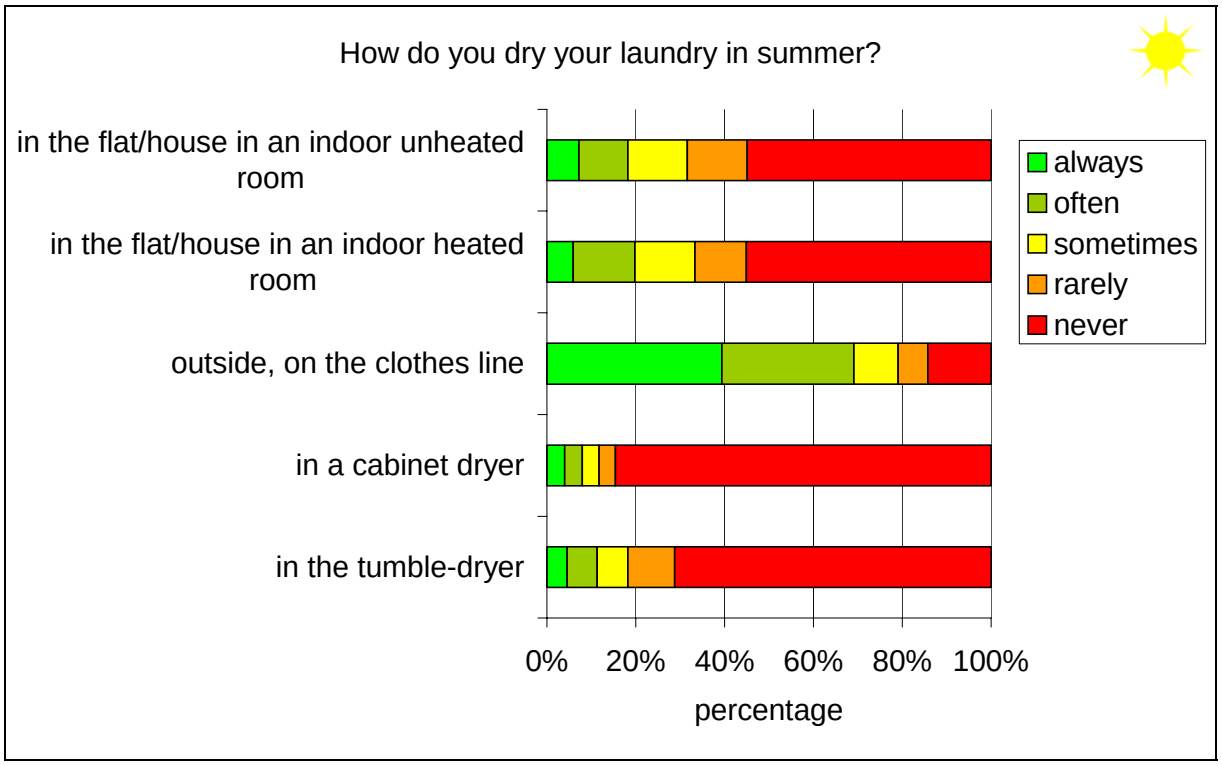


Figure 3.71: ways of drying clothes in summer time

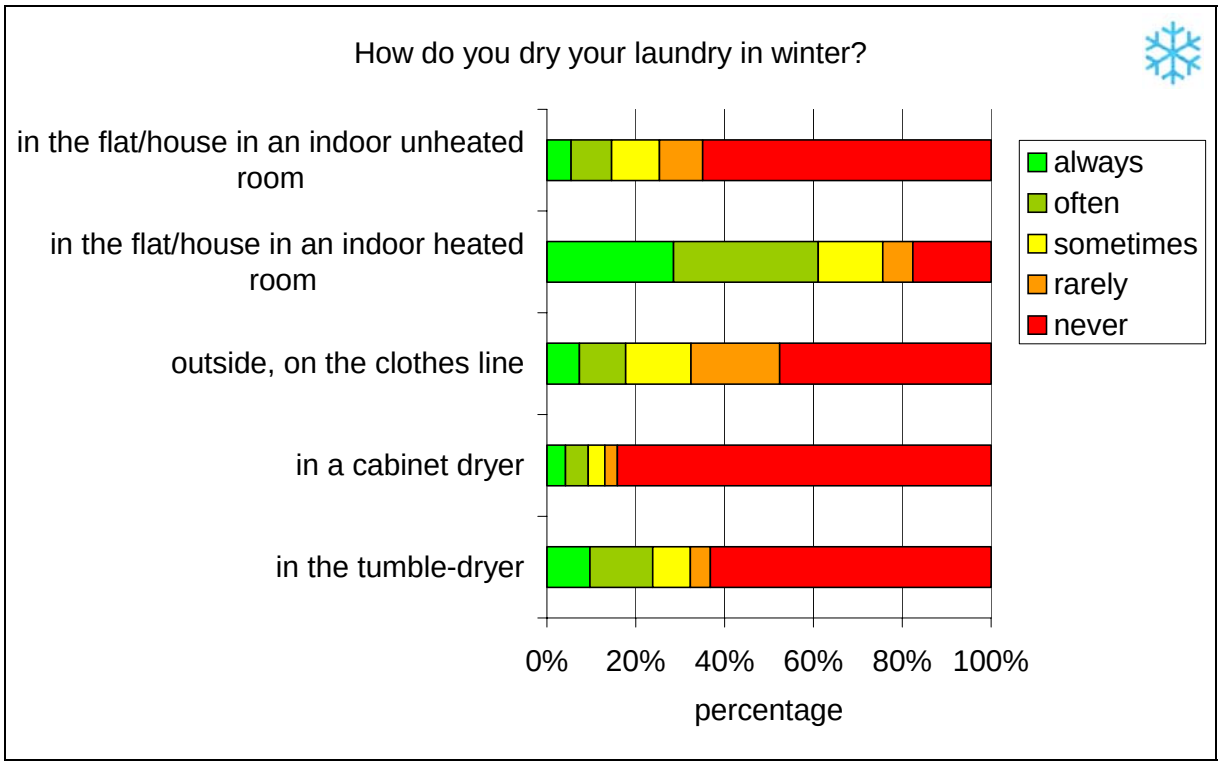


Figure 3.72: ways of drying clothes in winter time

In summary, the consumer behaviour regarding washing their laundry in a washing machine is characterised by:

- 4,9 washing cycles are done per week per household or 1,7 washing cycles per week per person
- the wash programme at 40 °C nominal temperature is the most frequently used for all kind of textiles (37 %) followed by the 60 °C programme (23 %)
- average nominal wash temperature is 45,8 °C (including all possible programme and textiles)
- cotton and mixed (cotton) are the most frequently used programmes
- the energy saving programme (or button) is the most frequently used option
- average spin speed used is 914 rpm, but there are higher and lower spin speed countries
- consumers claim to always use the full capacity of the washing machine
- delay start function is not used very often and only for short time delays
- about 70 % of the consumers switch off the appliance after the machine has ended or was unloaded
- while in summer most clothes are dried outside on a cloth line, in winter these are most commonly dried inside in a heated room

The consumer investigation has shown an average frequency of use of the washing machines of 4,9 cycles per household per week. Using this figure and the energy consumption of the standard base case washing machine, the effect of those factors that are not included in the standard testing procedure may be calculated.

3.5 USER DEFINED PARAMETERS: DISHWASHERS

3.5.1 Consumer behaviour and appliance energy consumption & saving

Also dishwashers are operated on consumer demand only, and their consumption in the use phase is due by the listed, mainly consumer driven, factors:

- Penetration of dishwashers
- Ambient condition
- Frequency of operation
- Selected programme and its consumption
- Programme temperature in combination with amount (and type) of detergent
- Option/feature chosen
- Machine efficiency under real use conditions
- Load size
- Low power mode (e.g. delay start, left-on, …)
- Manual washing of dishes

The ambient where the dishwasher is located and the resources that are used may have some influence on the actual consumption of these resources. While it may be calculated that the influence of the ambient temperature is relatively small, the temperature of the supply water may have some more significant influence, if the temperature of the selected wash programme is higher that the inlet water temperature.

The use of a hot and cold water supply has never been a real option for dishwashers. Since the water needs to be heated up in the main wash phase and in the final rinse of a washing cycle, a cold water intake in between would cool down the loaded tableware and would therefore cause a higher energy consumption in the final rinse. A better option for dishwashers could just to be connected to a hot water source: if the source has low installation costs, if the hot water generation is environmentally sound and losses are small this might be a viable infrastructural option. Most dishwashers are able to use this option. (in Task 4 a more detailed analysis of this infrastructural option is presented).

The frequency of operation depends mainly on the household size, as this defines the amount of tableware to be treated. Very simple considerations may be used to estimate the number of dishes to be cleaned, as for each meal every day of the year dirty dishes, glasses, cutlery and cooking utensils are produced. Assuming three meals per day and the use of one place setting per meal (each place setting consisting of 11 items), 1 095 place settings per person per year will have to be cleaned. Since meals are also taken outside of the house (e.g. at a canteen or a restaurant) the real place settings number will be considerably lower, depending on the working and living situation of the people in the household.

However, not all of the dishes will be washed in a dishwasher. First, not all households own a dishwasher: in Western Europe dishwashers are present in 42 % of the households, in Eastern Europe only in 3 % of the households[27]. In addition, larger families tend to have more frequently a dishwasher, therefore no more than half of the people living in the EU will have the possibility to wash dishes in a dishwasher. Second, also those households owning a dishwasher do not clean all items in it: it is estimated that only 30-40 % of all tableware is actually cleaned in a dishwasher. The rest is treated with a manual washing process, which also consumes resources.

Manual dishwashing was studied intensively and found in average to take more water and energy than washing the same amount of dishes in a fully loaded dishwasher (Figure 3.73)[28]. But since this condition may not always be fulfilled, the correlation between of the resources consumption of a dishwasher at lower load has to be considered. The study also revealed that the practice in washing the dishes by hand is very different from person to person.

[27] Information from: Technischer Arbeitskreis Maschinelles Geschirrspülen, ZVEI, Germany

[28] R. STAMMINGER, R. BADURA, G. BROIL, S. DÖRR, A. ELSCHENBROICH, A European Comparison of Cleaning Dishes by Hand. In: EEDAL 2003 Conference Proceedings, p. 735 - 743

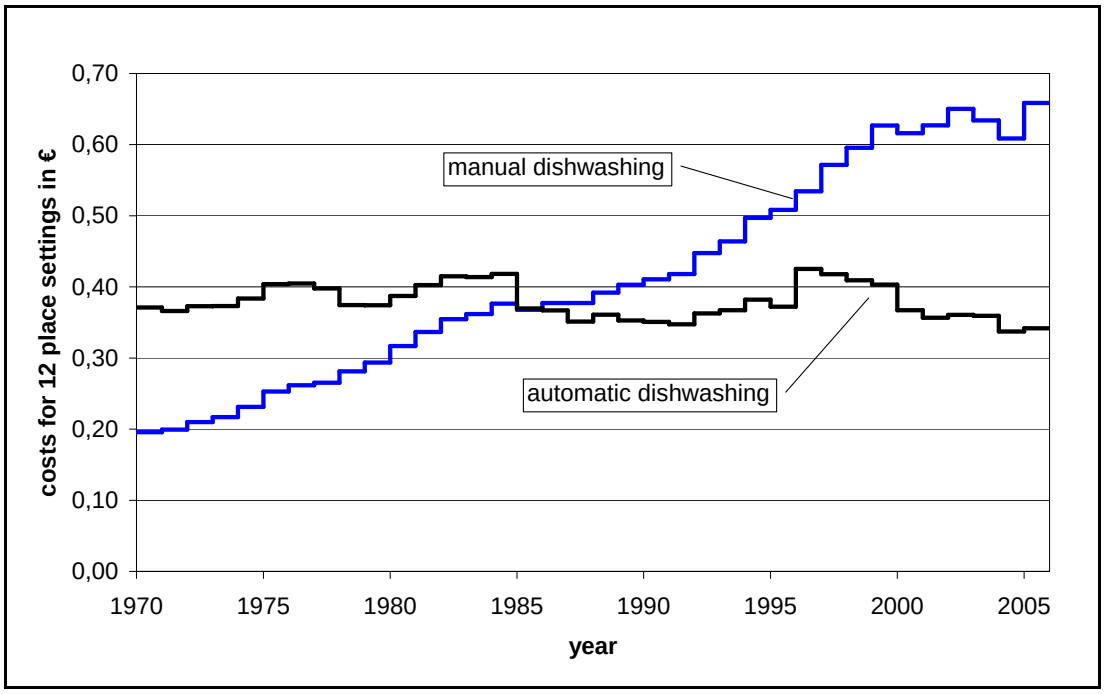


Figure 3.73: historical comparison of costs of washing 12 place settings of dishes by hand or in a dishwasher in Germany (source: R. Stamminger [31])

No general correlation was found[29] between the resources input and performance output of the manual dishwashing process (Table 3.8), therefore the logical conclusion is that there are ways to perform the dish washing consuming less water and energy than the evaluated average, but it is not clear which way is the best (in terms of resources consumption) nor how consumers can be made aware and trained about the optimal manual dish washing procedure.

[29] R. Stamminger, et al.; Washing-up behaviour and techniques in Europe. In: Hauswirtschaft und Wissenschaft 1-2007

, p. 31-40.

R. Stamminger, et al.; Dishwashing under various consumer-relevant conditions. In Hauswirtschaft und Wissenschaft 2-2007

Table 3.8: comparison of consumption for manual and automatic dishwashing (source: R. Stamminger et al.[29])

Country/region	**Water** (litre)	**Energy** (kWh)	**Time** (min)	**Cleaning** (0 – 5)
D	46	1,3	76	3,2
Pl /Cz	94	2,1	92	3,3
I	115	2,5	76	3,4
E / P	170	4,7	79	3,4
Tr	126	2,0	106	3,5
F	103	2,5	84	3,4
GB / Irl	63	1,6	65	2,9
Total manual	**103**	**2,5**	79	3,3
Dishwasher (new, A class)	**15 - 22**	**1,0 – 2,0**	Loading and unloading: 15 min Programme time: 100-150 min	3,3 - 4,3

A rough calculation[30] resulted in an overall energy consumption for cleaning dishes (only direct energy) in EU25 of about 88 TWh, with a saving potential of 33 TWh by introducing more dishwashers. The use of a dishwasher can also be seen as economically beneficial, as it could halve the costs for washing dishes[31]. This comparison presented in previous Figure 3.73 shows the historical development of the manual dishwashing costs in Germany in the last thirty years, assuming a constant way of washing dishes by hand. Due to the increasing price of water and energy, the costs for washing the dishes manually rise, while using a dishwasher the increase in costs could be balanced by the reduction of the energy and water consumption of new appliances (Figure 3.74 and Figure 3.75).

