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Consumer acceptance of smart appliances

D 5.5 of WP 5 report from Smart-A project

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(Smart-A)”**

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1 Introduction

The Smart-A project

The project „Smart Domestic Appliances in Sustainable Energy Systems (Smart-A)” aims at developing strategies how smart domestic appliances can contribute to load management in future energy systems. In order to do this, the project assesses the options for load-shifting by a variety of appliances across Europe and compares these with the requirements from energy systems both on the supra-regional and the local level. It is expected that these systems will have to integrate larger shares of renewable energy in the future, which are partly intermittent, and therefore will require a smarter management of generation, network capacities and demand.

The technical aspects of the assessment include an analysis of potential changes to appliances operation, of characteristics of local energy generation (from renewable energies and also cogeneration) and of load management requirements in the larger electricity networks. The project also features a detailed assessment of the acceptance of smart appliances operation by users, and an evaluation of the usability of available control technologies and communication standards. The overall potential of smart appliances is assessed based on a model which takes into account the variations of appliance use and the framework conditions in energy systems.

The project is conducted in cooperation with manufacturers of appliances and electric utilities. The findings from the analysis are being tested with experts in regional case studies in selected European countries.

This report

This report provides a summary of the results of the consumer research with its main findings. It gives an assessment of the acceptance level of consumers with regard to smart appliances. Based on the findings of the quantitative and qualitative research strategies are outlined how to increase the consumer acceptance.

2 Methodology

The acceptance of consumers concerning the new options offered by smart appliances is a key success factor for the introduction of this new technology on the market. Quantitative and qualitative consumer research using interviews, questionnaires and focus groups was conducted in five European countries, namely Austria, Germany, Italy, Slovenia and UK. The aim was to reveal to which extent consumers will agree to load-shifting, including e.g. delay the start of washing cycles or intermediate interruptions of the operation of appliances. Research questions focused on the readiness and flexibility of consumers to change their behaviour and the benefits they expect in order to accept the use of smart appliances.

The consumer research consisted of four sequential steps:

1. Analysis of existing studies and interviews with experts in the area

An analysis of existing European studies and reports on consumer research with regard to smart appliances, smart metering and variable electricity tariffs served as a basis to form preliminary hypotheses for the consumer survey. In addition to the literature review interviews with experts in the white goods industry as well as experts in consumer-related businesses provided further input to the topic. As consumer research is mostly performed for industry purposes, and therefore results including generic data are usually not publicly available, the interviews served the purpose to gain knowledge about unpublished surveys. Of main interest was also to gather the perception of various experts coming from different fields of the business concerning the consumer and to further shed light on the consumer's behaviour versus his attitude, how to motivate consumers and what strategies are supposed to be successful to implement smart appliances. All together 16 experts from Austria, Belgium, Germany, Italy, Spain, Netherlands and United Kingdom have been interviewed.

Detailed information on the results is available in the Smart-A report *D 5.1: Working paper on general consumer preferences and restrictions*.

2. Survey with questionnaires

The aim of the survey was to get information regarding the perception of smart appliances as well as to estimate whether people are willing to change their habitual behaviour or to accept higher costs of smart appliances.

The survey was performed in the countries: Austria, Germany, Italy, Slovenia and United Kingdom.

In the United Kingdom the interviews were done with an online-questionnaire, 232 questionnaires were filled in. In Slovenia and Italy face-to-face-interviews were performed, 200 interviews were obtained for each country. In Germany and Austria the questionnaires were distributed to client databases of two energy suppliers. In Germany

1332 questionnaires and in Austria 943 questionnaires were returned. All together 2907 answers were included in the analysis.

The results are summarized in the Smart-A report *D 5.2 Consumer survey on smart appliances – Evaluation report of the results of the survey*.

3. Phone interviews with consumers

The phone interviews were based on the precedent survey with questionnaires and had the aim to collect additional qualitative data to get a deeper insight into the attitudes and opinions of consumers. Additionally, they made it possible to compare the survey data with the opinions told on the phone. This approach allowed a better understanding and assessment of the survey results.

Phone interviews have been done in the countries Austria, Germany and United Kingdom. All together 30 interviews have been performed. The duration of the interviews was between 15 to 20 minutes.

A summary of the results is provided in the Smart-A report *D 5.3 Consumer acceptance of smart appliances – Summary report of the results of the phone interviews*.

4. Focus groups

Finally focus groups were performed to enable a thorough discussion of consumer attitudes towards smart appliances. As smart appliances are in the design phase participants of the focus groups cannot draw on their own experiences with such devices. So attention was paid to introduce the concept well illustrated. To be able to discuss all relevant questions it was decided to do serial focus groups (2 subsequent focus groups), to have enough time to introduce the concept and to enable participants to reconsider the discussion between the focus groups.

The design of the focus groups was based on the precedent survey with questionnaires and phone interviews. Aim of the focus groups was to question the obtained results and to gain additional information on existing attitudes of consumers. Main questions were whether consumers would adopt smart appliances and which scenarios have to be met in order to accept them.

Focus groups were performed in Austria (2 focus groups), Germany (2 focus groups), Slovenia (3 focus groups) and United Kingdom (3 focus groups). In Slovenia and United Kingdom the third focus group consisted of participants who can be qualified as so-called “early adopters”¹. These are consumers who are very interested in technological innovation and buy the “state-of-the-art” products.

¹ Rogers, Everett (2003): *The Fusion of Innovations*, 5th ed. New York, NY:Free Press

The findings of the focus groups are available in the Smart-A report *D 5.4 Consumer acceptance of smart appliances – Summary report of the results of focus groups*.

2.1 Sample characteristics

Table 2-1-1: Sample size

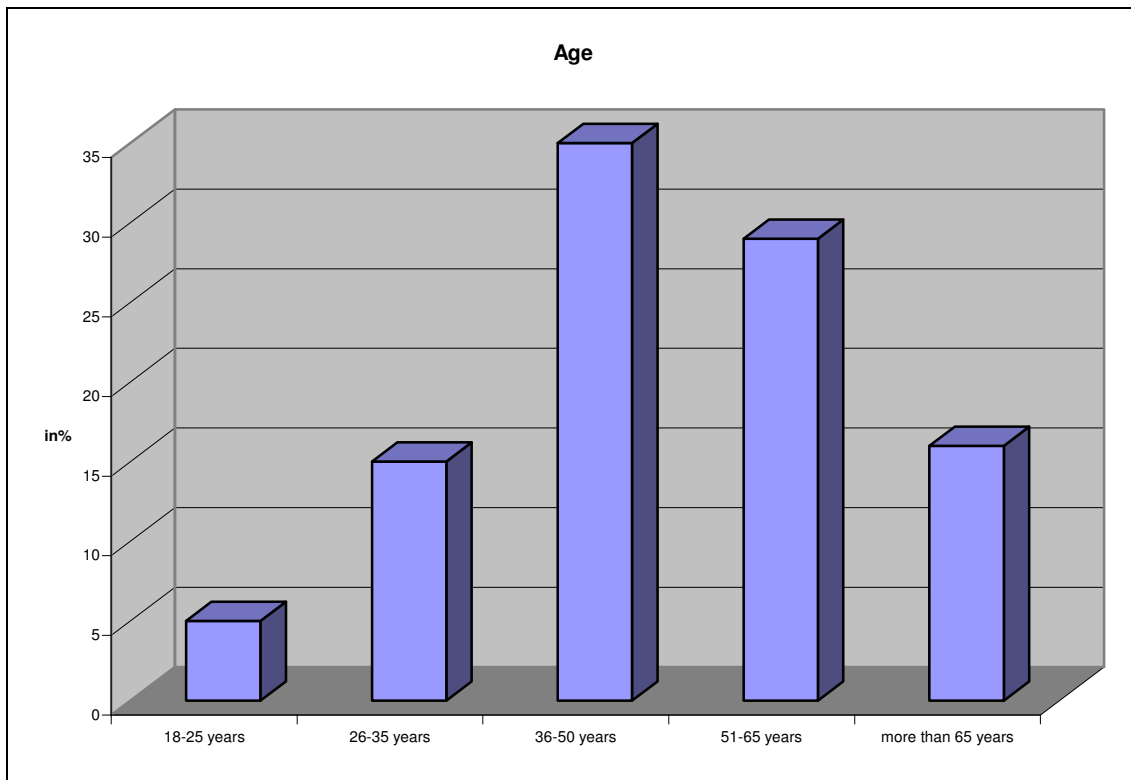
	Austria	Germany	Italy	Slovenia	United Kingdom
Survey	943	1332	200	200	232
Phone interviews	10	10	-	-	10
Focus groups	2	2	-	3	3

The sample size for the survey differs between the respective countries, due to the different modes of distribution, as explained above.

Also the gender-distribution differs in the five countries: In United Kingdom and Slovenia 70% of the respondents are female, whereas in Germany 83% of the respondents are male. In Austria and Italy the gender ratio is almost half male, half female. Summing up the respondents of all countries are 62% male and 38% female.

Considering all countries the majority of the respondents is middle-aged, between 36-50 years, followed by people between 51-65 years as the second largest group. Age distribution is varying between countries, though. In Austria and Germany the majority is middle-aged and only a small percentage is younger than 25 years. In Slovenia and Italy the majority of respondents is younger, between 18-25 years in Slovenia, respectively 26-35 years in Italy. In the UK, too, the peak is shifted to younger people between 26 and 35 years old.

Figure 2-1-1 Age (all countries)



Most of the respondents (60%) are employed (see figure 2-1-2). In Great Britain virtually all respondents are employed, in Slovenia about a third (there are more students in this sample). In Italy, in Germany and Austria, about half of the respondents are employed.

More than half of the respondents (53%) work or have worked in a technical field. This percentage is lower in Slovenia (29%) and Austria and Italy (about a third).

Almost 40% of all respondents have academic degrees, 25% compulsory school, 20% apprenticeship, about 10% have A-Level or other post 18 qualification (see figure 2-1-3). Regarding income the majority (30%) earns between 2000-3000 Euro. About a quarter between 1000 and 2000 Euro, 22% of the households have a monthly net income between 3000 and 4000 Euro, 10% earn between 4000 and 5000 Euro, 7% earn more than 5000 Euro or less than 1000 Euro (see figure 2-1-4). The income level is higher in Great Britain and Germany, it's lower in Slovenia and Austria and Italy.