[30] R.Stamminger, G.Goerdeler: Consumer habits and practises in manual dish-washing in Europe. In: Proceedings of *52. SEPAWA KONGRESS with European Detergent conference, 12.-14. October 2005, Würzburg, German*

[31] R. Stamminger, Daten und Fakten zum Geschirrspülen per Hand und in der Maschine. In: SFÖW - Journal, 3-2006

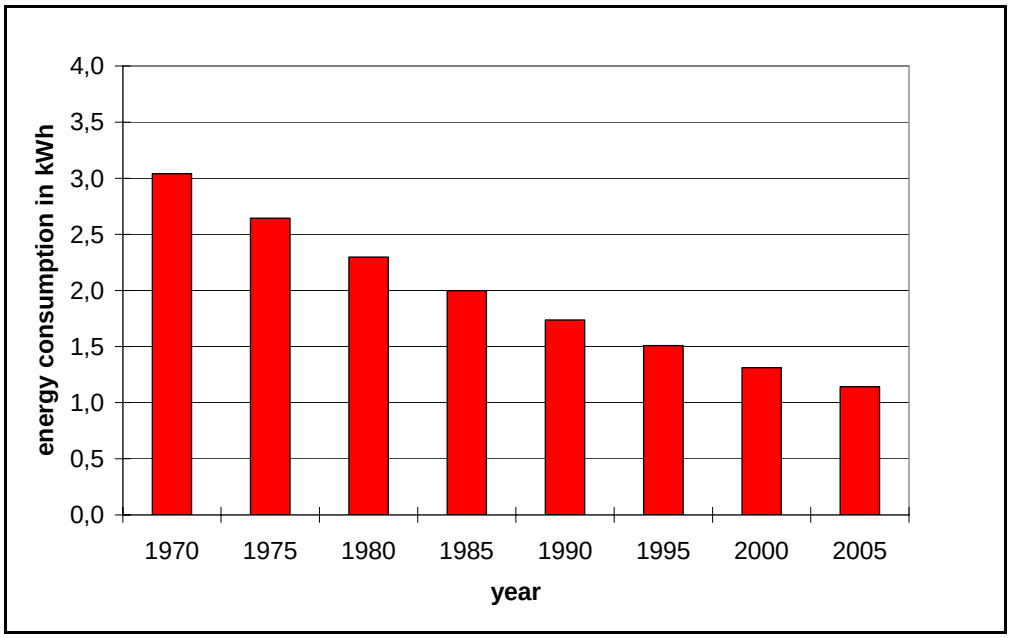


Figure 3.74: energy consumption of dishwashers versus year of testing (source: R. Stamminger [31])

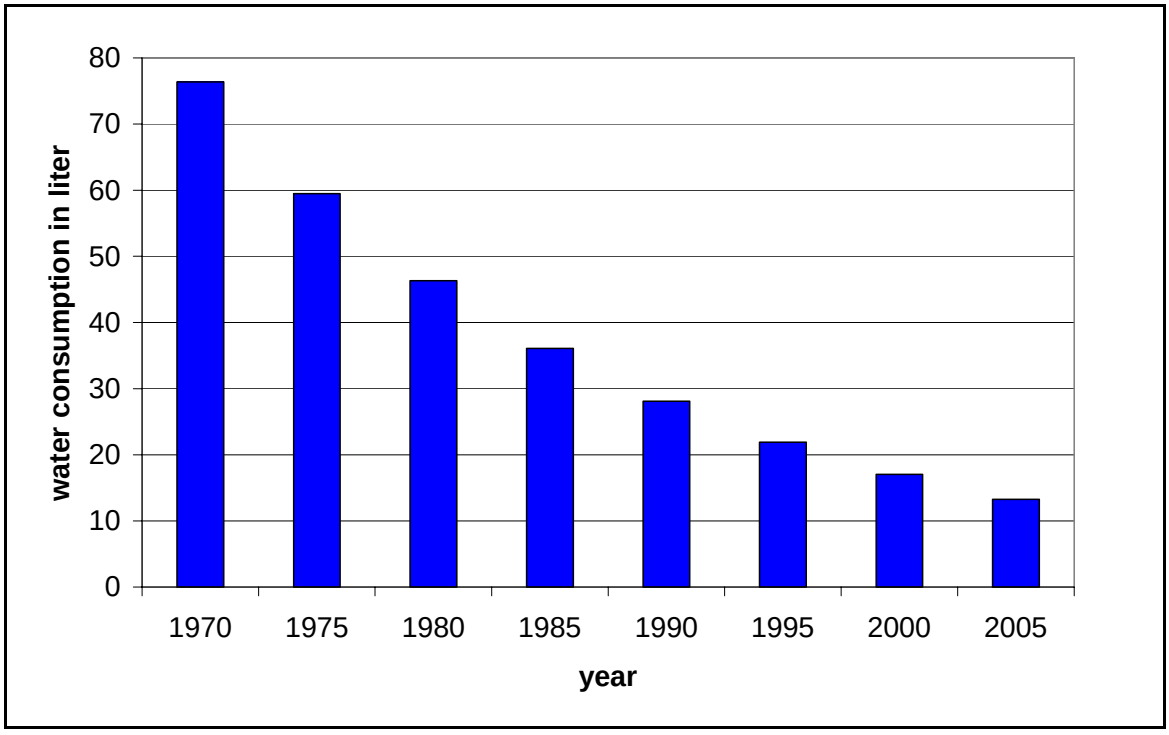


Figure 3.75: water consumption of dishwashers versus year of testing (source: R. Stamminger [31])

Since this comparison is based on the 'normal'-programme or in recent years on the economy-programme it is worth asking about the differences in the washing programmes. The German Stiftung Warentest has measured and recently published[32] (Figure 3.76) a comparison where on average the energy consumption of the "eco-programme" (normally the programme used for the energy label directive declaration) is 1,13 kWh, against 1,42 kWh for the "intensive programme"

[32] ‚test' of Stiftung Warentest, issue 7-2006, p.66-69

(which is recommended for heavily soiled pots and pans). Beyond these two programmes dishwashers usually offer additional programmes or options for other type of loads or soiling.

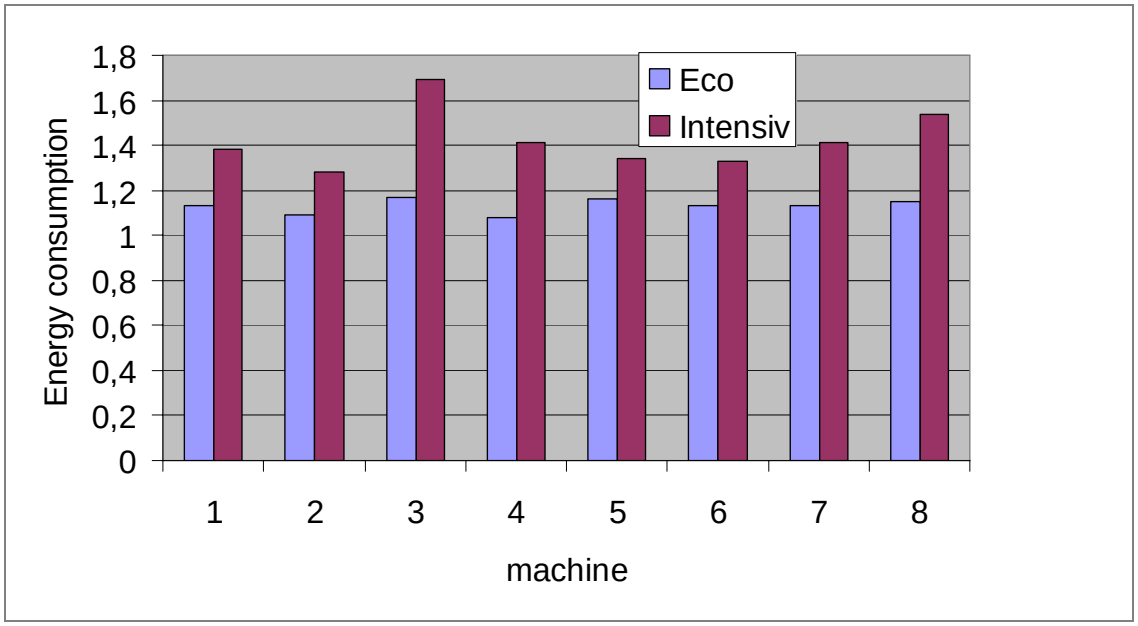


Figure 3.76 : intensive-programme (source: 'test'; graphic: R. Stamminger [32)]

No public data is available regarding the amount of dishes loaded under real life conditions in the dishwasher. Some information from Germany[33] show that the average number of dishes loaded in the dishwashers of 20 German households (Figure 3.77) is always below the number of dishes used for the measurements according to the EN 50242 standard used for the EU energy labelling scheme. This investigation has also shown that the splitting of the load in private homes into the different baskets of a dishwasher is somehow different to the standard procedure, with a lower number of items in the lower basket and in the cutlery basket as in the real life.

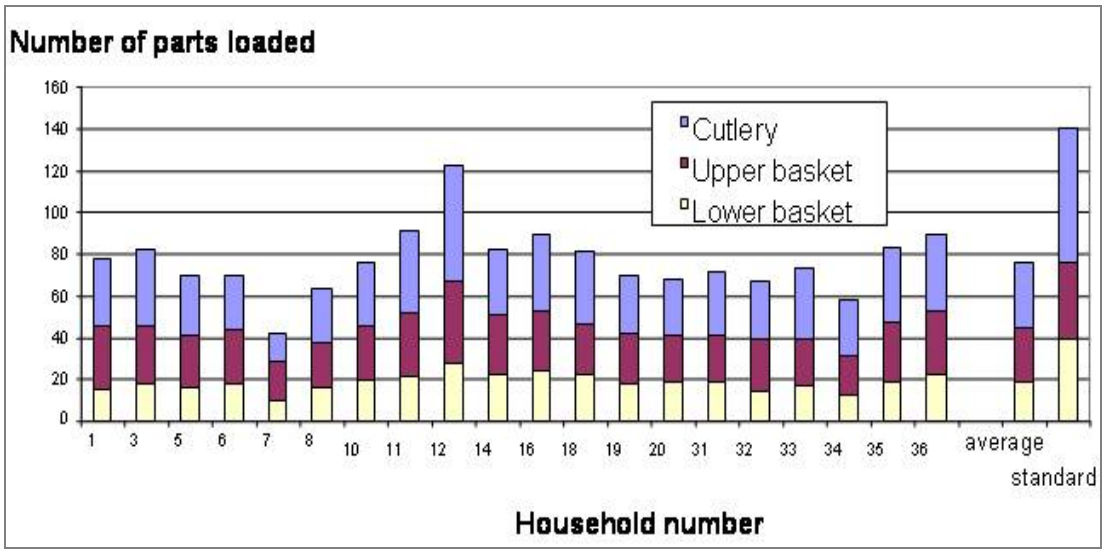


Figure 3.77: average number of parts loaded in dishwashers (12 place settings) in 20 households and comparison with the standard load according to EN 50242.[33]

[33] source: Dr. Ennen, Fa. Miele – private communication

The number of loaded items, or better their weight and heat capacity, may influence the amount of the energy used, since the load has to be heated to the selected washing cycle temperature. A lighter load will therefore lead to a lower energy consumption of the wash cycle (but higher consumption per place setting) without any adjustment needed from the machine side. Although in the past some dishwashers were equipped with a half-load button, this feature has almost disappeared from the market. Contemporarily, 'automatic' programmes have entered the market claiming to take into consideration also the amount of dishes loaded and adjusting the water and energy consumption accordingly.

Another aspect of the actual use of a dishwasher is the additional energy, which may be used when it is not performing its main function. These low power modes have been investigated in Germany in the framework of a research work for the international standardisation of dishwasher[34], which collected consumer data about the frequency of use of these modes in 9 households. Assuming an average power level of 1 W in standby and 5 Watt in programme-end and delay-start modes the following annual consumption values were calculated and reported:

- Consumption of washing programmes (213 cycles/year at 1 kWh/cycle): 213 kWh
- Consumption of standby mode (~8 000 h at 1 W): 8 kWh
- Consumption of programme-end mode (~240 h at 5 W): 1,2 kWh
- Consumption of delay-start mode (~40 h at 5 W): 0,2 kWh

A detailed analysis of the standby and other low power mode for washing machines, and a comparison between the definitions presented in Task 1 for washing machines and the Lot 6 outcome will be run in Task 6 of this study.

3.5.2 The results of the consumer behaviour questionnaire

The first classification of the dishwashing process has been done considering the way the dishes are washed: by hand or in a dishwasher. But also in those households owning a dishwasher, manual dishwashing is not completely banned (Figure 3.78). On average 16,6 manual dishwashing 'cycles' (meaning washing any number of dishes at a time) are done in households not owning a dishwasher per week, and 9,9 in those owning a dishwasher. But since the size of the household owning and not owning a dishwasher is different, a more correct comparison was run considering the number of manual dishwashing cycles per person per week, which resulted to be (Figure 3.79) on average 6,6 cycles per person per week for those households not owning a dishwasher and 3,3 cycles per person per week for those owning a dishwasher.

[34] DKE UK513.5 and AK513.5.3; Standby and other low power modes on dishwashers; Analysis of a small consumer investigation in Germany. Published also in IEC TC59, WG9

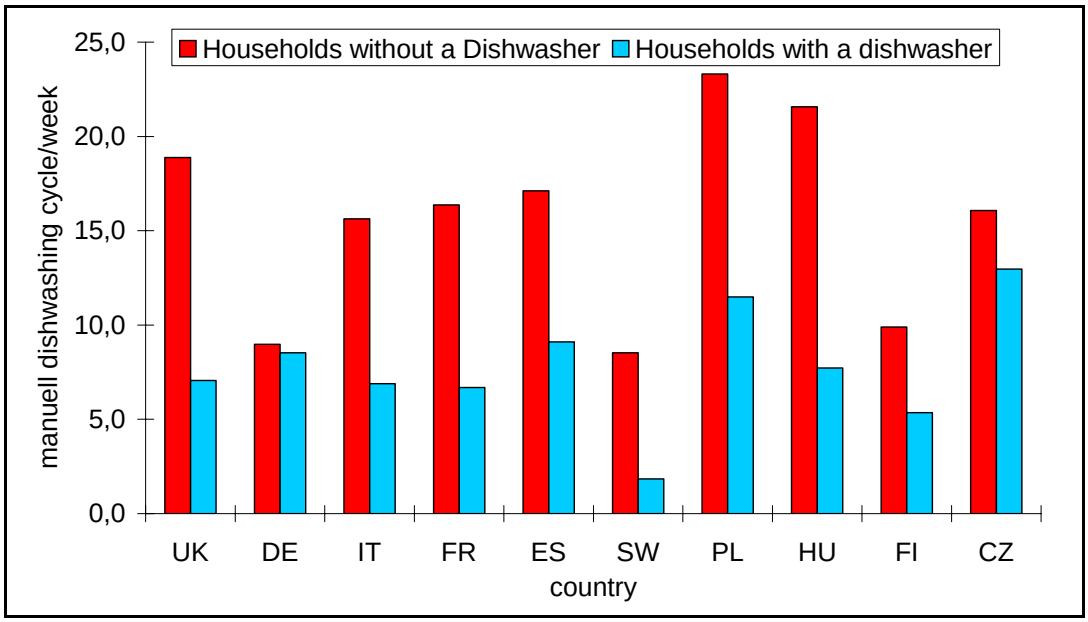


Figure 3.78: frequency of manual dishwashing per week in households with and without a dishwasher

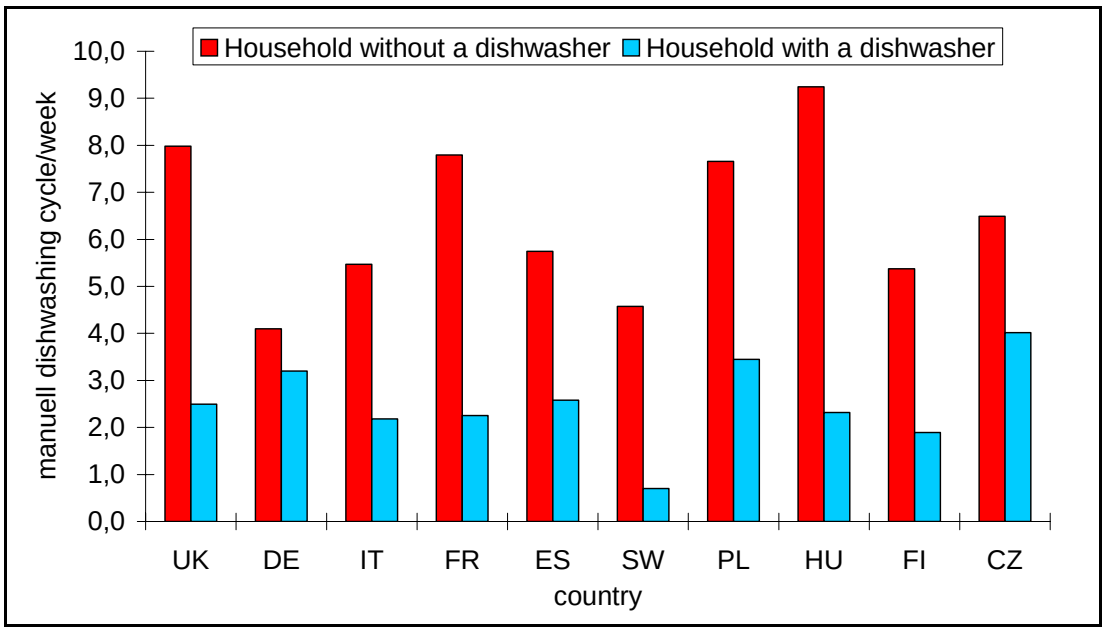


Figure 3.79: frequency of manual dishwashing per week per person in households with/without a dishwasher

Looking at the way the manual dishwashing is done, two main procedures were investigated in the consumer survey: washing the dishes 'in a sink or bowl' or washing 'under running tap water'. The answers show a large variation from country to country (Figure 3.80 and Figure 3.81) and from households with/without a dishwasher: the 'under running tap water' washing was the preferred method for less than 10 % (in UK) to about 50 % (in Spain, Hungary, Poland, Czech Republic) households without a dishwasher.