Figure 2-1-2 Employment status

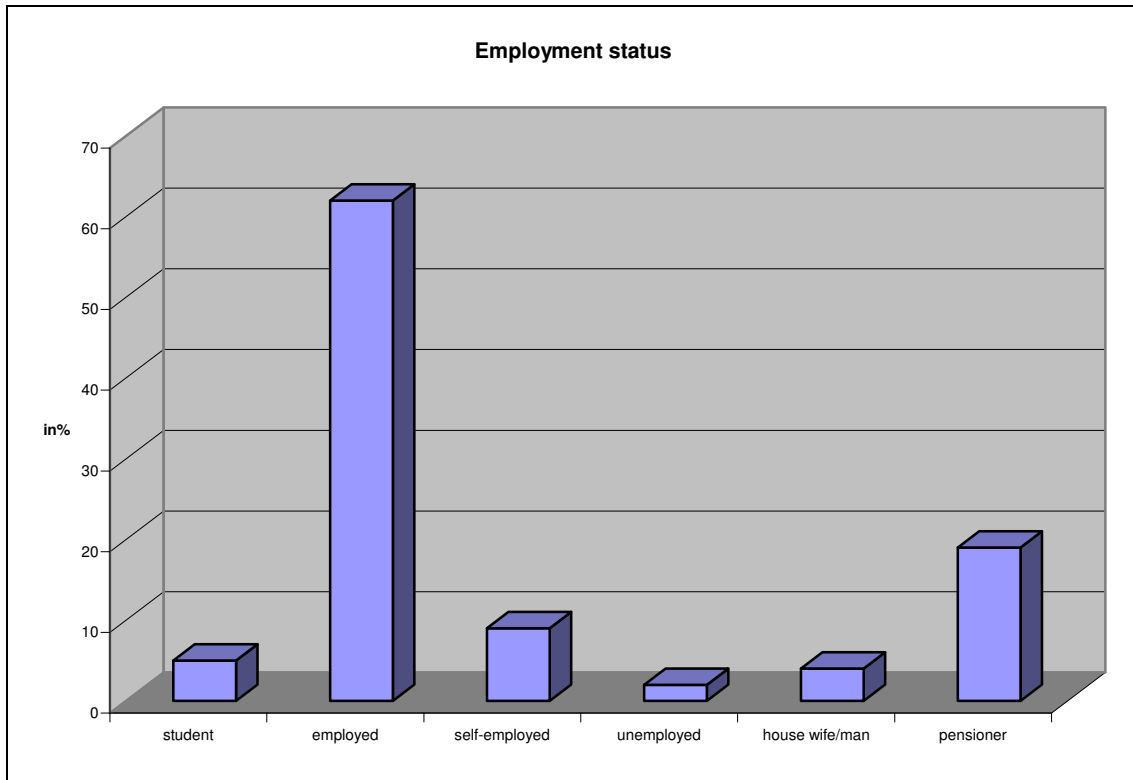


Figure 2-1-3 Highest education level

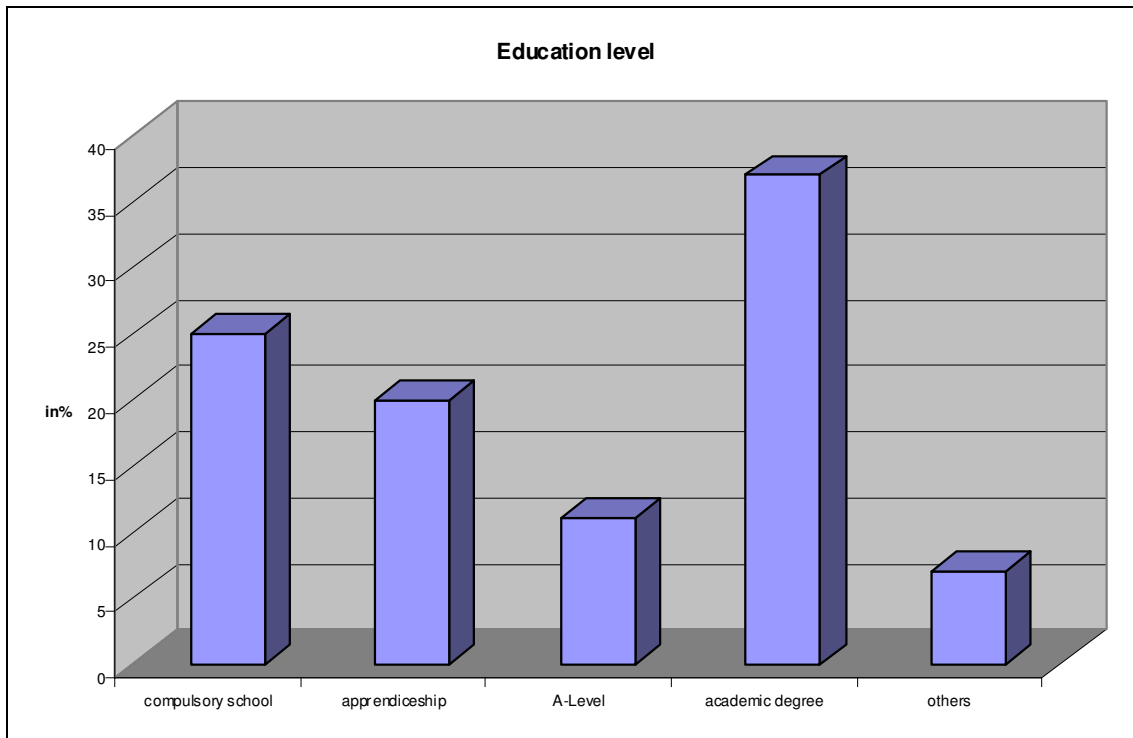
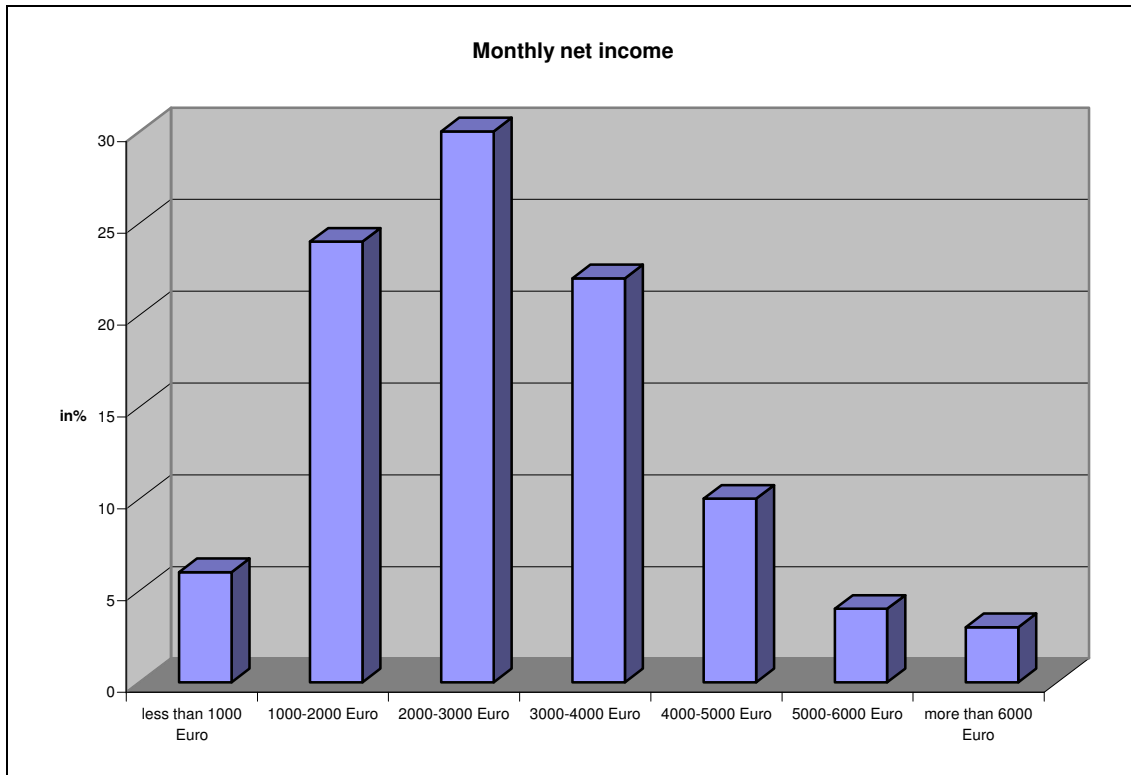


Figure 2-1-4 Monthly net income



Regarding the living situation about one quarter of the respondents are living in a small town in a rural area or in a village in a rural area or in a larger city (more than 100 000 inhabitants). 15% live in a smaller city (more than 100 000 habitants) and 6% in a small town in a municipal area (less than 10 000 habitants) (see figure 5).

67% of all respondents live in a house, 30% are living in a flat. About 27% of the respondents live in houses with solar collectors or photovoltaic panels. Among those, most of them are in Italy, less in UK and Slovenia and about 20 to 30% in Germany and Austria.

35% live in two-persons households, followed by 20% with three or four persons and 12% with more than four persons. 12% are single households. A high percentage of households (60%) have no children, this is more or less the same in all countries (in Slovenia only about 40%). Overall 18% of the households have two children, 15% one child.

Figure 2-1-5 Living area

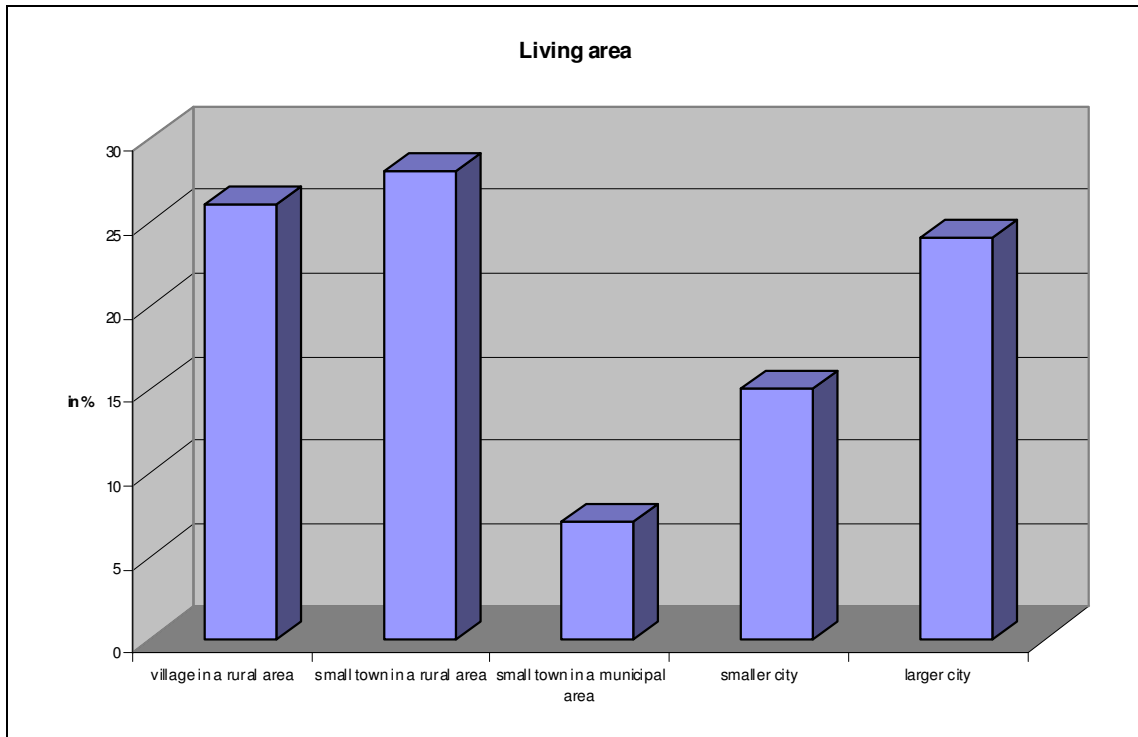


Figure 2-1-6 Number of people living in the household

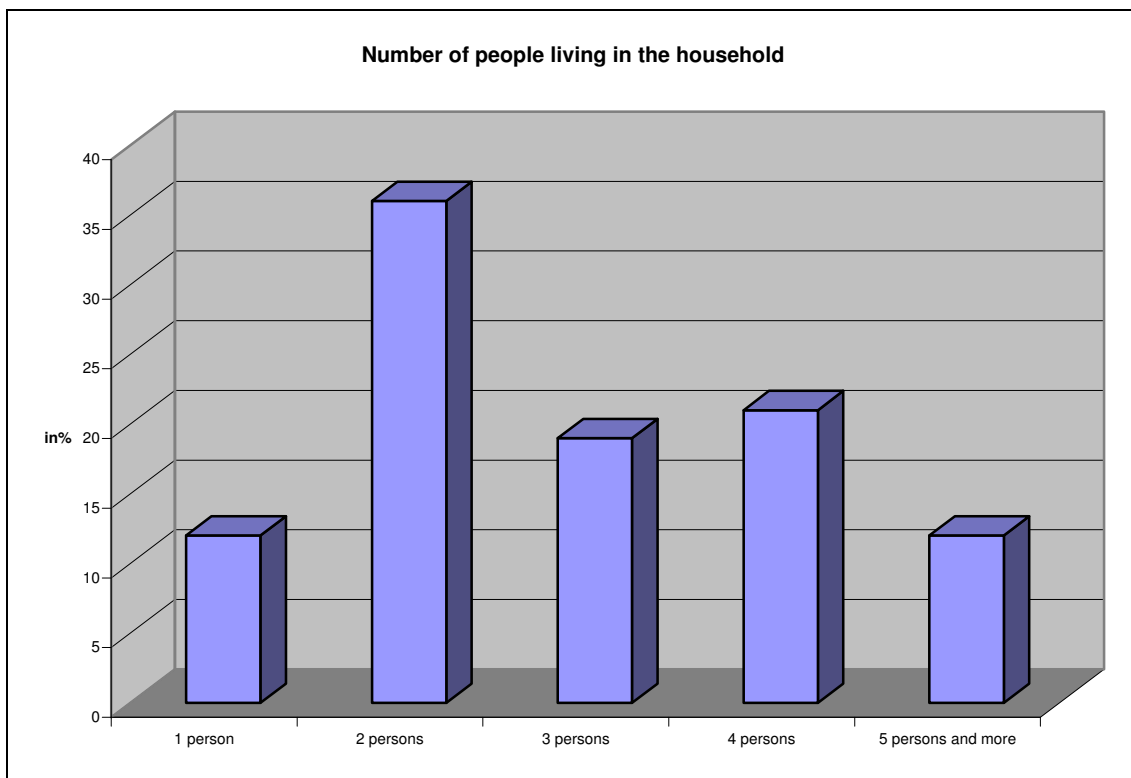
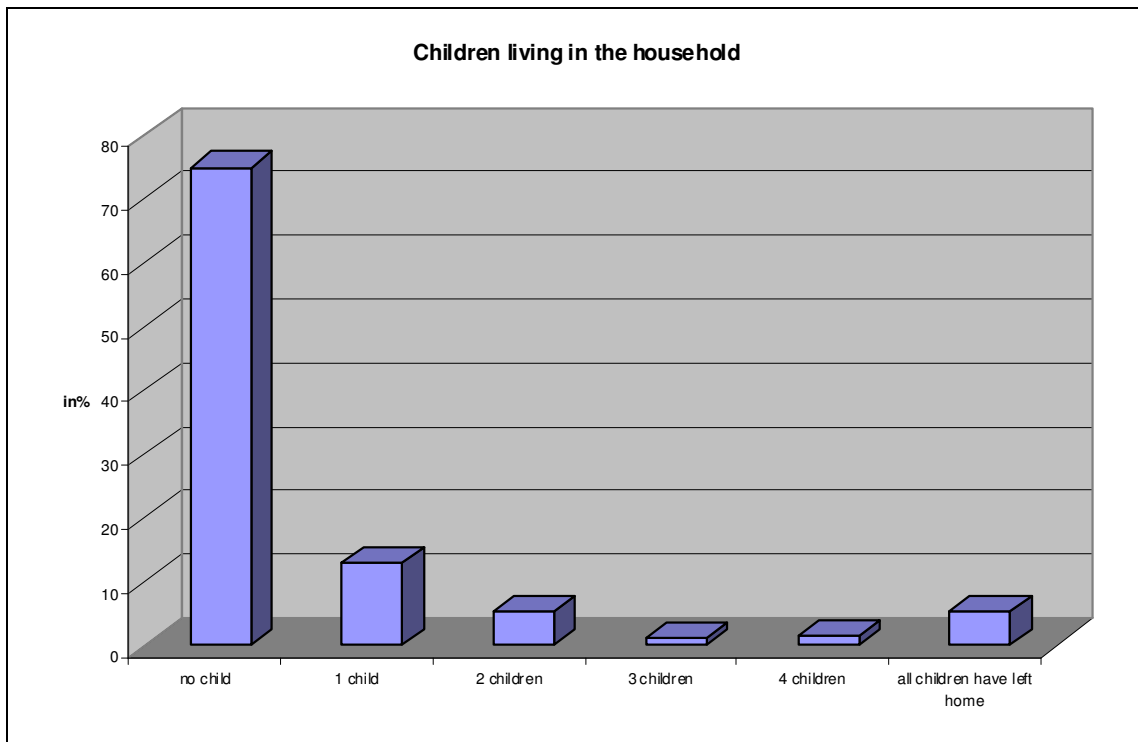


Figure 2-1-7 Number of children living in the household



Regarding the ecological awareness and corresponding activities of the respondents, almost half of the respondents claim that they know their electricity bill without looking it up. Only 9% purchase green energy for their households. Regarding ecological behaviour a high percentage claims to use energy saving bulbs (71%), let dishes cool down, before putting them in the refrigerator (94%), being aware of energy labels (86%), operate washing machine or dish washer only when they are full (93%), turn heat down when leaving home for a longer period (87%) and almost 50% of all respondents often use public transport, bicycle or walking for daily routines. Of course this positive picture is on the one hand due to social acceptability, on the other hand people who are interested and aware of energy efficiency topics are more likely to participate in such a study.

The project team assumed that there might be a correlation between energy saving behaviour and acceptance of smart appliances.

For the assessment an index was created ranking from faint energy saving behaviour to average energy saving behaviour to very energy conscious behaviour. Also for the acceptance of smart appliances an index was formed: very low acceptance, low acceptance, high acceptance, very high acceptance.

If we take all countries together, there is a slight influence of energy saving behaviour on the acceptance of smart appliances – the higher the energy saving behaviour the higher the acceptance. This is especially true for the acceptance of specific appliances like washing machine, dishwasher or tumble dryer. Whether people purchase green en-

ergy or whether they possess solar- or photovoltaic-panels has no influence on the acceptance of smart appliances for all countries.

If we check the particular countries we can see a distinct tendency in Slovenia (higher energy saving behaviour – higher acceptance), in Great Britain it seems to be the other way round (lower energy saving behaviour – higher acceptance), in Germany this is also true for specific advices but not for all, in Austria there is a slight trend and in Italy a clearer trend to more acceptance if energy saving behaviour is higher.