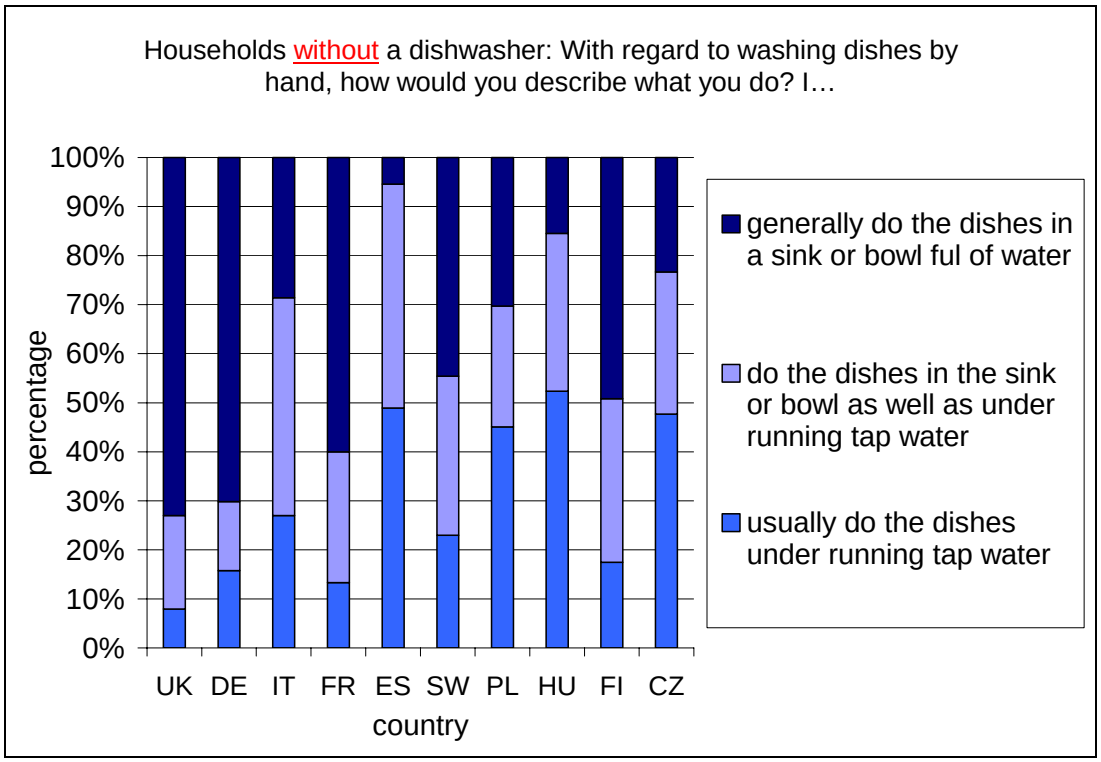


Figure 3.80: way of manually washing the dishes for households without a dishwasher

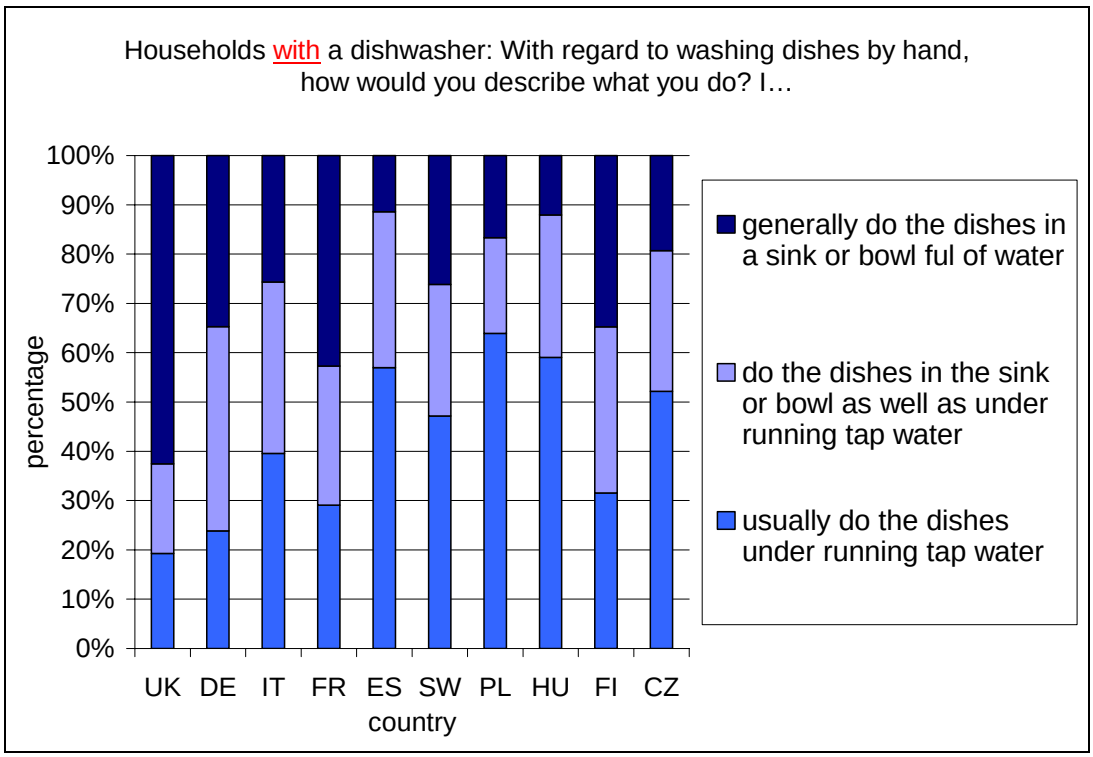


Figure 3.81: way of manually washing the dishes for households with a dishwasher

Differences between consumers owning and not owning a dishwasher were also found: people with the dishwasher prefer manual washing 'under running tap water'; on average, the manual washing 'under running tap water' increases from 34,5 % of the households without a dishwashers to 40,2 % of the households where a dishwasher is installed and contemporarily the 'in a bowl or sink' washing reduces on average from 35,1 % to 30,2 %. This may be explained by the fact that owners

of dishwashers do not place all tableware items to be washed in the dishwasher but tend to wash some pieces by hand, probably if an item is needed quickly or if it may require a special treatment. An important aspect affecting the use of resources by the automatic dishwashing is the number of wash cycles. Since the consumer questionnaire is representative of the household size of the investigated countries, the calculated values are very likely representative of the average number of dishwasher cycles per household (Figure 3.82). This figure goes from 3,5 (Germany) up to 4,5 (UK, Sweden) cycles per household per week, with an average of 4,06 cycles per household per week.

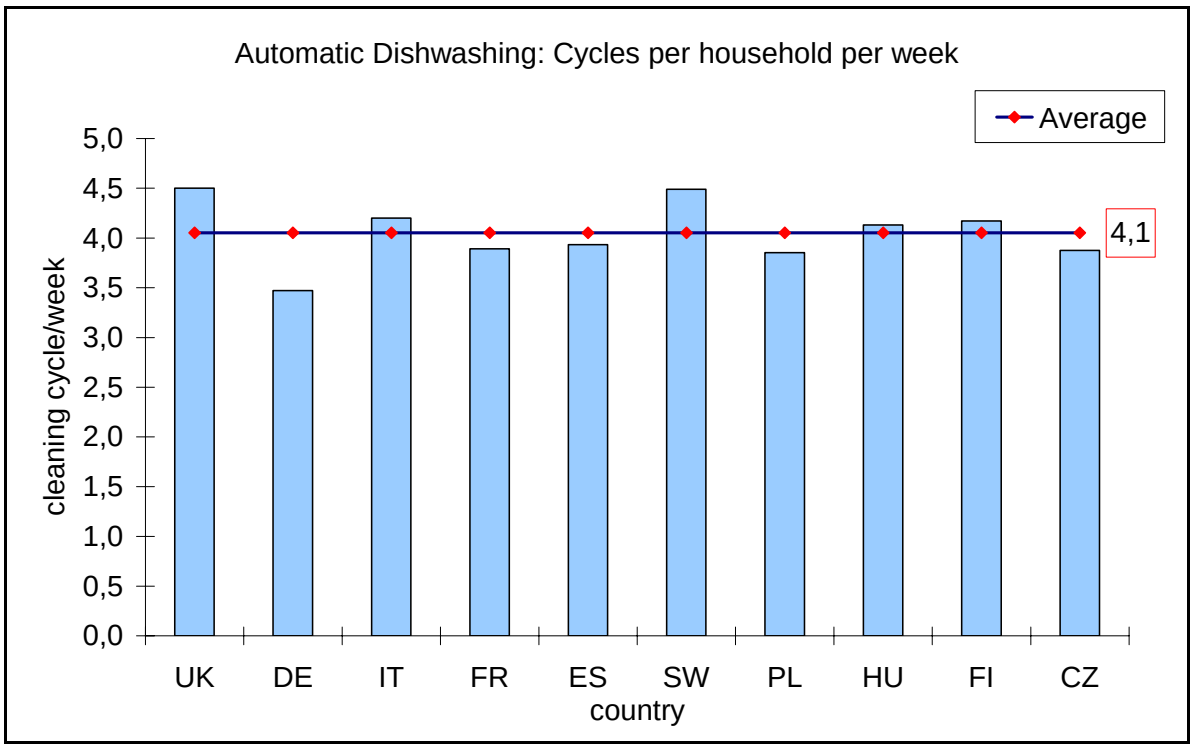


Figure 3.82: average number of dishwasher cycles per household per week

Since the penetration of dishwashers and the household size varies from country to country, it is more correct comparing the countries by the numbers of washing cycles per week per person (Figure 3.83): this number varies from 1,1 (Spain) and 1,7 (Sweden) dishwasher cycles per person and week, with an average of 1,34 cycles per person per week.

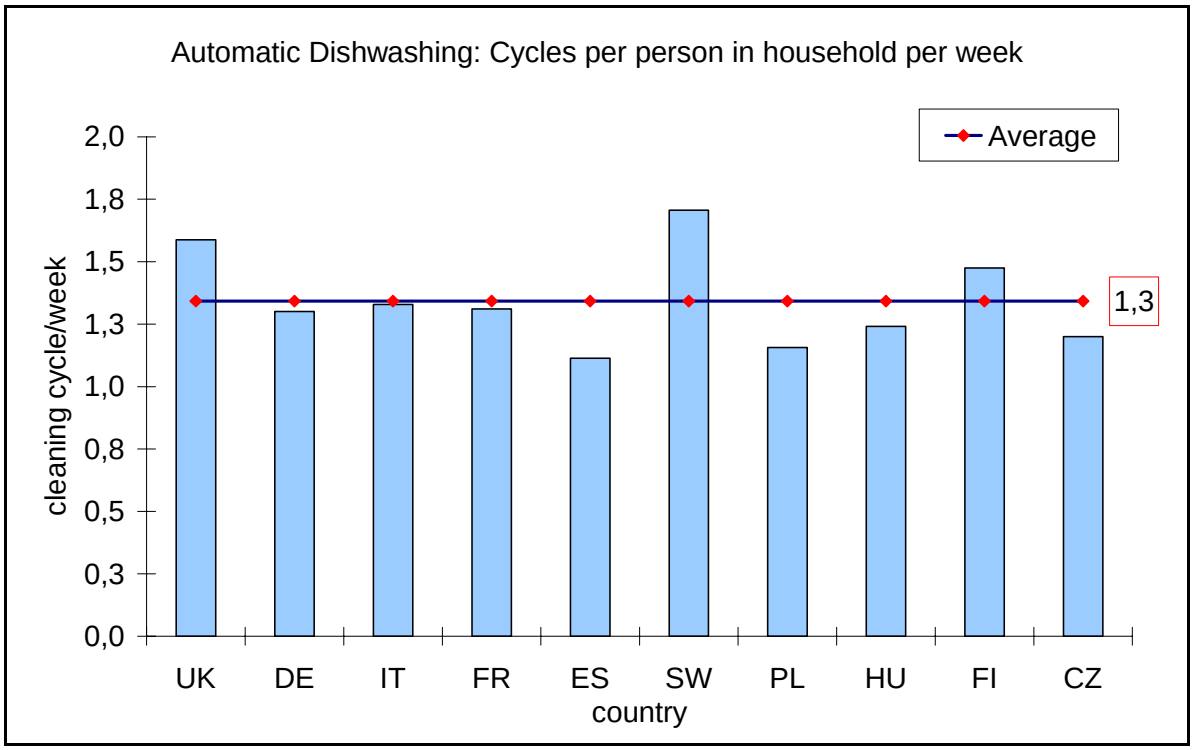


Figure 3.83: number of dishwasher cycles per person per week

The second important aspect affecting the energy consumption of a dishwasher is the temperature of the selected washing programme. The answers of 1 722 consumers from 10 countries did not show a clear preference (Figure 3.84): programmes at 50/55 °C (36,3 %) are as common as programmes at 60/65 °C (35,6 %); the same occurs for the programmes at higher temperature (70°C) which are used on average in 14,2 % of the cases, while lower temperature programmes (40/45 °C) are used in 13,9 % of the cases. The averaging nominal washing temperatures is 59,3 °C. It is worth noting that 22,2 % of the consumers could not report the temperature of the programmes they use, as this may be not indicated on the machine control panel.

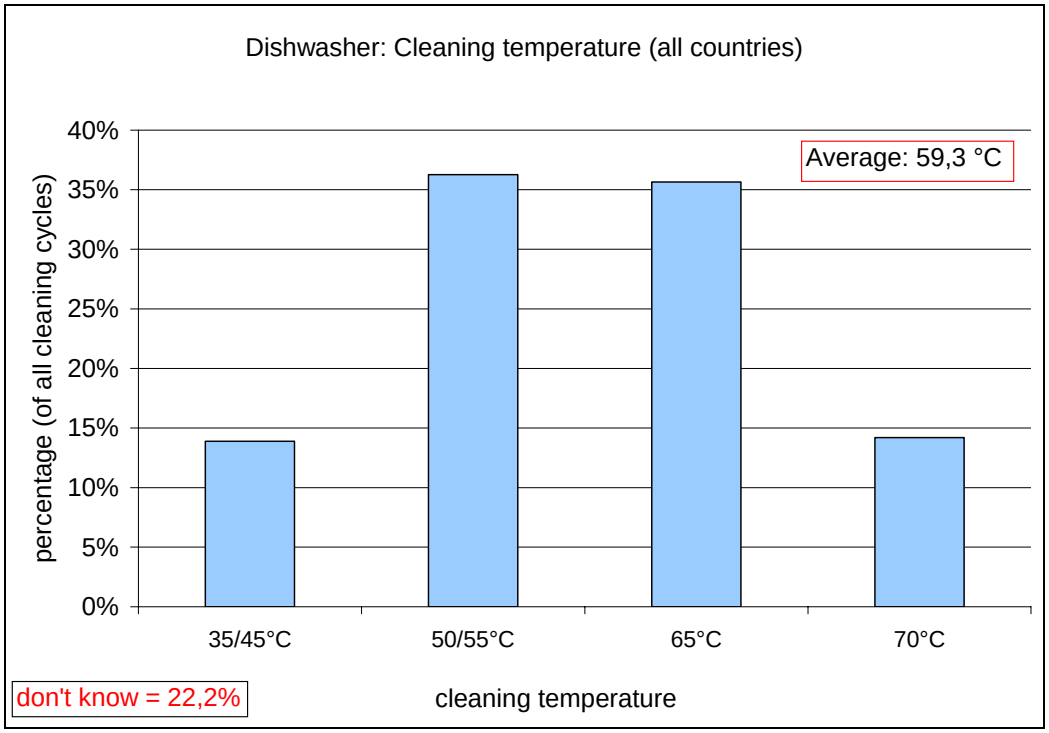


Figure 3.84: relative occurrence of dishwasher temperatures in Europe (average of 10 countries)

Analysing the questionnaire answers more in detail (Figure 3.85) the temperatures range in the investigated countries is quite different:

- in some countries high temperatures are used for less than 10 % of the cycles (France), in other countries they are used for more than 20 % of the cycles (Sweden, Italy);
- low temperature washing cycles are very common in Spain, with more than 30 % of the cycles being at 35 to 45 °C.

These differences are also visible when comparing the average wash temperatures for all of the 10 countries investigated (Figure 3.86), which range from 56,6 °C to 60,8 °C.