Figure 2-2-8 Knowledge about energy bill without looking it up

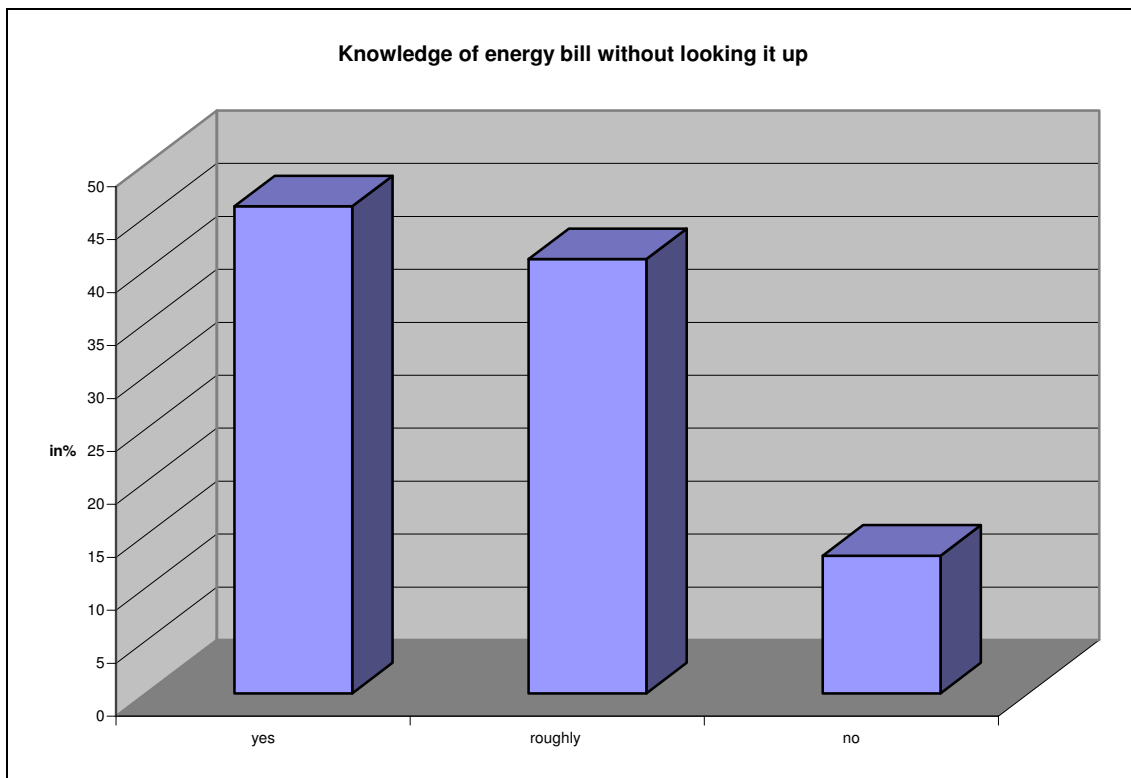


Figure 2-1-9 Purchase of green energy

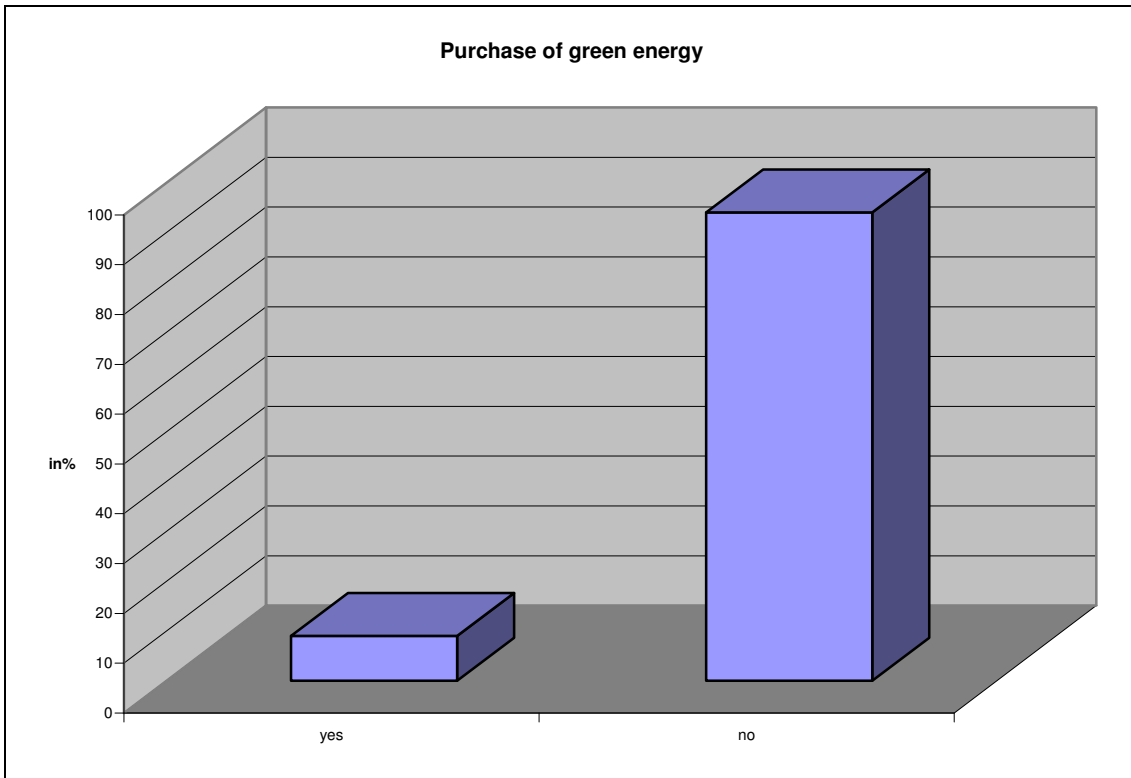
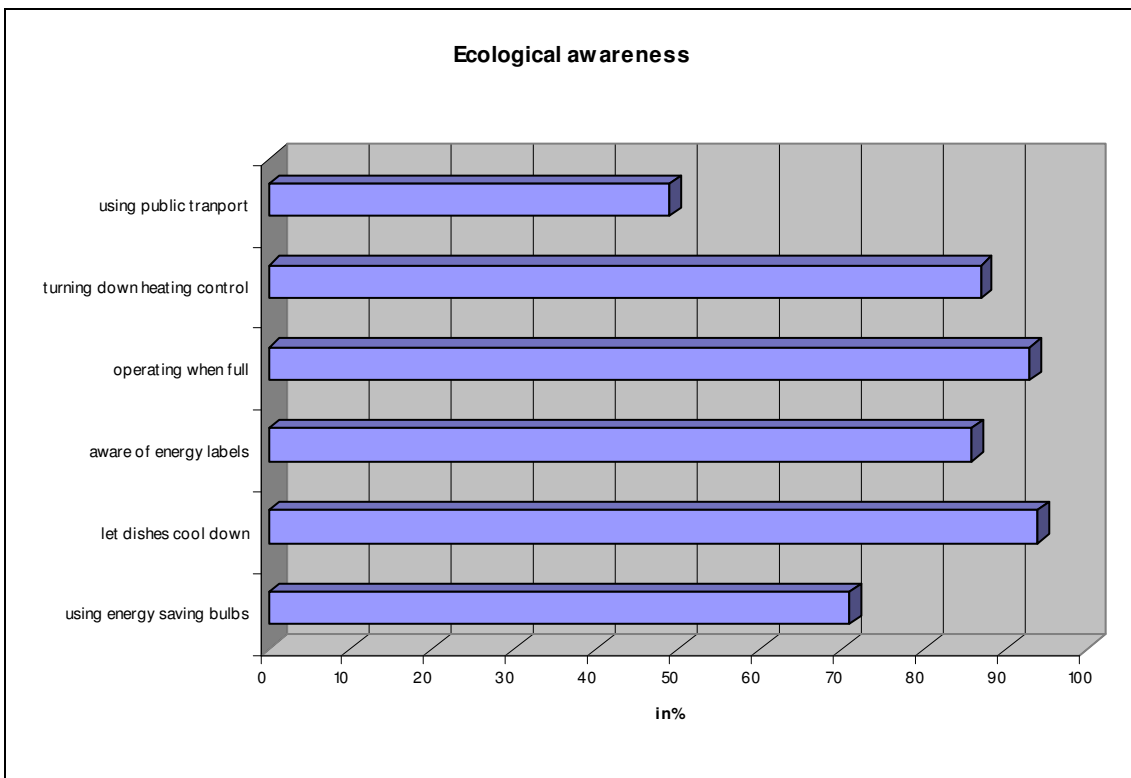


Figure 2-1-10 Components of Ecological awareness



For the interviews and the focus groups the participants were selected according to pre-defined criteria. For the phone interviews the aim was to select participants who have a very high or low acceptance level regarding smart appliances. This was not possible in all cases as there were only few extreme tendencies detectable. Further criteria for both the selection of participants for the phone interviews and focus groups were:

- Gender: 50% male, 50% female
- Age: Range of different ages
- Occupation: at least two persons should be housewife/house husband
- Income: Persons with middle and higher income
- Living area: the group should consist of persons from urban and rural areas
- Children: Half of the participants should have children

For the focus groups additionally the following aspects were considered:

- Experience with household appliances: all participants should use household appliances regularly
- Technical know-how/interest: half of the participants should either be working in a technical area or show a high interest in technologies
- Environmental attitudes: half of the participants should have strong environmental attitudes and/or engage in environmental behaviour
- Early adopter: At least one participant should be an early adopter

Despite the differences in the energy supply systems between Italy, UK and the other countries, albeit cultural distinctions in electricity use in general and in the attitude towards purchasing the major domestic appliances can be assumed, no major differences in the opinions of the different consumers could be found in the qualitative research.

This is consistent on the one hand with the experts opinions who stated that cultural differences rather decrease in quantity and quality because of economy homogenisation and life style homogenisation; but several experts thought that differences in habits might sustain (how to do the laundry, how to wash the dishes, etc.) and exert influence on the design and adoption of smart appliances. After all the markets in Europe are quite differently structured, different price segments are demanded by consumers. Also the evaluation of the sales volumes of the energy efficiency classes is a complex subject. Of course energy consumption and price correlate to a certain extent – a top energy efficient product is usually not the cheapest one – but the market cannot be explained as simple as this.

2.2 Conclusions

For the survey the research team tried to ensure a rather representative sample in every country, including consumers of different age, education, income and household status. This goal was more or less met in all countries, with exception of the United Kingdom. In the UK sample nearly 90% of the respondents were academics. The questionnaire in UK was distributed to a database of 11.000 persons on the university campus. The database included besides academic and research staff also administrative/management, clerical/secretarial, academic support and manual/craft staff, but it seems that mostly academics were answering. The same is the case for the other country samples. Thus, in all samples academics are over-represented. For the interpretation of the survey results we have to consider that we have an overall sample with a high share of males, of middle-aged people, with higher education, technical background and high ecological awareness, with the majority living in a house without children (about 60%).

We expected that people with higher education and income might be more in favour of smart appliances. The high percentage of academics in our sample and the fact that acceptance of smart appliances in all countries (see Chapter 3) is very high, seems to point in this direction, even though no significant correlations could be found. Also the sample specifics are not really surprising as people who are interested in ecological topics and have a technical understanding are more likely motivated to participate in such a survey than others.

However, the high acceptance of smart appliances as found in the survey might not be directly transferable to other social classes. As the findings of the qualitative research indicate families with children, older people and people with low income might be less enthusiastic about smart operation. But this will depend very much on the framework conditions such as costs, incentives and easy handling.

The phone interviews and focus groups give a more sophisticated picture about the underlying conditions for this acceptance and help to draft starting-points to optimise scenarios for the use of smart appliances. All in all the findings of the quantitative and qualitative research correspond with each other. The research shows that the consumer acceptance for smart appliances is high, with no substantial differences between the different countries. Despite the differences in the survey samples the attitudes and opinions about smart appliances are very similar in all included countries. Overall no significant correlations between age, gender, income, education and acceptance could be found. Only energy saving behaviour seems to have an influence: The more people engage in energy saving behaviour the higher is their acceptance of smart appliances.