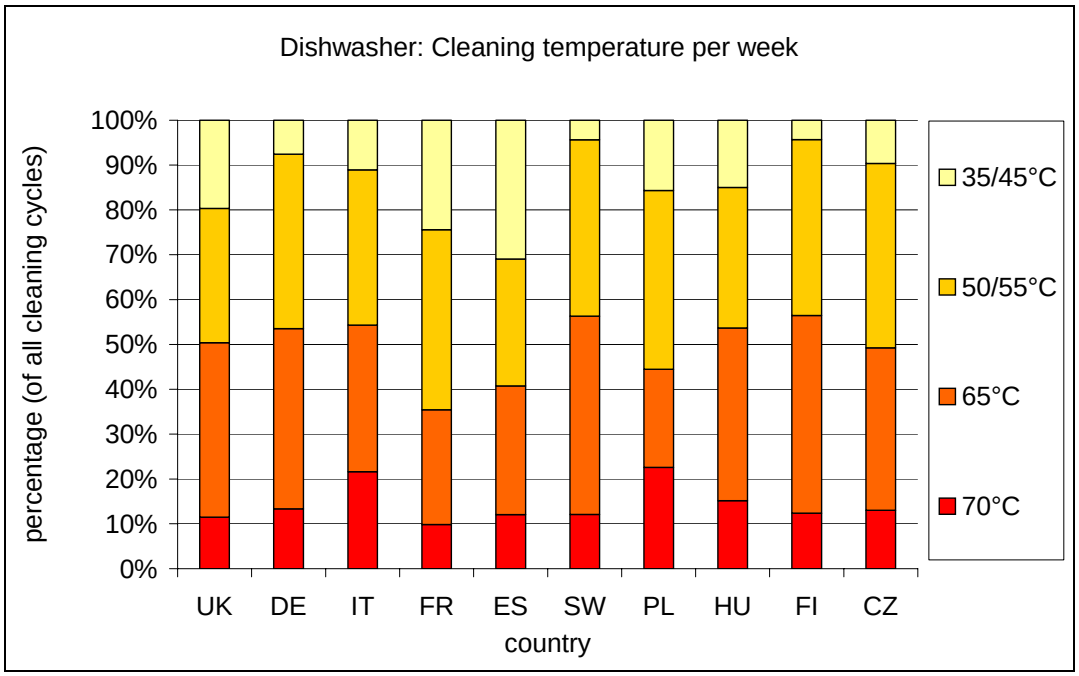


Figure 3.85: temperature distribution of dishwasher programmes in various countries

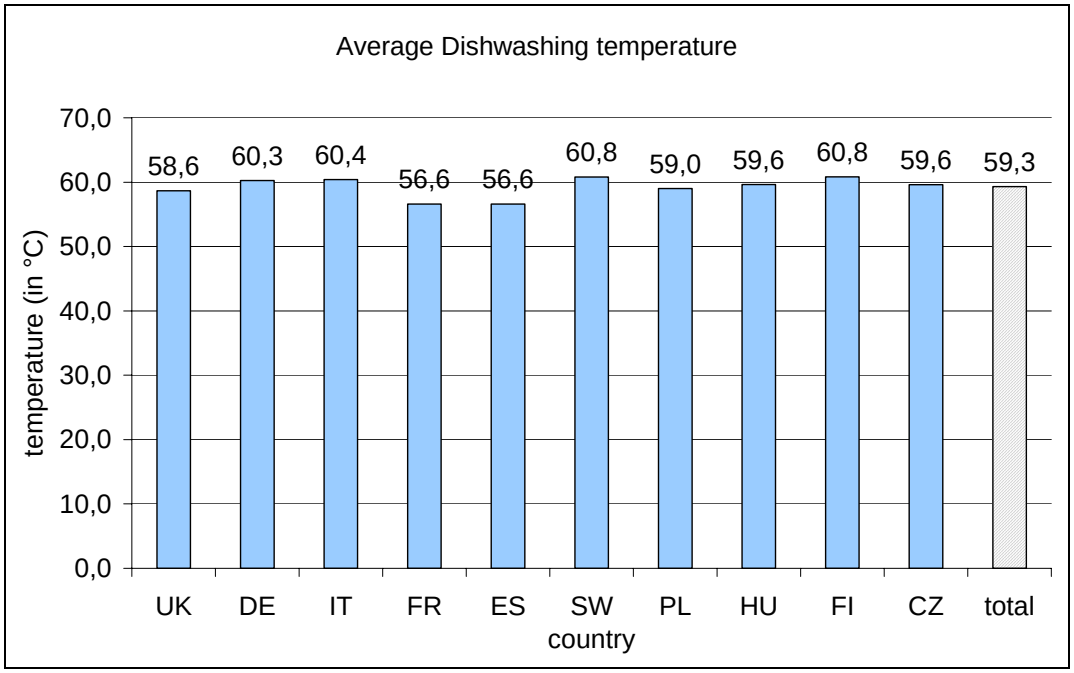


Figure 3.86: average nominal dishwashing temperatures for all countries

The type of the selected dishwasher programme shows (Figure 3.87) a dominance of the 'normal/regular' programme, where about 40 % of the consumers use it *always* and another 25 % *often*; the second most used programme is, when available, the 'automatic' programme (which claims to adjust to the machine consumption to the actual load or soiling level), almost as used as the 'eco'-programme, which is often indicated as the programme used for the EU energy labelling declaration); the less frequently used programme is the 'rinse and hold' cycle. The 'rinse and hold' cycle is intended to be used mainly to rinse off heavy residues from the dishes and to pre-rinse the dishes with some cold water if they are not immediately washed due to the time needed to fill the dishwasher with dirty tableware. However, some of the consumers seem to prefer to do this job manually (Figure 3.88): slightly more than 30 % quickly manually pre-rinse almost all items before putting them into the dishwasher.

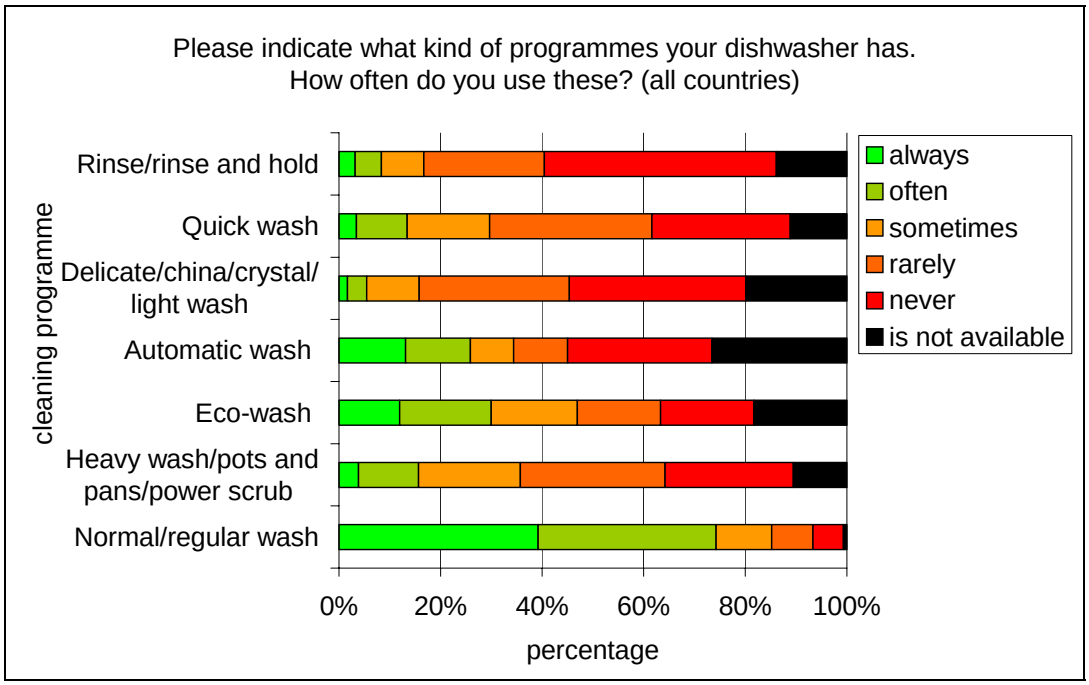


Figure 3.87: frequency of use of various programmes of a dishwasher

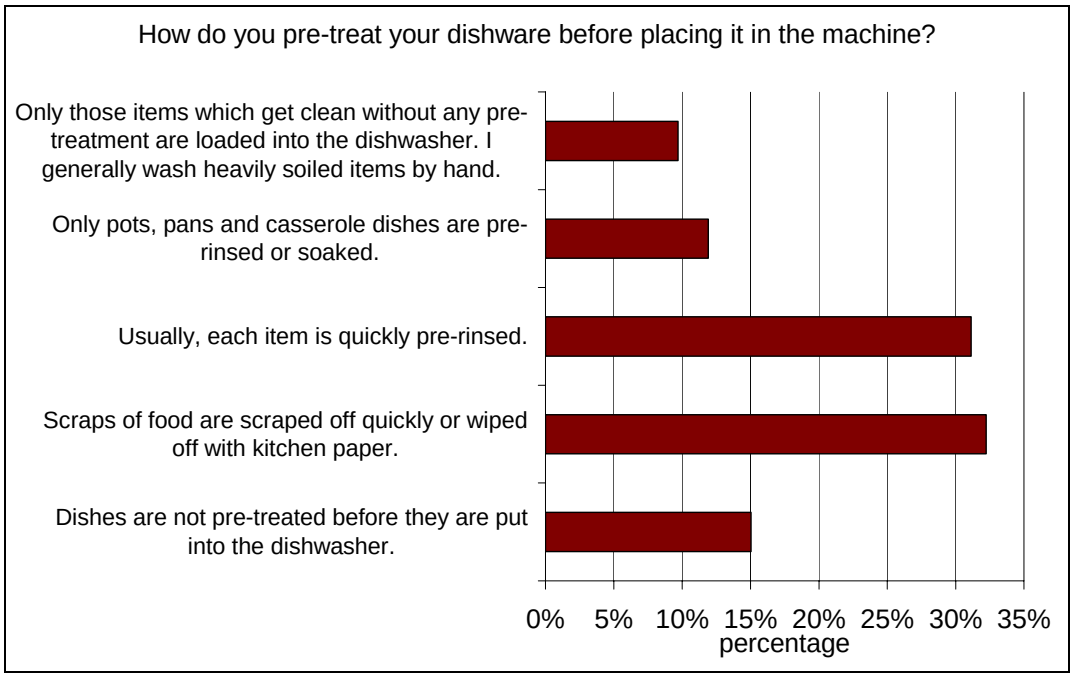


Figure 3.88: frequency and type of pre-treatment of dishes

Regarding the loading of the dishwasher, most of the interviewees declare to fill it completely and even to overload it; only about 10 % admit to run the dishwasher also when not completely filled or do not care about the amount of load in the appliance (Figure 3.89). Due to the structure of the consumer questionnaire it was not possible to verify what consumers mean in terms of load items amount when saying they load the dishwasher completely.

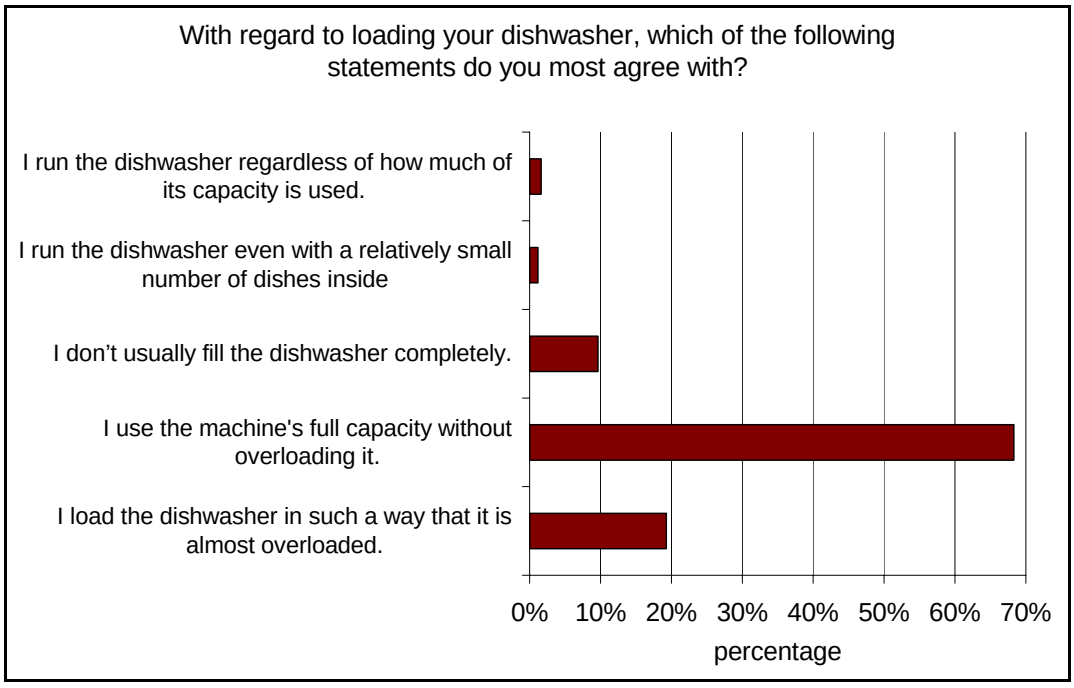


Figure 3.89: consumer answers about the load they are putting into the dishwasher

As a delay of the start of the dishwashing process may be used to postpone the energy (and water) consumption when - during the day or the night - cheaper (off-peak) tariffs may be offered, the selection and the frequency of use of this option have been investigated. Consumers were asked if their washing machine was equipped with a delay-start time pre-selection function: over 39 % of

the dishwashers are equipped with such an option, but with some differences among countries (Figure 3.90).

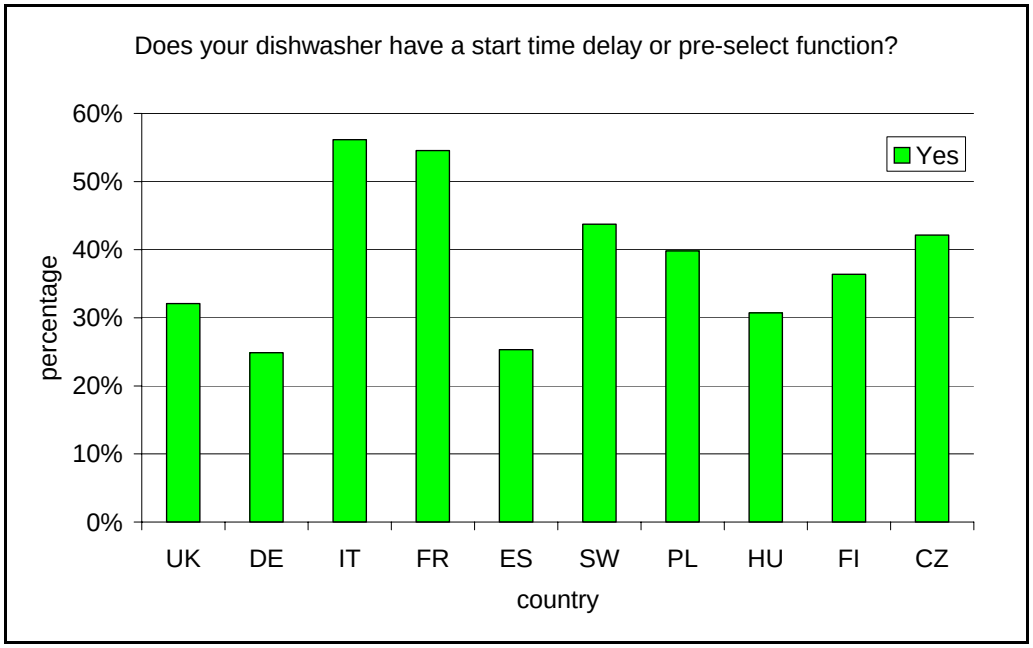


Figure 3.90 availability of a time delay function of the dishwasher

But when asked about the frequency of the usage of this delay-start option, 45 % of the consumers confess (Figure 3.91) to 'never' use it; 27 % say they use this function 'almost always' and another 15 % use it about 'once per week'. It would have been interesting to know also the reason why consumers select this option: if to match off-peak tariffs or for their personal convenience (clean tableware ready when needed), but this aspect was not included in the questionnaire.

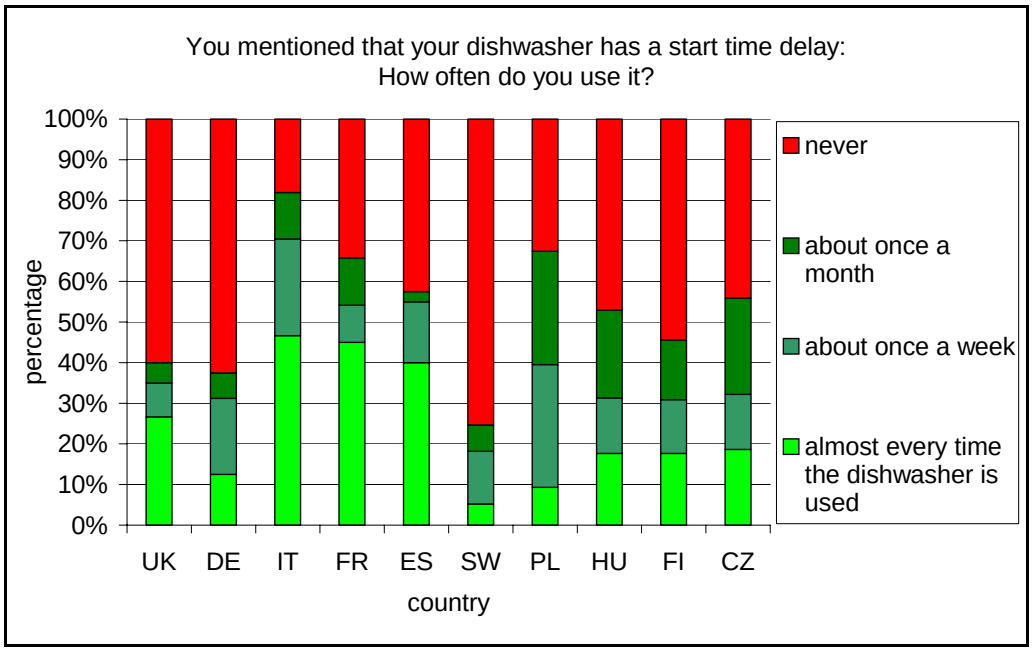


Figure 3.91: frequency of use of the time delay function

This function also has a possible negative impact on the energy consumption on one side because the consumer convenience may - at least potentially - lead to start the dishwashing cycle during peak hours, and on the other side because the machine consumes some energy when waiting for the start time. Asking (to those consumers having a delay start function in their dishwasher and making use of it), about the selected start time delay, on average 66 % chose a time between 0 and 3 hours (Figure 3.92), while 24 % use it to delay the start time between 4 and 6 hours and 10 % to delay it for more than 7 hours.

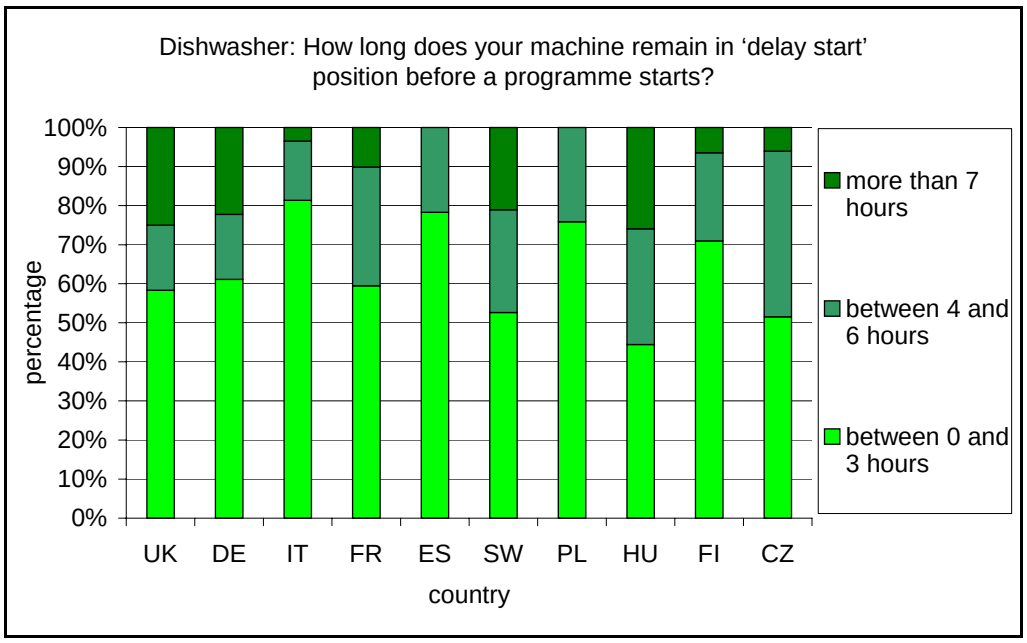


Figure 3.92: frequency of start time delay hours

Additional energy may be consumed when the machine is entering the programme-end-mode, which may be defined as the time between finishing the dishwashing programme (including the final hot rinse) and unloading. During this time the machine may do some additional drying function. Asked about how long this mode normally is, on average 33 % of the consumers (Figure 3.93) open the door immediately after the programme has ended; 54 % do this within a maximum of 3 hours; and only 13 % admit to wait for more than 3 hours.

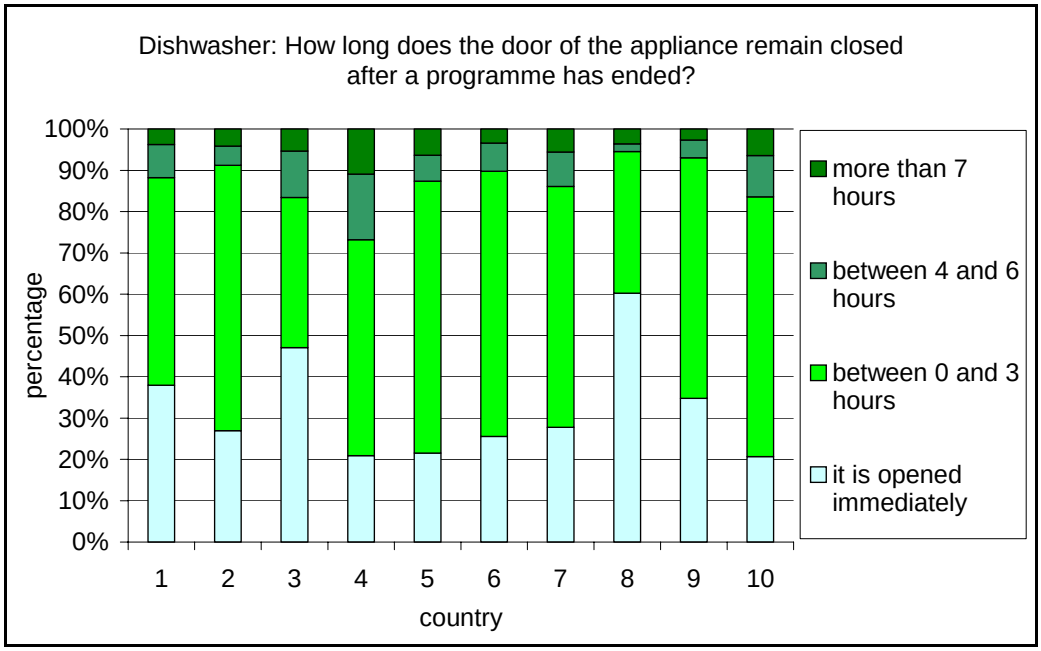


Figure 3.93: time of keeping the door closed after programme end

Also after the dishwasher is unloaded there may be additional energy consumption when the machine is "left on" and not switched off completely. On average 44 % of the consumer declared (Figure 3.94) to switch off the appliance immediately and additional 14 % to do this after unloading; only 12 % of the consumers claim not to switch off the appliance always or most of the time.

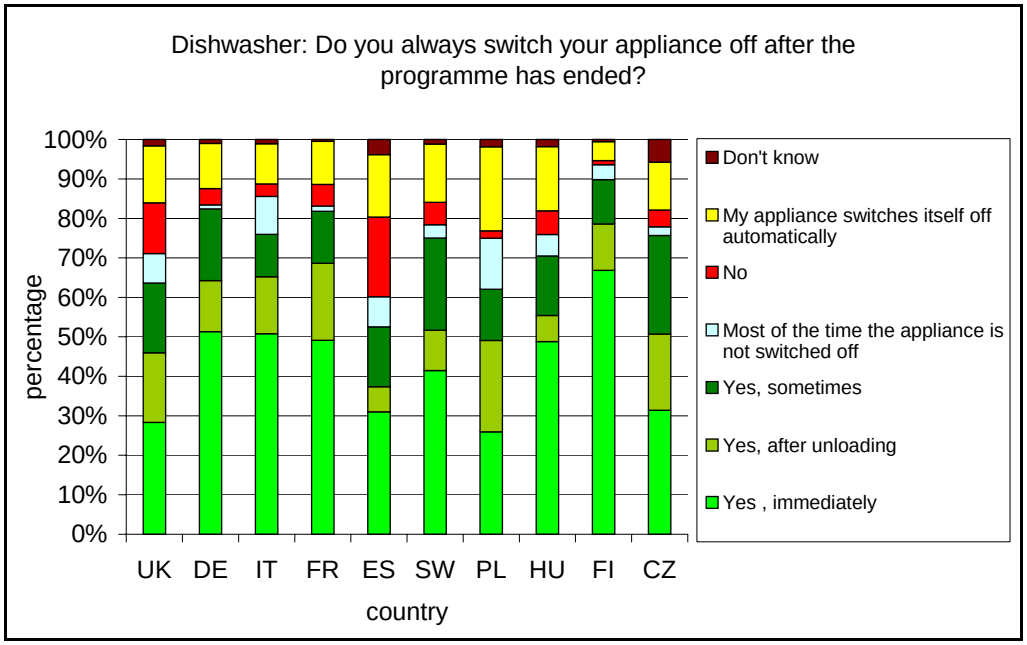


Figure 3.94: action after programme has ended regarding off-switching

In summary, the consumer behaviour regarding washing their tableware in a dishwasher is characterised by:

- on average 4,1 automatic dishwashing cycles are done per week per household or 1,34 dishwashing cycles per week per person
- programmes at 50/55 °C (36,3 %) are as common as programmes at 60/65 °C (35,6 %), with an average programme temperature of 59,3 °C
- normal/regular programme is the most frequently used programme (65 % of the households always or often)
- the automatic programme is the second most frequently used, when available, almost as used as the 'eco'-programme (often the basis for the EU energy labelling scheme declaration)
- consumer claim to load the dishwasher almost always at the full capacity or even more
- delay-start function, present on average in 39 % of the dishwashers, is not used by about half of the households, and when used it is very often only for short time delays (0-3 hours)
- about 58 % of the consumer switch the appliance off after the machine has ended the washing programme or was unloaded
- additional energy and water is consumed by pre-treatment (soaking, pre-rinsing) of dishes which are then loaded into the dishwasher
- manual dishwashing (3,3 cycles per person per week) is also regularly done in households owning a dishwasher
- manual dishwashing 'under running tap water' is a common practise in many households and more frequently used in households owning a dishwasher (40,2 %)
- manual dishwashing procedures show a large variation from country to country, more than automatic dishwashing.

3.6 ELEMENTS FOR THE COMPARISON OF REAL LIFE AND STANDARD CONDITIONS FOR WASH APPLIANCES

Consumers behaviour for laundry washing and dishwashing shows a large variability, and differences may be found also with the standard conditions defined in the European measurement methods, and used within the energy labelling schemes, to evaluate the consumption and the performance of washing machines and dishwashers. These differences are summarised in the following paragraphs as far as they may affect the energy and water consumption of the laundry- or dish-washing process.

The final decision about the elements to be considered in the definition of the real-life base case(s) for washing machines and dishwashers will be taken in Task 5 of this study.

3.6.1 The laundry washing process

The differences between the real-life and the standard conditions for the laundry washing process are summarised here. Not considered here is the energy consumption associated with manual washing of laundry (which was not investigated due to the selection criteria of the consumers questionnaire sample), and with manual processes done in addition to the automatic washing on garments which are then placed into the washing machine, which are considered to be very small.

The factors, which are not considered among the standard conditions, but are relevant for the energy consumption under real life, are:

- the consumer survey has shown an average frequency of use of the washing machines of 4,9 cycles per household per week. Using this figure the energy consumption under standard conditions and the effect of those factors which are not included in the testing procedure may be calculated;
- the real life average nominal washing temperature was found to be 45,8 °C which is considerably lower than the nominal 60 °C used under standard conditions for the energy labelling declarations. The effect of this reduced temperature can be calculated applying the energy consumption increase per degree Celsius between 40 and 60 °C nominal wash temperature found in the German (0,0031 kWh/K) or the AISE studies (0,027 kWh/K) to the energy consumption of the average 2005 washing machine model at 60 °C, or 0,998 kWh/cycle.

An alternative is considering the specific energy consumption of the average 2005 washing machine model, or 0,187 kWh/kg cycle and comparing it with the average specific energy consumption found by Stiftung Warentest[35] of 0,110 kWh/kg cycle for a 40°C cotton programme: a temperature effect of 0,0038 kWh/kg/K results. This latter factor is used in the following calculations;

in Germany the average annual water inlet temperature may be significantly lower than defined in standard conditions (15 °C). As no proven European survey on these temperatures was found, an average water inlet temperature of 10 °C was assumed. Compared to the standard conditions the additional energy to heat up the main wash water volume (assumed to be 15 litres) to 15°C needs to be considered. This assumption – valid for Germany - may be challenged for other countries if their average water inlet temperature is higher than 15 °C; should this the case some less energy to heat up the main wash water volume will be used compared to standard conditions.

Real load sizes are somewhat smaller than the maximum capacity used under standard conditions. Although the underlying calculation assumptions may be challenged, an average load of 3,2 kg was estimated using the consumer answers and correlating it to metering data from Germany. Since the consumers in this questionnaire most likely have one of the machines produced in the last decade, this quantity can be compared to the average capacity of the washing machines as reported in the CECED databases (see Task 2). The most frequent washing machine model from 1997 to 2005 has a rated capacity of 5,0 kg, leading to a loading of 64 % of the rated capacity in the average real life case. The reduced real life load, compared to the nominal capacity of the machine, will also require a reduced amount of energy to be washed. Taking the average found in a study of 20 washing machines measured at 60°C, this can be estimated to be 0,08 kWh per kg reduced load.

Since the average wash temperature is considerably lower, this slope will also be lower: therefore this load dependency factor is scaled down accordingly to now be at 0,057 kWh/kg of reduced load when the previous 0,0038 kWh/kg/K factor is applied. This factor is applied to the 2005 average washing machine model capacity.

Standby and low power modes:

- investigation has shown the delay start function is used in about 8 % of the programme cycles for delaying the start by an average of less than 3 hours. Average power level may be estimated to be at 4,3 W according to Consumer Organisations and 2,5 W as suggested by CECED

[35] Communication to CENELEC TC59X, WG1, SG1.6

- after the programme has ended, the washing machine is not unloaded immediately, but left for an average of 3 hours in 50 % of the cases. Power level may be assumed to be at 3,3 W following Consumer Organisations information or 1,6 W as suggested by CECED
- even after unloading some 10 % of the consumers may not switch off the appliance but leave it in 'ON'-status up to the next programme starts. Power level in this left-on mode is assumed to be the same as at programme end
- the other 90 % of the consumers switch their appliance off and therefore only consume the associated power. On average this mode is assumed to have a power of 0,6 W or 0,5 W depending on the information source.

All these individual items of energy consumption can be summarised (Table 3.9) to obtain the total energy used for laundry washing in an average household in one week and compared it to what a similar calculation would yield just for taking the average washing machine model in 2005 under standard conditions multiplied by the same number of cycles per week.

Table 3.9: comparison of the washing machine energy consumption under real-life versus standard conditions (in kWh)

Activity	Effect	Real life conditions	Standard conditions
Programme selection	Average washing temperature 45,8°C	3,469	4,890
Colder water inlet temperature	15 litre of water heated from 10°C (real life tap water) to 15°C (water inlet under standard conditions)	0,427	--
Real average load size	64 % of the average rated capacity (or 5,36 kg) under standard conditions at -0,0567 kWh/kg	-0,537	--
Low power modes consumption:			
delay start	3 h at 4,3W for 8 %	0,005	
programme end	3 h at 3,3W for 50 %	0,024	--
left-on	the remaining time at 3,3 W for 10 %	0,052	
off-mode (standby)	the remaining time at 0,6 W for 90 %	0,084	
	Total consumption per week	3,525	4,890
	difference	- 1,365 or -27,9 %	

Comparing the figures (Figure 3.95), the total energy used for laundry washing in real life is lower than under standard conditions: this is mainly due to the lower wash temperature, lower inlet water temperature and lower filling of the drum used in real life. Re-calculating the real life energy consumption per washing cycle leads to an energy consumption of 0,72 kWh/cycle.

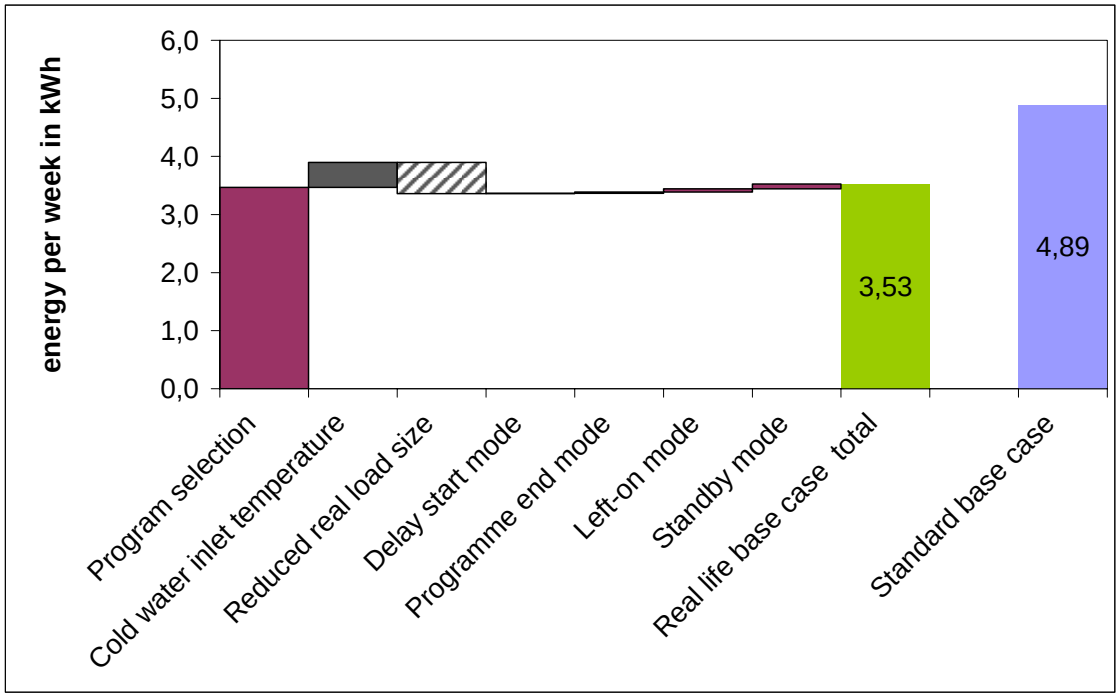


Figure 3.95: graphic representation of factors under real-life and standard conditions for the energy consumption per week of washing machines

Asking the consumer to fill the machines more would theoretically reduce the 'benefit' given in this calculation, but would in real life provide an even higher saving if this better loading is reflected in a reduced number of washing cycles.