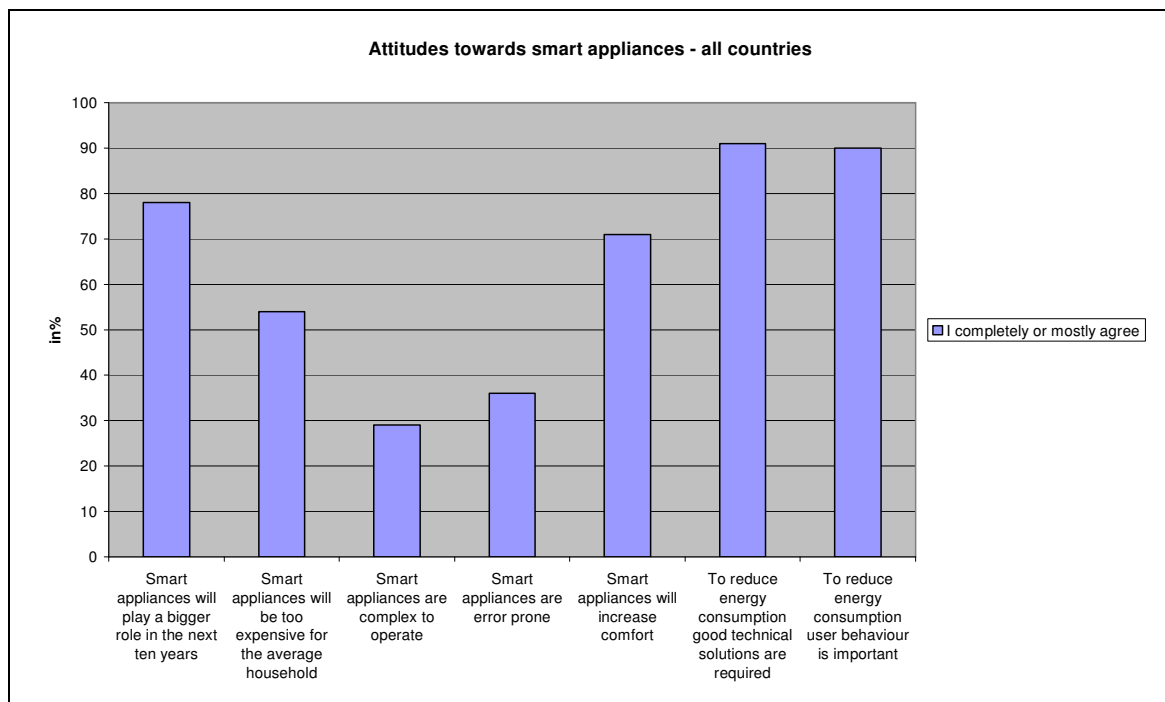
3 Summary of qualitative and quantitative research results

3.1 Consumer acceptance

There is a clear tendency in all countries included in the research regarding consumer acceptance of smart appliances. In general the acceptance level is very high and consumers have a rather positive attitude towards smart appliances. Averaging over all countries up to 90% of the respondents would accept different options for smart operation of appliances.

From both the qualitative and quantitative research we know that consumers expect that the future development will lead to sophisticated technical solutions for appliances and that smart appliances will play a bigger role. They hope that such solutions will make life more comfortable and housework less time-consuming and they therefore have a positive attitude to adopt these technologies.

Figure 3-1-1 Attitudes towards smart appliances (all countries)



Despite this positive tenor two aspects have to be considered for assessment of the consumer acceptance: First, smart functions of appliances are currently hardly known or used by consumers. At the most start time delay function for washing machine and dish washer are available. Consumers have only a vague idea how smart appliances might work and have to some degree difficulties to understand the underlying technology. Second, the consumers included in the research are currently not using all appliances they were asked about (see table below). Appliances like washing machine, dish washer, refrigerator and freezer have a high penetration rate in the surveyed countries,

whereas dryer and air conditioner and electric space heating are not so widespread. Considering these aspects we have to keep in mind that consumers are estimating their future behaviour using appliances in a smart way – appliances about which they do not know very much and which they might not even be using now in the conventional way. Furthermore, the questionnaire did not ask how respondents really use their appliances, but how they can imagine to use them. There will be always a gap between real actions and attitudes. Subsequently the high acceptance level and readiness to change their user behaviour in order to be able to use smart appliances has to be evaluated with a certain cautiousness. It also has to be considered that consumers have many objections and pre-conditions when they are going to use smart appliances. This objections are elaborated in more detail in section 3.5.

Table 3-1-2: Use of household appliances in Percent

Household appliance	Austria	Germany	Slovenia	UK	Italy
Washing machine	97	100	100	98	98
Refrigerator	98	100	99	98	99
Deep freezer	81	91	77	71	57
Dishwasher	81	95	61	40	58
Electric cooker	93	98	43	65	33
Tumble dryer	30	76	34	42	7
Central heating pump	10	16	44	61	26
Electric heated boiler (80 litres)	16	22	37	17	8
Electric water heater (10 litres)	10	10	20	14	14
Electric space heating	3	20	15	13	9
Air conditioner	1	6	18	1	27

Modes of smart operation

For the research three simplified user scenarios were presented to the consumers and they had to estimate whether they would accept it and under which conditions.

- **Mode A:** The user presses a “smart mode” button and defines till when the operation has to be finished at the latest. Operation starts after the appliance receives a signal (e.g. power-line triggered) that renewable energy is available. Applicable for washing machine, tumble dryer, dish washer, air conditioner.
- **Mode B:** The user receives an information via a display on the appliance that for financial and ecological reasons it would be better to start operation at a specific time later that day. The user has to decide whether to wait with the operation or not. Applicable for washing machine, tumble dryer, dish washer, air conditioner.
- **Mode C:** The appliance is set in a “smart operation mode” by pressing a button on it. During operation short interruptions might occur or the operation might be prolonged. Applicable for air conditioner, refrigerator, freezer, electric water heater, electric heated boiler, central heating pump.

The consumers would accept all three presented options. No clear preferences for one of these operation modes could be found. Consumers who preferred operation mode A claimed that this use option would be more convenient, as no further user interaction is required, after setting the appliance. However they want to be able to determine both the starting and finishing time of operation.

The second operation mode gives consumers more control and they can be sure that renewable energy is used, whereas in the first case, it could also happen that conventional electricity has to be used to finish operation till a predefined time.

Regarding automatic regulation as described in operation mode C some consumers had difficulties to grasp the concept. They could not see the benefits of this solution as many of the respective devices use night tariffs anyway. They also had doubts that the technology is working safely and whether this solution is really energy-efficient. On one hand this operation mode is viewed as the most convenient one as no user interaction is required. On the other hand consumers fear a loss of control and comfort. In case that they are able to override smart operation, if desired, and no loss of comfort occurs, this mode is also widely accepted.

This finding also corresponds with expert opinions, who perceived that people want immediate action (heating or cooling) once they are not comfortable any more. But on the other side these systems have a high potential for smart operation. As intermittent operation will certainly remain unnoticed by the users it leaves much room for remote control.

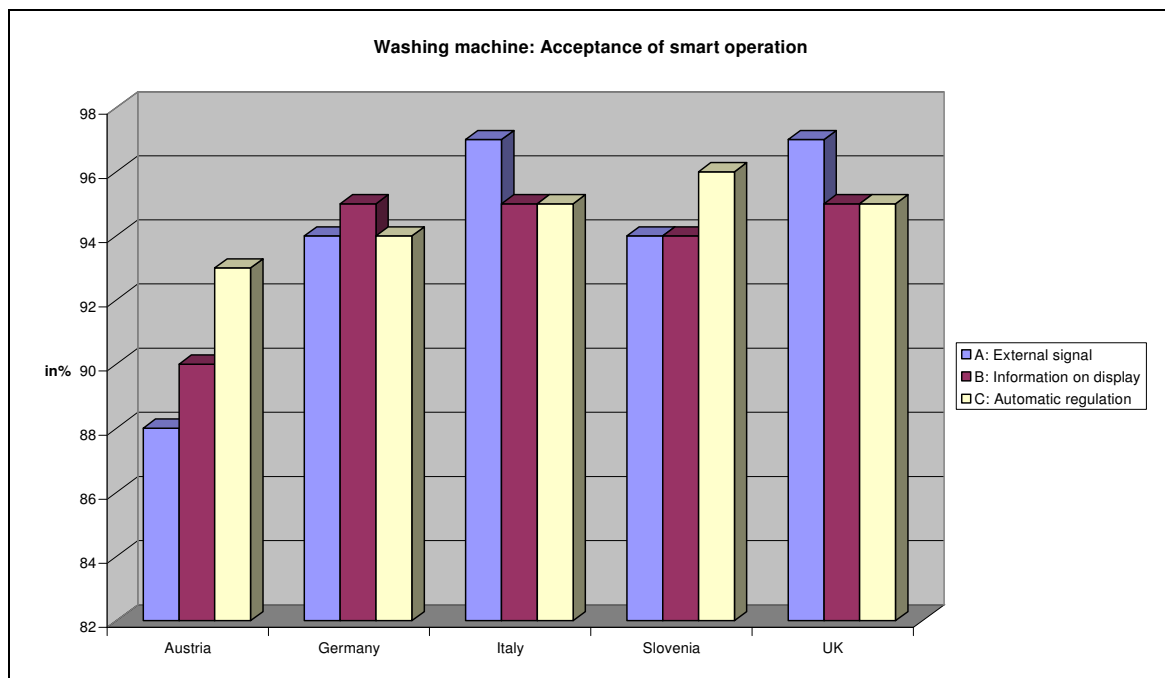
3.2 Acceptance of smart operation for household appliances

The acceptance of the smart operation mode depends on the respective device. No generalisation is valid for all appliances.

3.2.1 Washing machine

The smart operation acceptance concerning the washing machine was very high in all countries (range between countries: 88 to 97%). All three above described operation modes were acceptable for the consumers. But washing is a very sensitive area, where consumers are not very flexible to change their behaviour and they are afraid that clothes might be damaged through smart operation. Although consumers would be willing to postpone operation, they do not want to leave wet laundry for a longer time in the machine (e.g. getting mouldy). Thus, the time interval for smart operation in this case will be rather limited. About 77% of the consumers would at least accept a shift of 3 hours. Consumers are also reluctant to operate their machine during night being afraid of noise and again they do not want to leave the wet laundry in the washing machine. Also some doubts exist that the quality of the wash will deteriorate. The timer function of a smart machine is viewed as a benefit with regard to a conventional machine, as it gives consumers more flexibility and control. People claimed they would use the smart mode up to 90 or 100% of the time, but this depends very much on individual habits and is difficult to predict.