Concerning the low-power modes consumptions, only the left-on mode and the off-mode (standby) seem to have a minor influence on the real life energy consumption: when the data from Stiftung Warentest is used this influence is <5 % when data from CECED is used, this influence is reduced to 3 %.

Not considered here is the difference in the amount of detergent used between the standard conditions and real life. The European standard requires the use of the standardised detergent "A*" (see in Task 1 the description of the EN 60456 standard) whereof for a 5 kg load 134 g are used for a water hardness of 2,5 mmol/l. In real life detergent dosage may be lower in absolute values but due to under-loading of the drum the specific amount of detergent used per kg load may be more inline with the standard conditions. Anyhow the real life detergent is somewhat different from the standard detergent.

Regarding water consumption the average 2005 washing machine results in 248 litres[36] per week. This value is reduced by about 27 litres due to the reduced filling of the drum in real life and the automatic adjustment of the washing machine to it. Extra rinse cycles or selecting additional water is not used very commonly but will add an extra amount of water; only 4,2 % of the consumers state to always use extra rinsing water and 8,9 % use it often; assuming 10 % of the wash cycles are done with an extra rinse of 10 litre per cycle, a water consumption of about 5 litres is added to the average consumption per household per week in real life. In total, the consumer will actually consume about 227 litres per week (Table 3.10).

[36] due to the rounding in the calculation, a specific water consumption of 9,5 litre/kg results when dividing the average water consumption of 50,7 litre/cycle for the average load capacity of 5,36kg, instead of the 9,6 litre/cycle reported in this Task. When a consumption of 9,6 litre/kg are used, the overall water consumption per week is 252,1 litres.

Table 3.10 real life vs. standard water consumption calculation for washing machines (in litre)

Activity	Effect	Real-life conditions	Standard conditions
Basis	50,7 litre per wash in a 5,36 kg machines	248,4	248,4
Real average load size	64 % of rated capacity at 2,817 l/kg	-26,6	--
Extra rinse cycle	10 % at 10 litre	4,9	--
	Total litres per week	226,7	248,4
	difference	-21,7 or -8,7 %	

In summary, the comparison of standard conditions with real life consumer behaviour results in a lower amount of energy used in real life than when calculating that the same number of cycles is run with the average 2005 washing machine model under standard conditions. The energy consumed for washing per week is 1,36 kWh or about 28% lower than when calculated under standard conditions. This difference is roughly confirmed by the lower average energy consumption measured per cycle (0,89 kWh) in a recent metering study in Germany, considering that the German stock of washing machines is less efficient than the average 2005 model. As far as the water consumption is concerned, the difference is about 22 litres or 8,7 % lower in the real life compared to the standard conditions, mainly due to the reduced water taken by the lower average load

It should be nevertheless highlighted that the use of the washing machine at the rated capacity would increase the energy and water efficiency which in turn might allow having less washing cycles with a reduction in the energy/water consumption of both under real life and standard conditions.

In trying to assess the sensitivity of the results to the household size, calculations were done also for the average consumer behaviour of single-person-households and of 4-person-households:

- average washing frequency was found to be 2,6 times per week for single- and 6,2 for 4 person households;
- load size and temperature selection were found not to differ significantly with the household sizes and were therefore kept constant;
- real life energy consumption for a washing machine per cycle in a single household (Figure 3.96) was calculated to 25 % lower and 29 % lower for a 4 person household (Figure 3.97). The contribution of standby and low power modes energy consumption increases 4 % of the total consumption for a 4-person household and 8 % for a single person household.

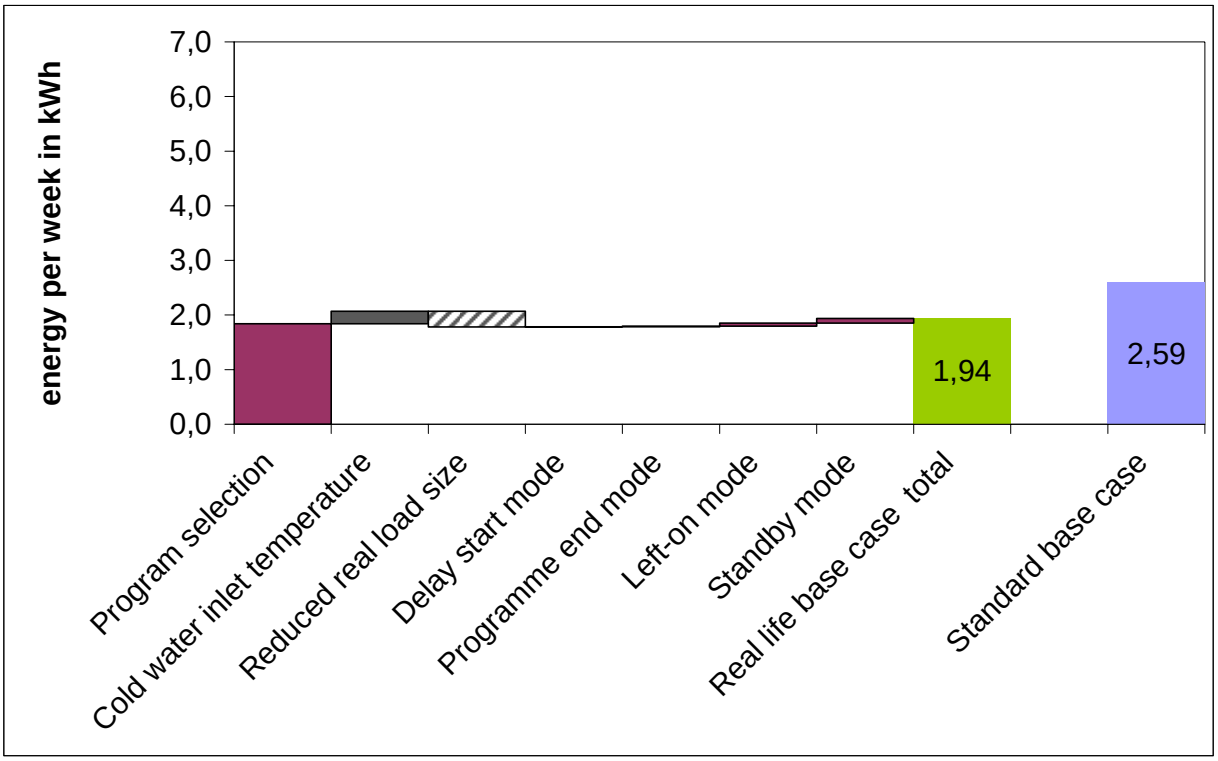


Figure 3.96: real life condition energy consumption per week for an average single-person-household compared to standard conditions for washing machines

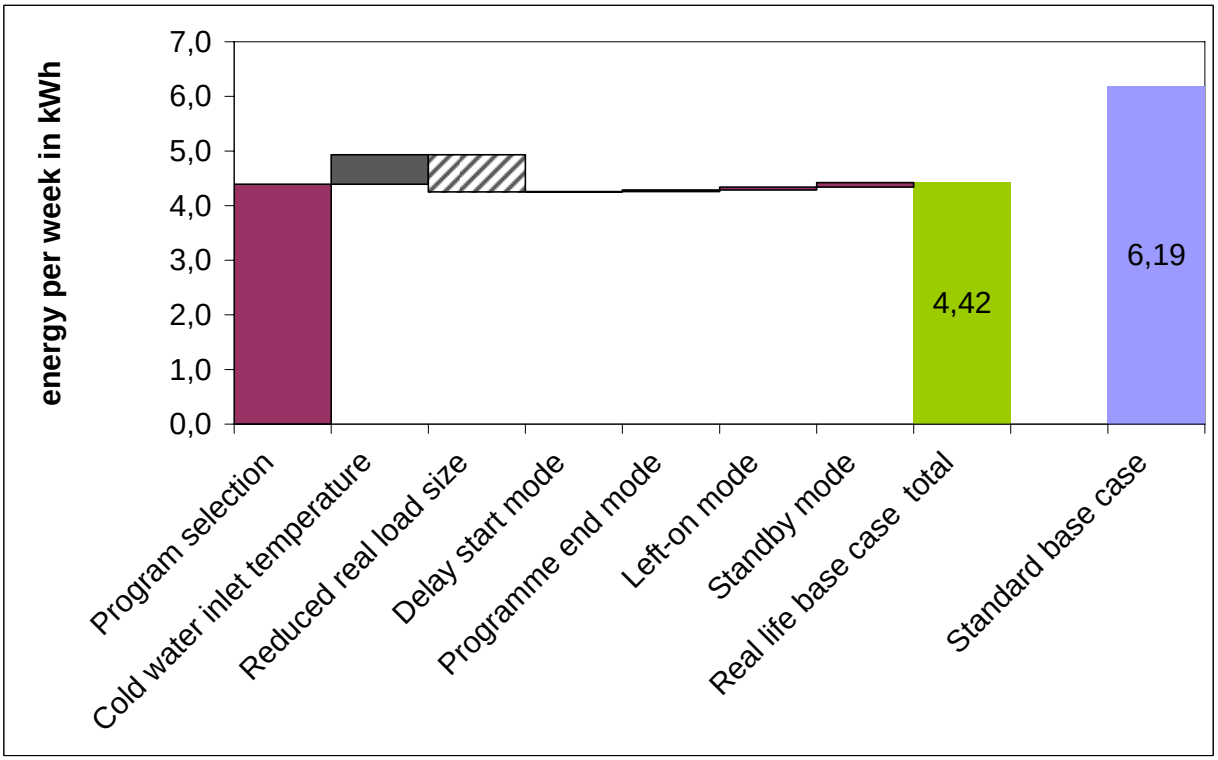


Figure 3.97: real life conditions energy consumption per week for an average 4-person-household compared to standard conditions for washing machines

3.6.2 The dishwashing process

The differences between the real-life and the standard conditions for the dishwashing process are summarised here. It is worth noting that the energy consumption associated with manual dishwashing (which is still the only way to have clean tableware for about half of the EU population) and the energy used for those cleaning processes done in addition to the automatic dishwashing (such as for example for the manual washing pots and pans) is not considered. For sake of completeness of the description, the additional pre-rinsing and cleaning processes done on those items which are then placed into the dishwasher are here evaluated: it is assumed that these processes may be avoided by providing the right information to the consumer and by proper functioning of the dishwasher, but it is not known whether pre-rinsing is due to a poor washing performance or to a consolidated bad habit of consumers.

The consumer investigation has shown an average frequency of use of the dishwasher at 4,06 cycles per household per week for those households owning a dishwasher, and which have also a larger size (in terms of the number of persons per household) than the average household. Using this figure and the energy consumption of the average 2005 dishwasher 12 place setting model (see Task 5) the effect of the conditions not explicitly considered in the European test method are evaluated.

The factors that are not considered among standard conditions, but are relevant for the energy consumption under real life conditions are:

31 % of the households are found to pre-rinse their dishes before placing them into the dishwasher. This causes an additional consumption of water and energy. Based on the result of investigating manual dishwashing it is assumed that 0,1 kWh and 3 litres of water are used per place setting (for 6 place settings per cycle).

In real life the most frequently used programme is the normal/regular programme at an average temperature of 59,3°C which will cause higher energy consumption than in the eco-programme. It is assumed this will add 10 % to the energy consumption compared to the standard condition programmes running at 50 or 55 °C.

in Germany the average annual water inlet temperature may be significantly lower than defined in standard conditions (15°C). As no proven European survey on these temperatures was found, an average water inlet temperature of 10 °C was assumed. Compared to the standard conditions the additional energy to heat up the main wash water volume (assumed to be 15 litre) to 15°C needs to be considered. This assumption – valid for Germany - may be challenged for other countries if their average water inlet temperature is higher than 15°C; should this the case then some less energy to heat up the main wash water volume will be used compared to the standard conditions.

Real load sizes are somewhat small than the maximum capacity used for standard measurements. Since about 1/3 of the energy is used to heat up the load and about 1/3 less of the maximum capacity may be loaded on average, an acceptable assumption may be to allocated a 10 % reduction of the energy consumption under the real life condition due to this factor.

Standby and low power modes:

- investigation has show the delay start function is used in about 10% of the programme cycles for delaying the start by an average of 3 hours. Average power level is found to be at 4,3 W (same as for washing machines)
- after the programme has ended, the dishwasher is not unloaded immediately, but left for an average of 3 hours in 50 of the cases. Power level is reported to be at 3,3 W (same as for washing machines)

- even after unloading some 30 % of the people may not switch off the appliance but leave it in 'ON'-status up to the next programme starts. Power level in this mode is assumed to be the same as at programme end
- the other 7 % are switching their appliance off and are therefore only consuming the power that is associated with this mode. On average this mode is assumed to have a power of 0,6 W (same as for washing machines).

All these factors can be summarised (Table 3.11), to evaluate the total energy used for dishwashing in an average household in one week in comparison with the consumption of the average 2005 dishwasher models under standard conditions for the same number of cycles per week.

Comparing the figures, the total energy used for the real dishwashing cycles is almost identical in real life and under standard conditions (real life: 4,779 kWh – 0,406 kWh = 4,313 kWh) because the energy consumption reduction for under-loading the dishwasher is of the same magnitude than the additional energy associated with the higher washing programme temperature. This substantial equivalence will no be longer valid if the programme used in the test method is further optimised without a contemporary action inducing the consumers to decrease the actual washing programme from their habit of using other washing programmes at higher temperatures.

The overall consumption of the dishwashing cycle under real conditions and standard conditions is similar when the pre-rinsing is not considered: 4,87 kWh per week against 4,34 kWh per week, but this will require a change in a (bad) consumers habit.

Table 3.11: comparison of real-life versus standard conditions energy consumption in kWh for dishwashers

Activity	Effect	Real life conditions	Standard conditions
Manual pre-rinsing	31 % using 0,1 kWh and 3 litres of water per place setting (for 6 place settings per cycle)	0,755	--
Programme selection	Normal/regular programme selected at 59,3°C (10 % higher consumption than under standard conditions assumed)	4,779	4,344
Colder water inlet temperature	10 litre of water heated from 10°C (real life tap water) to 15°C (water inlet under standard conditions)	0,236	--
Real average load size	9 place settings	-0,406	--
Low power modes consumption:			--
delay start	3 h at 4,3 W for 10 %	0,005	
programme end	3 h at 3,3 W for 50 %	0,020	
left-on	the remaining time at 3,3 W for 30 %	0,162	
off-mode (standby)	the remaining time at 0,6 W for 70 %	0,069	
Total consumption per week		5,620	4,344
difference		+1,28 or +29,4	
Total consumption per week without pre-rinsing		4,865	4,344
difference		+0,54 or +12,2 %	

As far as the standby and other low-power modes consumption is concerned (Figure 3.98) only the left-on and the off (standby) modes seem to have some minor influence on the real life energy consumption (in total less than 5%). When data from CECED is used, this influence is reduced to 3 %.

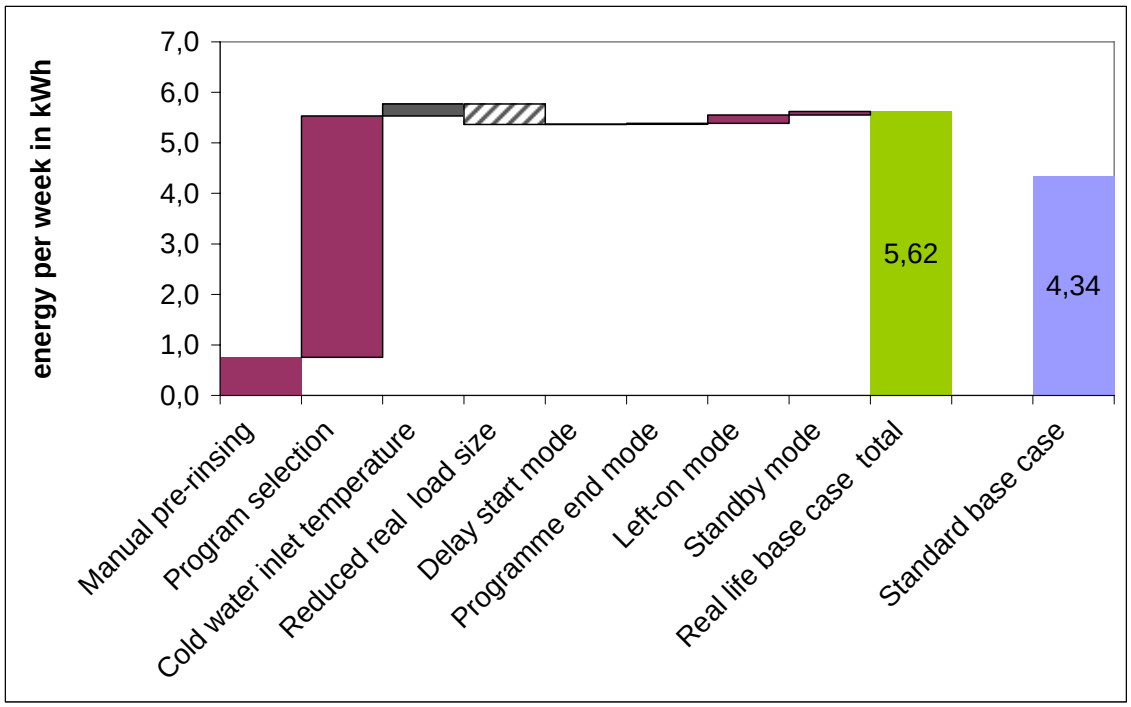


Figure 3.98: graphic representation of factors under real-life and standard conditions for the energy consumption per week of dishwashers

Regarding the water consumption, under standard conditions the total amount is 62 litres per week per household owning an automatic dishwasher. This value is increased by about 23 litres or 37 % when the additional pre-rinsing done by 31 % of the consumers (for the calculation it is assumed this is done on 6 place settings per cycle and it takes 3 litres per place setting). The extra rinse cycles or rinse and hold is used by only 3,2 % of the consumer always and 5,2 % often. Assuming that 5 % of the wash cycles are done with an extra rinse of 5 litres per cycle, this will add a water consumption of 1 litre to the average consumption per household per week. In total under real life conditions water consumption will reach 85 litres per week per household owning a dishwasher (Table 3.12).

Table 3.12: comparison of real-life vs. standard conditions water consumption (in litre) for dishwashers

Activity	Effect	Real-life conditions	Standard conditions
Basis	15,2 litre per wash for 4,06 cycle/week	62	62
Manual pre-rinsing	31 % using 0,1 kWh and 3 litres of water per place setting (for 6 place settings per cycle)	23	--
Extra rinse cycle	5 % at 5 litre	1	--
Total litres per week with pre-rinsing		86	62
difference		+24 or +39 %	
Total litres per week without pre-rinsing		63	62

Another relevant difference between the dishwashing process under standard and real life conditions is the amount of detergent used: the standard calls for 30 g of reference detergent B (see the description of EN 50242 standard in Task 1) for a 12 place setting machine, while in practise some consumers use tablets which have only a weight of about 20 g. Although the chemical ingredients are different, the reduced quantity might have an impact on the total life cycle.

The calculations also exclude water and energy consumption used for additional manual dishwashing, which is done by almost all households.

The comparison of the average consumption under standard and real life conditions results in a higher amount of energy used in real life: per week the energy taken for running an automatic dishwasher is 1,28 kWh or nearly 29 % higher as it is under standard conditions when the manual pre-rinsing is considered, if it is not included in the calculations, the consumption under real life conditions is 12,2 % higher than under standard conditions.

Regarding water consumption the difference is 24 litres or 39 % higher in the real life compared to the standard conditions due to the pre-rinse done before the dishwasher is started. When again this pre-rinse is not considered the water consumption is almost the same.

Additional energy and water are consumed by doing manual dishwashing, but here no difference between standard and real life conditions can be expected.

In trying to assess the sensitivity of the results with the household size, calculations were done also for the average single-person households and for the 4-person households: Since the single household will most likely not have a standard dishwasher (with 60 cm width), the energy and water consumption of the average 2005 9 place setting machine was used. Other input data were adjusted accordingly. Average operation frequency is found to be 2,33 times per week for single-person and 4,86 for 4-person households. Real life energy consumption for running a dishwasher for a single household turns out (Figure 3.99) to be 33 % higher and 29 % higher for a 4 person household (Figure 3.100) when the additional pre-rinse is considered. The contribution of standby and low power modes energy consumption is increasing from 4 % of the total consumption for a 4 person household to 10 % for a single person household.

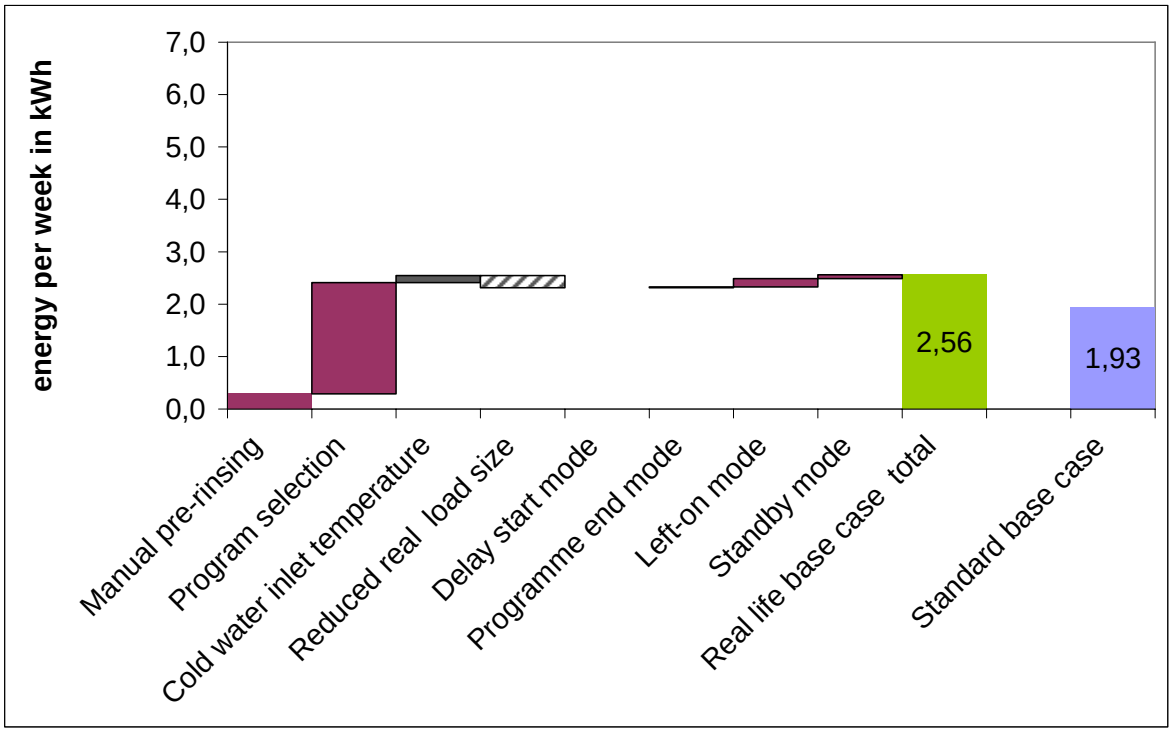


Figure 3.99: real life energy consumption per week for a single person household compared to standard conditions for dishwashers

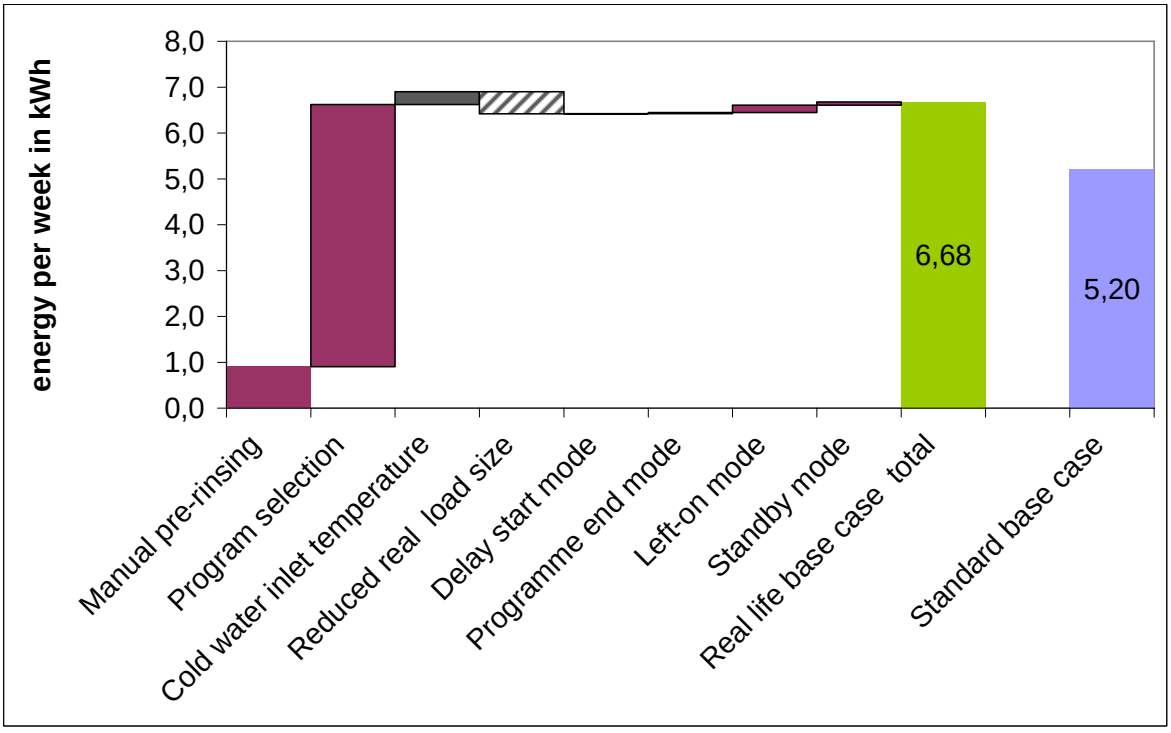


Figure 3.100: real life energy consumption per week for a 4 person household compared to the standard conditions for dishwashers

3.7 SUMMARY

Consumer survey on an almost representative sample of consumers from 10 European countries covering 75 % of the population revealed a very high level of awareness of the consumer towards the environmental aspects of household appliances. This is also reflected when buying decisions are taken and the European energy label is seen as an informational tool almost as important as the own experience and the information available on the Internet.

3.7.1 Washing machines

In European countries washing machines are available in almost 100 % of the households (not necessarily in the own apartment). But since these appliances remain in the household for normally 10 years and more, their energy/water consumption and performance is as it was at the time of the production. Eco-design improvements will therefore take more than 10 years to get fully implemented in the market. This time is even longer when second-hand appliances are used. As the survey has shown, the second-hand models account for only a minor share of the market.

Consumers asked about the relative influence of washing machines on the total energy consumption of a household considered this appliance as the most energy using product. This is associated with a high level of willingness to use energy saving options.

Consumer behaviour has been identified as being the main source of influence on the actual energy consumption and environmental impact on the washing process. In particular:

- the average nominal washing temperature is 45,8 °C and the most frequently used programme is at 40 °C (including all programmes for wool, silk, synthetics, etc),
- nevertheless the cotton 60 °C programme is still the most frequently used programme and consumes more energy than a cotton 40 °C programme,
- the average wash frequency is 4,9 cycles per week,
- most consumers normally use the full loading capacity of their washing machine, but it is agreed that this does not mean that the rated capacity is really used,
- delay start options are only used in approximately 8 % of the cycles with a shift of the washing starting time by an average of 3 hours (no reason could be identified for this delay),
- at programme end the machine may stay in this mode in about 50 % of the cases for an average of 3 hours. Afterwards in about 90 % of the cases the machine is switched off.

This information about the consumer behaviour and recent data on the energy consumption allow to estimate the average energy and water consumption of laundry washing per household per week: for an average household size of 2,9 people using the average 2005 washing machine model under real life conditions the energy consumption is 3,5 kWh and the water consumption 230 litres. This is a 28% lower energy consumption than the same number of cycles calculated for a machine operated under standard conditions. The difference is mainly due to the lower average temperature of the wash programmes as well as by the effect of under-loading the machine.

Nevertheless it should be highlighted that the use of the washing machine at the rated capacity would increase the washing energy efficiency and would reduce the energy consumption under both the real life and the standard conditions if resulting in a lower number of washing cycles per week (or year).

The difference of the water consumption under real life and standard conditions is 9 %.

Standby and other low power modes have been estimated to contribute on average between 4 and 8 % of the real life energy consumption. These figures may be higher if consumers do not switch off the washing machine after unloading; showing again that the individual consumer behaviour has a major influence on the amount of energy and water used in the specific household.

Therefore consumer training and education is a very important element for the further decrease of the energy and water consumption in real life. The second element to be taken into consideration is the definition of measurement methods in the European standards more in line with the consumer real life behaviour.

3.7.2 Dishwashers

Penetration of dishwashers in European households varies with the country. But since these appliances remain in the household for normally 10 years and more, their energy/water consumption and performance is as it was at the time of the production. Eco-design improvements will therefore take more than 10 years to get fully implemented in the market. This time is even longer when second-hand appliances are used. As the survey has shown, the second-hand model accounts for only a minor share of the market.

The manual dishwashing process done in all households, which do not own a dishwasher, causes – on average – a higher consumption of energy and water. But also households owning a dishwasher do manual dishwashing for some part of their tableware and even some of the items then loaded into a dishwasher undergo a pre-cleaning process. This last process of manual dishwashing is closely linked to the automatic dishwashing process but it is not requested by dishwashers manufacturers and could be avoided through a correct information provided to the consumers, It was preliminary considered in the shown calculation as an additional consumption under real life conditions for the dishwashers.

All other consumptions related with manual dishwashing are not considered, but may be higher than those of the automatic dishwashing machine.

Consumers asked about the relative influence of dishwashers on the total energy consumption of a household considered this appliance having a moderate up to great impact.For nearly 15 % of the consumers the high energy and water consumption is an element against the purchasing of a dishwasher. This opinion is more important in those countries where the penetration of the dishwasher is lower. Another negative element (for nearly 23,5 % of the consumers) is the initial purchasing price. In general there is also a high level of willingness in using energy saving options in automatic dishwashing.

Consumer behaviour has been identified as having a high influence on the energy and water consumption of the automatic dishwashing process under real life conditions. It is shown, that

- the average dishwashing temperature is at a nominal temperature of 59,3 °C and the most frequently used programme, followed by eco- and automatic programmes,
- the average automatic dishwashing frequency is at 4,1 cycles per week,
- most consumer are using normally the full loading capacity of their dishwasher, but it is not known if this mean that the rated capacity is used,
- delay start function is only used in approximately 10 % of the cycles with an average shift of 3 hours (it was not identified for what reason this shifting is done),
- at programme end the machine may stay in this mode in about 50 % of the cases for an average of 3 hours. Afterwards in about 70 % of the cases the machine is switched off.

All the information about the consumer behaviour and the recent data on the energy consumption allow estimating the average energy and water consumption per household per week: for an average household size of 2,9 people using the average 2005 dishwasher model under real life conditions, the amount of electricity used for automatic dishwashing is at 5,63 kWh and the amount of water is at 86 litres, when the manual pre-rinsing is included and 4,88 kWh and 63 litres when this non requested but used process is not considered. This is 29,4 % higher in electricity than when calculated under standard conditions, which is reduced to + 12,2 % when the pre-rinsing is not taken into account. Main differences are caused by the high average (nominal) temperature of the programmes used as well as by the additional energy consumption for the manual pre-rinsing of the dishes.

Nevertheless it should be highlighted that the use of the dishwasher at the rated capacity would increase the automatic dishwashing energy efficiency and would reduce the energy consumption under both the real life and the standard conditions if resulting in a lower number of washing cycles per week (or year).

The water consumption under real life is 39 % higher than under standard conditions when the manual pre-rinsing is considered, and almost the same if the latter is not taken into account.

Standby and other low power modes have been estimated to contribute on average between 3 and 10 % of the real life energy consumption. These figures may be higher if consumers do not switch off the dishwasher after unloading; showing again that the individual consumer behaviour has a major influence on the amount of energy and water used in the specific household.

These figures may be higher if consumer do not switch off the gadget after unloading, showing again, that the individual consumer behaviour has a major influence on the amount of energy and water used in the individual case.

Therefore consumer training and education is a very important element for the further decrease of the energy and water consumption in real life. The second element to be taken into consideration is the definition of measurement methods in the European standards more in line with the consumer real life behaviour.

3.8 ANNEX 1

Annex 1- 1: population by household size and age group: comparison results own survey vs. Eurostat data[37]

United Kingdom		Age group			total
		20-39 years	40-59 years	60-74 years	
results own survey	1 person	3,9%	7,1%	4,2%	15,1%
	2 persons	11,6%	12,2%	10,6%	34,4%
	3 persons	11,6%	10,9%	1,6%	24,1%
	4 persons	8,0%	8,7%	1,0%	17,7%
	more than 4 persons	4,8%	3,9%	0,0%	8,7%
	total	*39,9%*	*42,8%*	*17,4%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	4%	5%	5%	*14%*
	2 persons	10%	13%	12%	*36%*
	3 persons	10%	9%	2%	*21%*
	4 persons	10%	8%	1%	*19%*
	more than 4 persons	6%	4%	0%	*11%*
	total	*41%*	*39%*	*20%*	*100%*
		Age group			
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	0,1%	-2,1%	0,8%	-1,1%
	2 persons	-1,6%	0,8%	1,4%	1,6%
	3 persons	-1,6%	-1,9%	0,4%	-3,1%
	4 persons	2,0%	-0,7%	0,0%	1,3%
	more than 4 persons	1,2%	0,1%	0,0%	2,3%
	total	*1,1%*	*-3,8%*	*2,6%*	*0,0%*

France	Age group			total
	20-39 years	40-59 years	60- 74 years	

[37]Own calculation: Population by household size and age group based on EUROSTAT data.