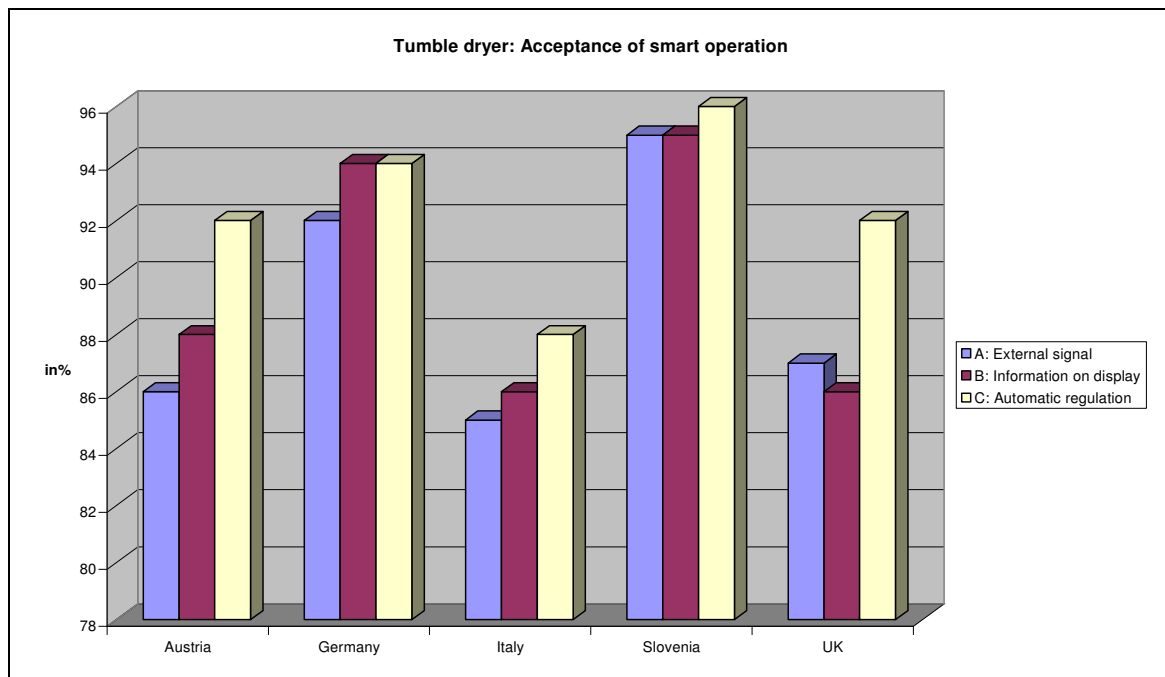
Figure 3-2-1-1 Washing machine: Acceptance of smart operation



3.2.2 Tumble dryer

The acceptance level for smart tumble dryers was equally high as for smart washing machines (range between countries: 85-96%). Here also 77% of the users claim that they would accept a shift of 3 hours. This result is surprising as smart operation of the tumble dryer does not seem very likely for the majority of consumers. The use of the dryer is closely connected to the use of the washing machine. Normally users wait till the washing process is finished and put the laundry directly into the dryer. As the consumers stressed in the qualitative research, a postponement of operation does not make sense for them. If they have time to wait for the service they do not use the dryer, but dry the laundry on the clothesline. This high theoretical acceptance level might be due to the fact that many consumers reject to use a dryer anyway as it is not considered as ecological. So a smart dryer would be favoured as it is perceived as more environmentally friendly as a conventional one. Also the majority of the interviewed consumers do not have a dryer, so they lack the experience how they would use it. In case the dryer is integrated into the washing machine a smart operation seems acceptable as no additional user interaction is required. But in this case consumers object to leave the laundry for a longer time in the machine, as it might get wrinkled.

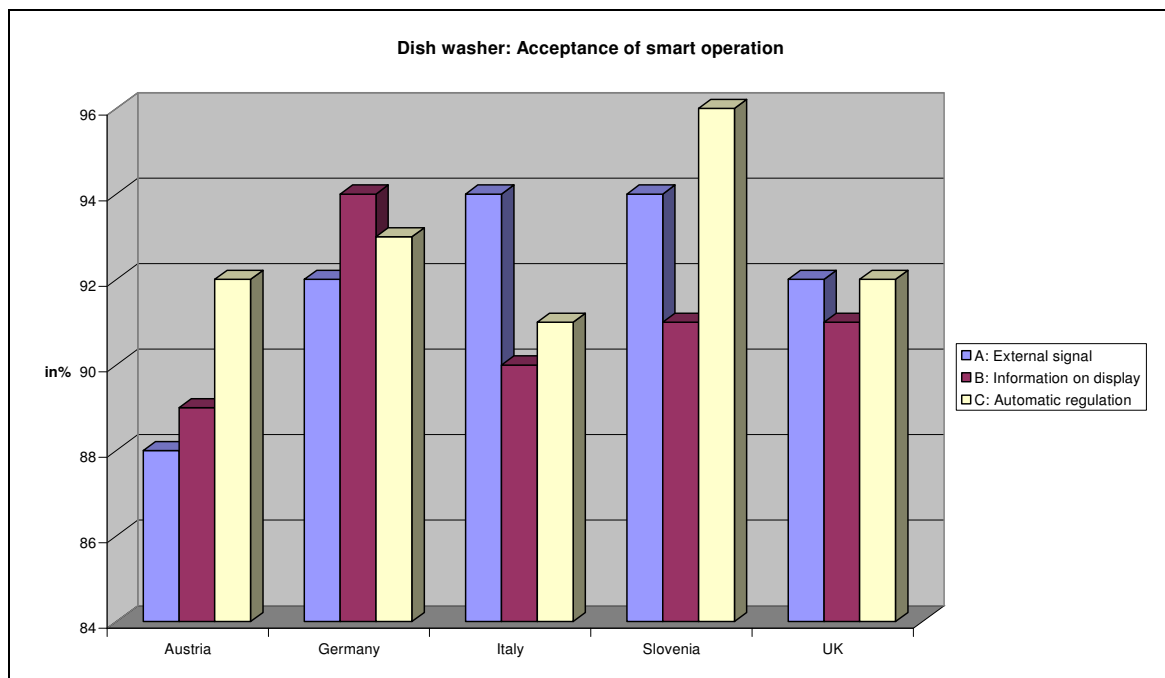
Figure 3-2-2-1 Tumble dryer: Acceptance of smart operation



3.2.3 Dish washer

The acceptance level for a smart operation of the dish washer is very high in all countries (range between countries: 88 to 96%). Again the majority (77%) of the consumers would accept a time shift of at least 3 hours. For the dish washer the flexibility of smart operation seems higher than for the other appliances as consumers mostly don't care when the device is working. Also they are already used to operate the dish washer during night or when they are not at home. Only a few consumers expressed concern about leaving the dirty dishes for a longer time in the machine. Major concern against using a smart dish washer is noise during night. For the dish washer many consumers could imagine to use the smart operation mode up to 80% or 100% of the time.

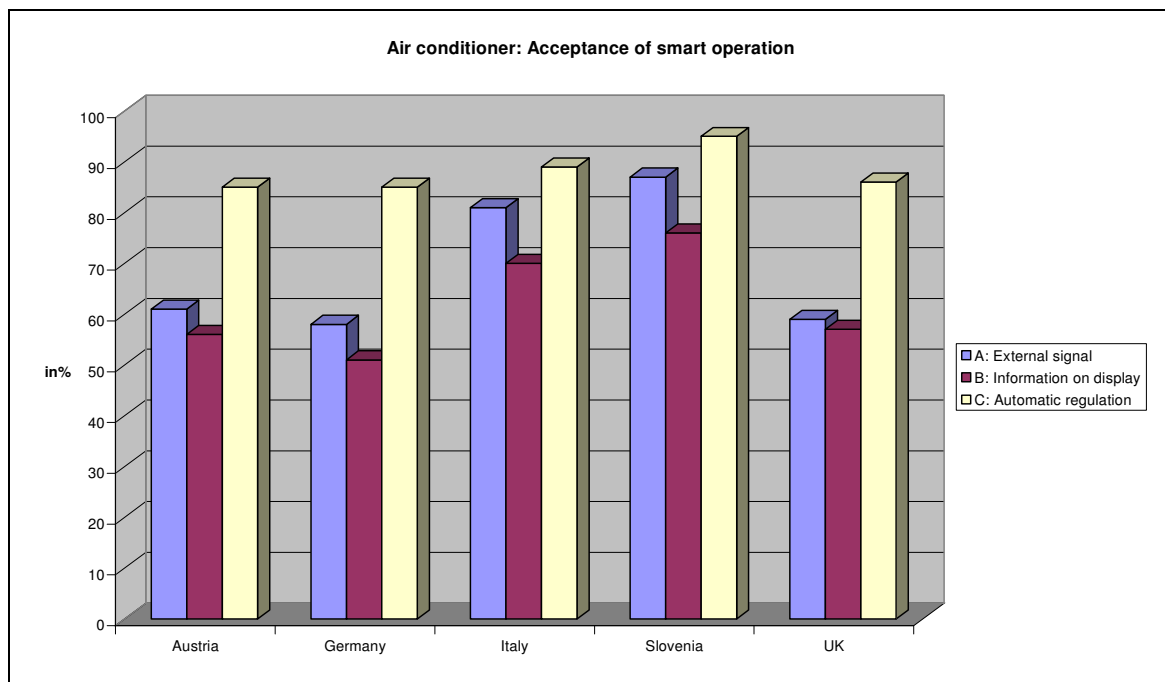
Figure 3-2-3-1 Dish washer: Acceptance of smart operation



3.2.4 Air conditioner

For the air conditioner the situation is similar as for the tumble dryer. Most of the interviewed persons do not use air conditioning. In Austria and United Kingdom only 1% of the interviewed persons have an air conditioner. Only in Italy the penetration rate is higher with 27%. In the phone interviews and focus groups consumers claimed that they would not buy an air conditioner in the future, because they don't need it and think it is not ecological. The acceptance of smart operation for an air conditioner is lower than for the other appliances, as consumers want the service on demand and are not ready to postpone it or wait for it. However, an automatic regulation would be highly accepted (range between countries: 85 to 95%) if there is no loss of comfort. As the power demand for air conditioning is high and consumers perceive it as not environmentally friendly there might be a potential for smart operation.

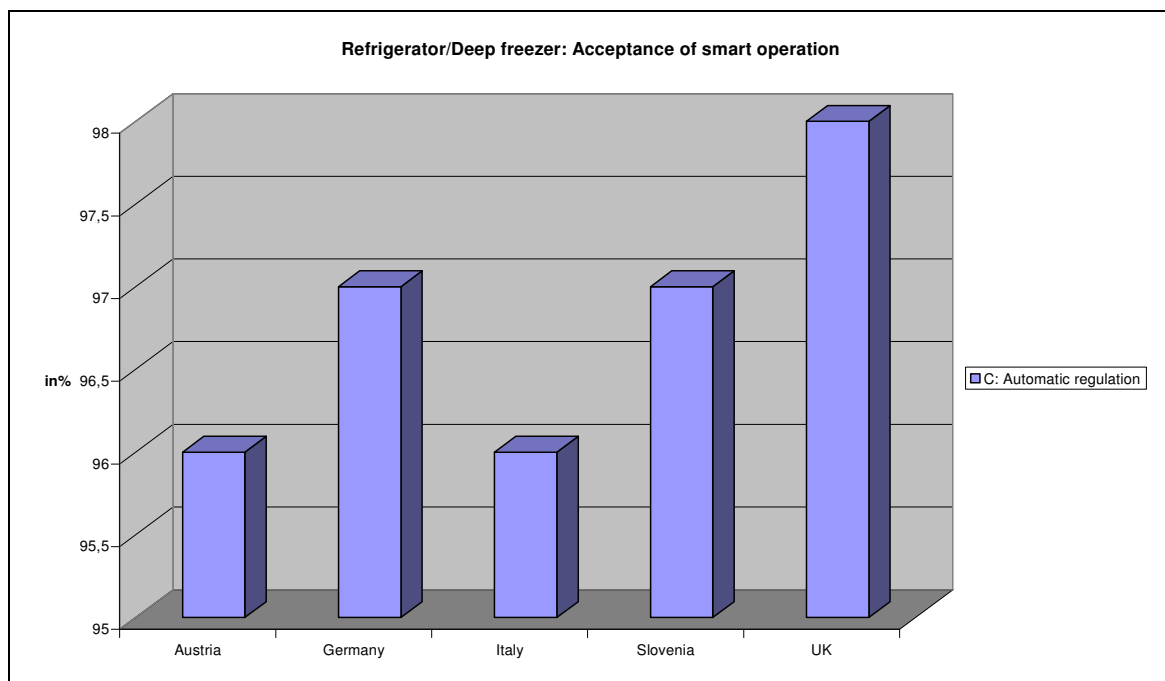
Figure 3-2-4-1 Air conditioner: Acceptance of smart operation



3.2.5 Refrigerator/deep freezer

The results of the survey show a high acceptance of smart operation of refrigerator and freezer (range between countries: 96-98%). The phone interviews and discussions in focus groups showed that also strong objections exist: consumers are concerned whether food quality will remain the same and whether the technology will be working safely. If food quality is influenced there will be no acceptance, as risks will be rated higher than the benefits. The concerns regarding refrigerator and freezer are to a certain degree based on the fact that many consumers do not know how their current appliances work (constant low temperature is maintained even though appliances automatically switches on and off). More information and an easily visible thermostat and a visible record of temperature/timeline might help to overcome barriers. Consumers also need reassurance that conventional energy is used if not enough renewable energy is available, also a fail-safe device that switches the machine back on if left off for too long would provide reassurance.

Figure 3-2-5-1 Refrigerator/Deep freezer: Acceptance of smart operation



3.2.6 Electric water heater/electric boiler

High consumer acceptance is given (range between countries 88 to 94%), if there is no loss of comfort. The acceptance will also depend to a certain degree on the costs of a smart appliance. As water heaters usually have rather low costs, high additional costs for a smart one will not be easily accepted. Those consumers who reject a smart operation, mostly do so because hot water is needed on demand.

Figure 3-2-6-1 Electric water heater: Acceptance of smart operation

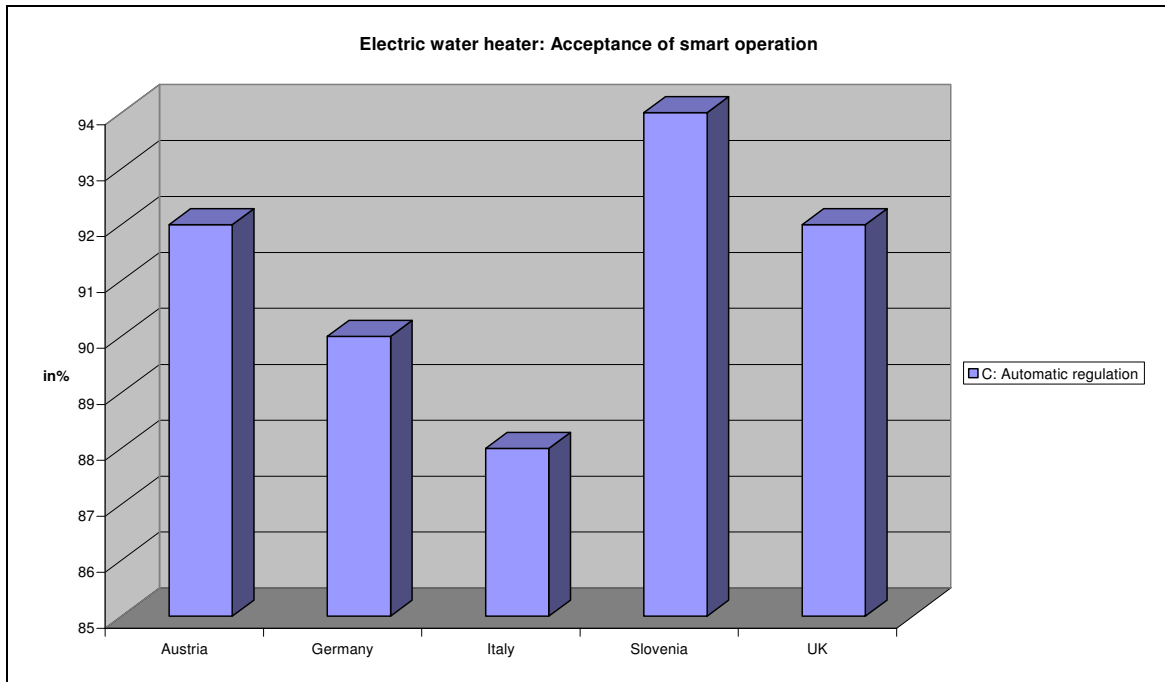
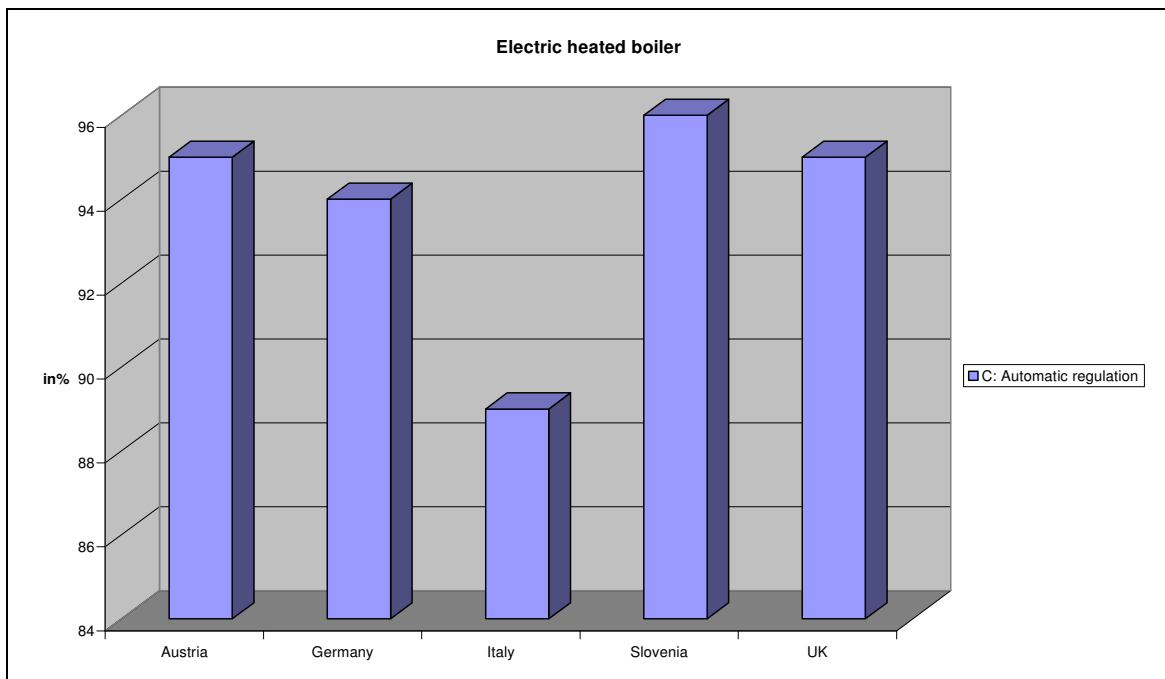


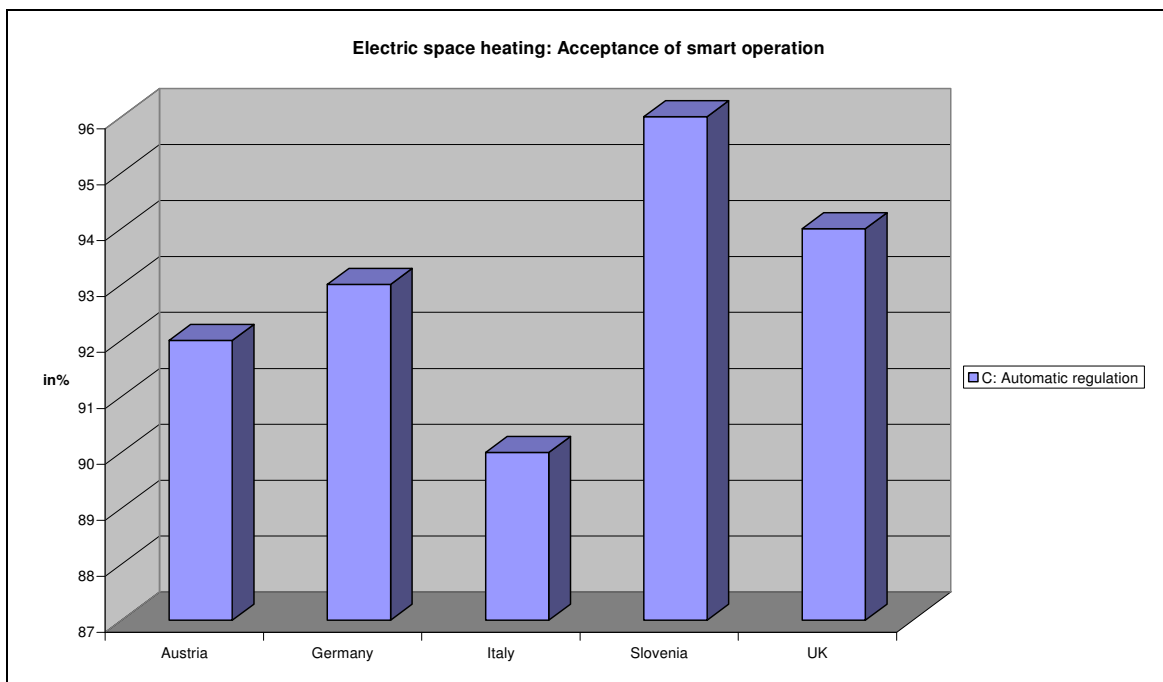
Figure 3-2-6-2 Electric heated boiler: Acceptance of smart operation



3.2.7 Electric space heating

Also for electric space heating a smart operation is widely accepted (range between countries: 90 to 96%). In the interviews some consumers expressed objections that the energy supplier could regulate their devices and they prefer to keep full control over the heating system. Electric heating is expensive and perceived as not environmentally friendly, therefore it is estimated that users have a high motivation to find better solutions. For the future however the potentials might be rather low, as consumers prefer other technologies for heating, if possible.