* Own calculations: crosstabs with EUROSTAT data of population by age group and household size

	1 person	5,9%	3,9%	3,9%	13,8%
	2 persons	9,1%	11,0%	11,8%	31,9%
results own survey	3 persons	9,8%	9,8%	2,0%	21,7%
	4 persons	11,0%	7,9%	1,2%	20,1%
	more than 4 persons	7,5%	5,1%	0,0%	12,6%
	total	*43,3%*	*37,8%*	*18,9%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
	1 person	6%	4%	4%	*15%*
	2 persons	9%	11%	12%	*32%*
Eurostat*	3 persons	10%	9%	2%	*22%*
	4 persons	11%	8%	1%	*19%*
	more than 4 persons	7%	5%	0%	*12%*
	total	*42%*	*38%*	*20%*	*100%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
	1 person	0,1%	0,1%	0,1%	1,2%
	2 persons	-0,1%	0,0%	0,2%	0,1%
Differences	3 persons	0,2%	-0,8%	0,0%	0,3%
	4 persons	0,0%	0,1%	-0,2%	-1,1%
	more than 4 persons	-0,5%	-0,1%	0,0%	-0,6%
	total	*-1,3%*	*0,2%*	*1,1%*	*0,0%*

Czech Republic		Age group			total
		20-39 years	40-59 years	60- 74 years	
	1 person	4,0%	5,3%	4,0%	13,4%
	2 persons	6,1%	10,9%	9,3%	26,3%
results own survey	3 persons	12,1%	11,3%	2,0%	25,5%
	4 persons	15,0%	10,1%	1,2%	26,3%
	more than 4 persons	5,3%	3,2%	0,0%	8,5%
	total	*42,5%*	*40,9%*	*16,6%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	5%	5%	5%	*14%*
	2 persons	6%	11%	10%	*27%*
	3 persons	12%	11%	2%	*25%*

	4 persons	15%	10%	1%	*25%*
	more than 4 persons	5%	3%	0%	*9%*
	total	*42%*	*40%*	*18%*	*100%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	1,0%	-0,3%	1,0%	0,6%
	2 persons	-0,1%	0,1%	0,7%	0,7%
	3 persons	-0,1%	-0,3%	0,0%	-0,5%
	4 persons	0,0%	-0,1%	-0,2%	-1,3%
	more than 4 persons	-0,3%	-0,2%	0,0%	0,5%
	total	*-0,5%*	*-0,9%*	*1,4%*	*0,0%*

Germany		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	6,3%	6,0%	4,8%	17,2%
	2 persons	11,8%	14,8%	12,7%	39,3%
	3 persons	10,3%	9,4%	1,8%	21,5%
	4 persons	9,4%	6,0%	0,0%	15,4%
	more than 4 persons	3,9%	2,7%	0,0%	6,6%
	total	*41,7%*	*39,0%*	*19,3%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	7%	5%	5%	*18%*
	2 persons	8%	14%	16%	*38%*
	3 persons	9%	9%	2%	*21%*
	4 persons	9%	7%	0%	*17%*
	more than 4 persons	4%	3%	0%	*7%*
	total	*38%*	*38%*	*24%*	*100%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	0,7%	-1,0%	0,2%	0,8%
	2 persons	-3,8%	-0,8%	3,3%	-1,3%
	3 persons	-1,3%	-0,4%	0,2%	-0,5%
	4 persons	-0,4%	1,0%	0,0%	1,6%
	more than 4 persons	0,1%	0,3%	0,0%	0,4%
	total	*-3,7%*	*-1,0%*	*4,7%*	*0,0%*

Spain		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	3,1%	2,0%	3,1%	8,2%
	2 persons	6,3%	5,5%	7,8%	19,5%
	3 persons	10,9%	7,8%	5,1%	23,8%
	4 persons	13,7%	11,7%	2,0%	27,3%
	more than 4 persons	11,7%	7,8%	1,6%	21,1%
	total	*45,7%*	*34,8%*	*19,5%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	3%	2%	3%	*7%*
	2 persons	7%	5%	8%	*20%*
	3 persons	11%	8%	5%	*24%*
	4 persons	14%	12%	2%	*28%*
	more than 4 persons	11%	8%	2%	*21%*
	total	*45%*	*35%*	*20%*	*100%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	-0,1%	0,0%	-0,1%	-1,2%
	2 persons	0,8%	-0,5%	0,2%	0,5%
	3 persons	0,1%	0,2%	-0,1%	0,2%
	4 persons	0,3%	0,3%	0,0%	0,7%
	more than 4 persons	-0,7%	0,2%	0,4%	-0,1%
	total	*-0,7%*	*0,2%*	*0,5%*	*0,0%*

Finland		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	7,6%	7,2%	5,2%	19,9%
	2 persons	10,0%	13,9%	12,4%	36,3%
	3 persons	7,6%	9,6%	1,6%	18,7%
	4 persons	8,4%	7,6%	0,0%	15,9%
	more than 4 persons	5,2%	4,0%	0,0%	9,2%
	total	*38,6%*	*42,2%*	*19,1%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74	

				years	
Eurostat*	1 person	7%	7%	5%	*20%*
	2 persons	10%	14%	11%	*35%*
	3 persons	8%	9%	2%	*19%*
	4 persons	8%	7%	0%	*16%*
	more than 4 persons	5%	4%	0%	*10%*
	total	*38%*	*43%*	*19%*	*100%*

		Age group			total
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	-0,6%	-0,2%	-0,2%	0,1%
	2 persons	0,0%	0,1%	-1,4%	-1,3%
	3 persons	0,4%	-0,6%	0,4%	0,3%
	4 persons	-0,4%	-0,6%	0,0%	0,1%
	more than 4 persons	-0,2%	0,0%	0,0%	0,8%
	total	*-0,6%*	*0,8%*	*-0,1%*	*0,0%*

Hungary		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	1,9%	3,9%	5,1%	10,9%
	2 persons	6,2%	10,9%	9,7%	26,8%
	3 persons	11,7%	10,9%	3,1%	25,7%
	4 persons	11,7%	9,3%	1,6%	22,6%
	more than 4 persons	7,8%	5,1%	1,2%	14,0%
	total	*39,3%*	*40,1%*	*20,6%*	*100,0%*

		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	2%	4%	5%	*11%*
	2 persons	6%	11%	10%	*27%*
	3 persons	11%	11%	3%	*25%*
	4 persons	12%	9%	1%	*23%*
	more than 4 persons	8%	5%	1%	*15%*
	total	*40%*	*40%*	*20%*	*100%*

		Age group			**total**
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	0,1%	0,1%	-0,1%	**0,1%**
	2 persons	-0,2%	0,1%	0,3%	**0,2%**

	3 persons	-0,7%	0,1%	-0,1%	**-0,7%**
	4 persons	0,3%	-0,3%	-0,6%	**0,4%**
	more than 4 persons	0,2%	-0,1%	-0,2%	**1,0%**
	total	***0,7%***	***-0,1%***	***-0,6%***	***0,0%***

Italy		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	4,2%	4,5%	3,2%	12,0%
	2 persons	8,4%	5,8%	7,5%	21,8%
	3 persons	12,0%	10,4%	4,2%	26,6%
	4 persons	14,9%	11,4%	1,6%	27,9%
	more than 4 persons	6,5%	4,5%	0,6%	11,7%
	total	*46,1%*	*36,7%*	*17,2%*	*100,0%*
Eurostat*	1 person	3%	3%	4%	*9%*
	2 persons	7%	6%	10%	*23%*
	3 persons	12%	10%	5%	*27%*
	4 persons	13%	12%	2%	*27%*
	more than 4 persons	6%	5%	1%	*13%*
	total	*41%*	*36%*	*23%*	*100%*
		Age group			**total**
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	-1,2%	-1,5%	0,8%	**-3,0%**
	2 persons	-1,4%	0,2%	2,5%	**1,2%**
	3 persons	0,0%	-0,4%	0,8%	**0,4%**
	4 persons	-1,9%	0,6%	0,4%	**-0,9%**
	more than 4 persons	-0,5%	0,5%	0,4%	**1,3%**
	total	***-5,1%***	***-0,7%***	***5,8%***	***0,0%***

Poland		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	3,2%	4,0%	3,6%	10,7%
	2 persons	4,0%	8,3%	7,9%	20,2%
	3 persons	9,9%	10,3%	3,2%	23,4%

	4 persons	11,9%	9,9%	1,2%	23,0%
	more than 4 persons	11,9%	9,1%	1,6%	22,6%
	total	*40,9%*	*41,7%*	*17,5%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	3%	4%	4%	*10%*
	2 persons	4%	8%	8%	*20%*
	3 persons	10%	10%	3%	*23%*
	4 persons	12%	10%	1%	*23%*
	more than 4 persons	12%	9%	2%	*23%*
	total	*42%*	*41%*	*18%*	*100%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	-0,2%	0,0%	0,4%	**-0,7%**
	2 persons	0,0%	-0,3%	0,1%	**-0,2%**
	3 persons	0,1%	-0,3%	-0,2%	**-0,4%**
	4 persons	0,1%	0,1%	-0,2%	**0,0%**
	more than 4 persons	0,1%	-0,1%	0,4%	**0,4%**
	total	***1,1%***	***-0,7%***	***0,5%***	***0,0%***

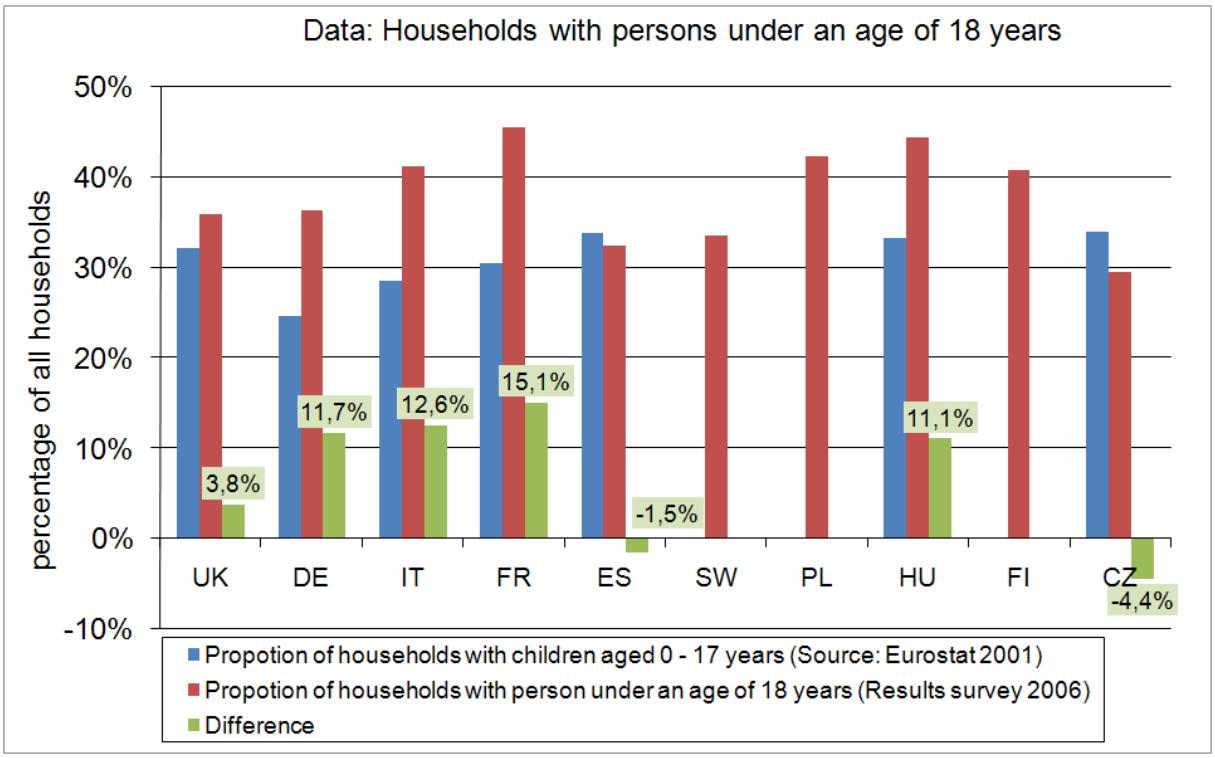
Sweden		Age group			total
		20-39 years	40-59 years	60- 74 years	
results own survey	1 person	12,5%	8,6%	5,9%	27,0%
	2 persons	7,8%	12,1%	15,2%	35,2%
	3 persons	7,0%	7,0%	1,2%	15,2%
	4 persons	7,4%	7,8%	0,0%	15,2%
	more than 4 persons	3,5%	3,9%	0,0%	7,4%
	total	*38,3%*	*39,5%*	*22,3%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60- 74 years	
Eurostat*	1 person	12%	9%	6%	*27%*
	2 persons	8%	12%	15%	*35%*
	3 persons	7%	7%	1%	*15%*
	4 persons	8%	8%	0%	*16%*
	more than 4 persons	3%	4%	0%	*7%*
	total	*38%*	*40%*	*23%*	*100%*

		Age group			total
		20-39 years	40-59 years	60- 74 years	
Differences	1 person	-0,5%	0,4%	0,1%	**0,0%**
	2 persons	0,2%	-0,1%	-0,2%	**-0,2%**
	3 persons	0,0%	0,0%	-0,2%	**-0,2%**
	4 persons	0,6%	0,2%	0,0%	**0,8%**
	more than 4 persons	-0,5%	0,1%	0,0%	**-0,4%**
	total	***-0,3%***	***0,5%***	***0,7%***	***0,0%***

Annex 1- 2: population by household size (results of this survey vs. Eurostat data)

	People per household	**CZ**	**DE**	**ES**	**FR**	**IT**	**HU**	**PL**	**FI**	**UK**	**SW**
Source: EUROSTAT (2005)[38]	1 person	30,3%	35,8%	20,3%	31,0%	24,9%	26,2%	24,8%	37,3%	30,2%	no data
	2 persons	28,2%	33,8%	25,2%	31,1%	27,1%	28,8%	23,2%	31,5%	33,9%	
	3 persons	18,9%	14,5%	21,2%	16,2%	21,6%	19,7%	19,9%	13,6%	15,5%	
	4 persons	17,5%	11,5%	21,5%	13,8%	19,0%	16,5%	18,0%	11,1%	13,4%	
	> 4 persons	5,2%	4,4%	11,8%	7,9%	7,5%	8,7%	14,1%	6,5%	7,0%	
		CZ	**DE**	**ES**	**FR**	**IT**	**HU**	**PL**	**FI**	**UK**	**SW**
Results survey	1 person	13,4%	16,0%	8,4%	13,2%	12,4%	11,2%	10,8%	20,0%	16,0%	26,8%
	2 persons	26,3%	40,4%	19,6%	32,4%	20,0%	26,8%	22,0%	36,4%	32,8%	35,6%
	3 persons	25,5%	22,0%	23,6%	21,6%	26,4%	26,4%	26,4%	18,4%	24,0%	15,2%
	4 persons	26,3%	14,8%	27,6%	20,4%	29,2%	22,4%	21,2%	16,0%	18,0%	15,2%
	> 4 persons	8,5%	6,8%	20,8%	12,4%	12,0%	13,2%	19,6%	9,2%	9,2%	7,2%
		CZ	**DE**	**ES**	**FR**	**IT**	**HU**	**PL**	**FI**	**UK**	
Differences	1 person	-17%	-20%	-12%	-18%	-12%	-15%	-14%	-17%	-14%	
	2 persons	-2%	7%	-6%	1%	-7%	-2%	-1%	5%	-1%	
	3 persons	7%	7%	2%	5%	5%	7%	6%	5%	8%	
	4 persons	9%	3%	6%	7%	10%	6%	3%	5%	5%	
	> 4 persons	3%	2%	9%	4%	5%	4%	6%	3%	2%	

[38] http://epp.eurostat.ec.europa.eu/extraction/retrieve/en/theme3/cens/cens_nheco?OutputDir=EJOutputDir_1244&user=unknown&clientsessionid=2D0572A025FB02509B4413EF05D8A0DC.extraction-worker-1&OutputFile=cens_nheco.htm&OutputMode=U&NumberOfCells=72&Language=en&OutputMime=text%2Fhtml&



Annex 1-3: population: households with persons under an age of 18 years (results of this survey vs. Eurostat data, for Sweden, Finland, Poland no data available)