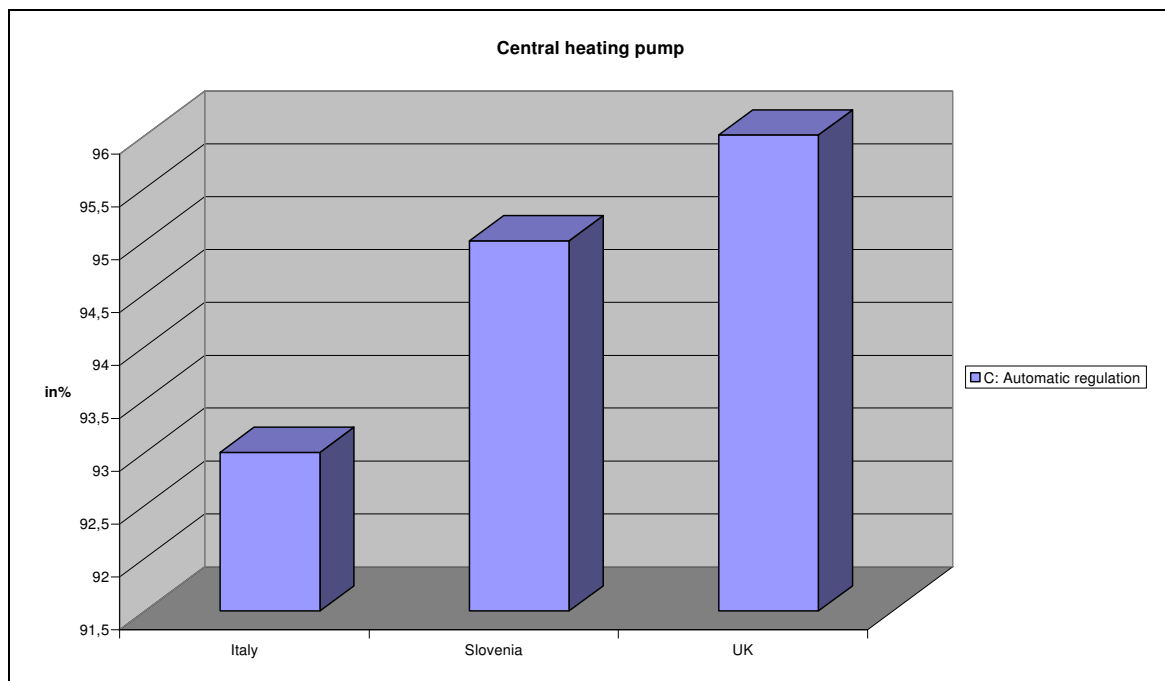
Figure 3-2-7-1 Electric space heating: Acceptance of smart mode



3.2.8 Central heating pump

A smart operation of the central heating pump is widely accepted, if there is no loss of comfort and consumers are able to override smart operation, in case they feel this is necessary. A few consumers reject smart operation because they need constant heating or prefer to use thermostats and timers.

Figure 3-2-8-1 Central heating pump: Acceptance of smart mode (note: values for Austria and Germany are missing)



3.3 Willingness to change consumer behaviour

Consumers would accept changes of their user behaviour to a minor degree. In general consumers had some difficulties to estimate how often e.g. per month they would use the smart operation mode. According to the interviews they think they would use the smart mode frequently, with a range from 25 to 100% of the time. However this estimation has to be put in the right perspective. Consumers do not have any real experiences with smart appliances so far and seem to be over-optimistic about this issue. Discussions within the phone interviews and focus groups showed that they have difficulties to estimate their own behaviour. The use is on one hand strongly related to individual habits and living conditions (working hours, children in the house, living in flat or house) and on the other hand depends on the respective appliance. A precondition to change ones own user behaviour is a financial benefit.

Similar is the situation with regard for the time interval for postponing the service. The survey showed that consumers are willing to postpone operation for long time intervals, in Italy more than the half, in UK and Slovenia more than 40% of the respondents

claimed that they would accept a postponement of the operation of washing machine, dish washer and tumble dryer up to 24 hours. In Germany and Austria about a third were willing to accept such long intervals. Asked again in the phone interviews, the respondents were more cautious. Realistic is a shift between half an hour and three or four hours.

Figure 3-3-1 Washing machine – Willingness to postpone start (all countries)

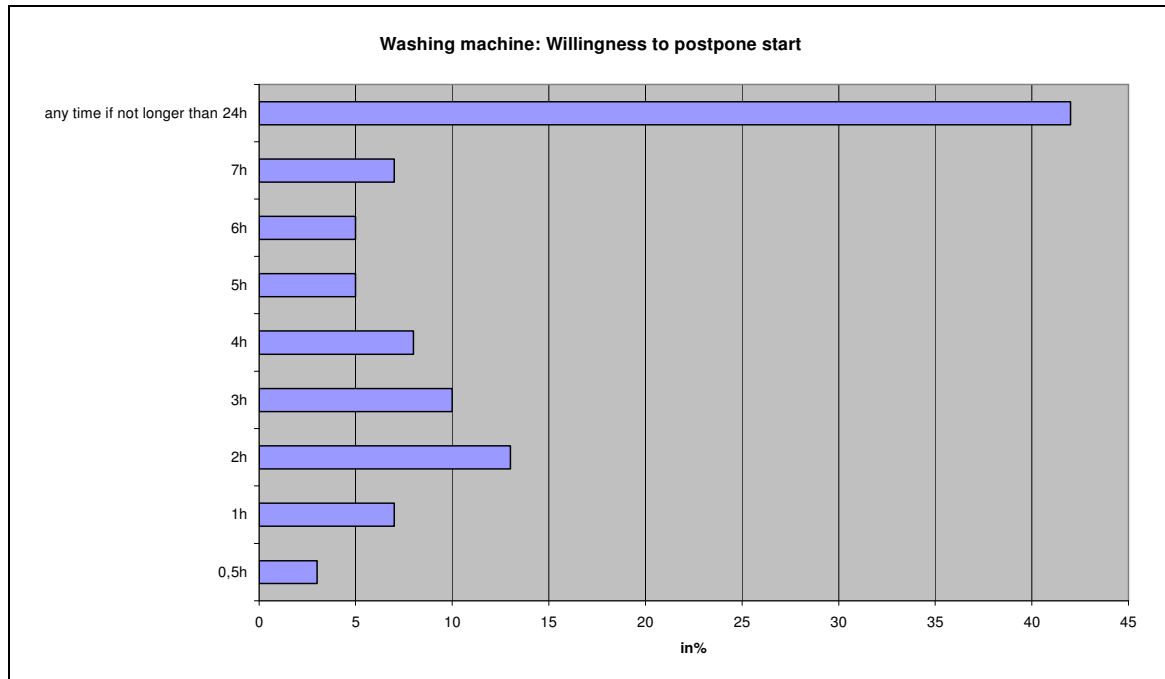


Figure 3-3-2 Dish washer: Willingness to postpone start (all countries)

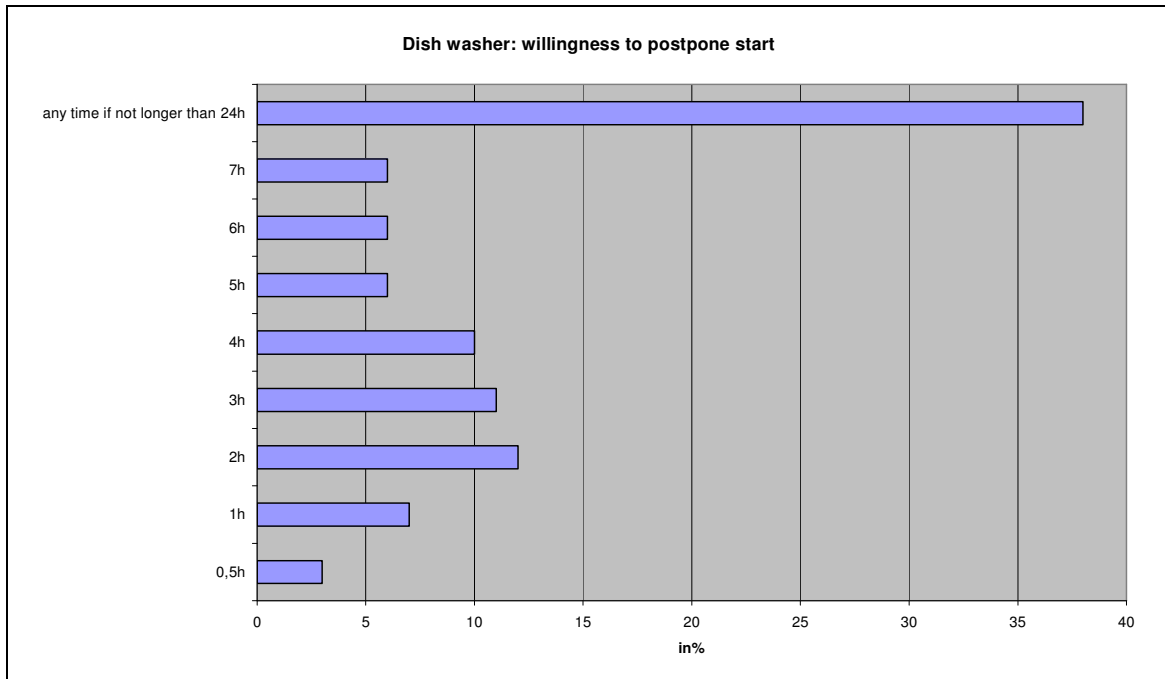


Figure 3-3-3 Tumble dryer: willingness to postpone start (all countries)

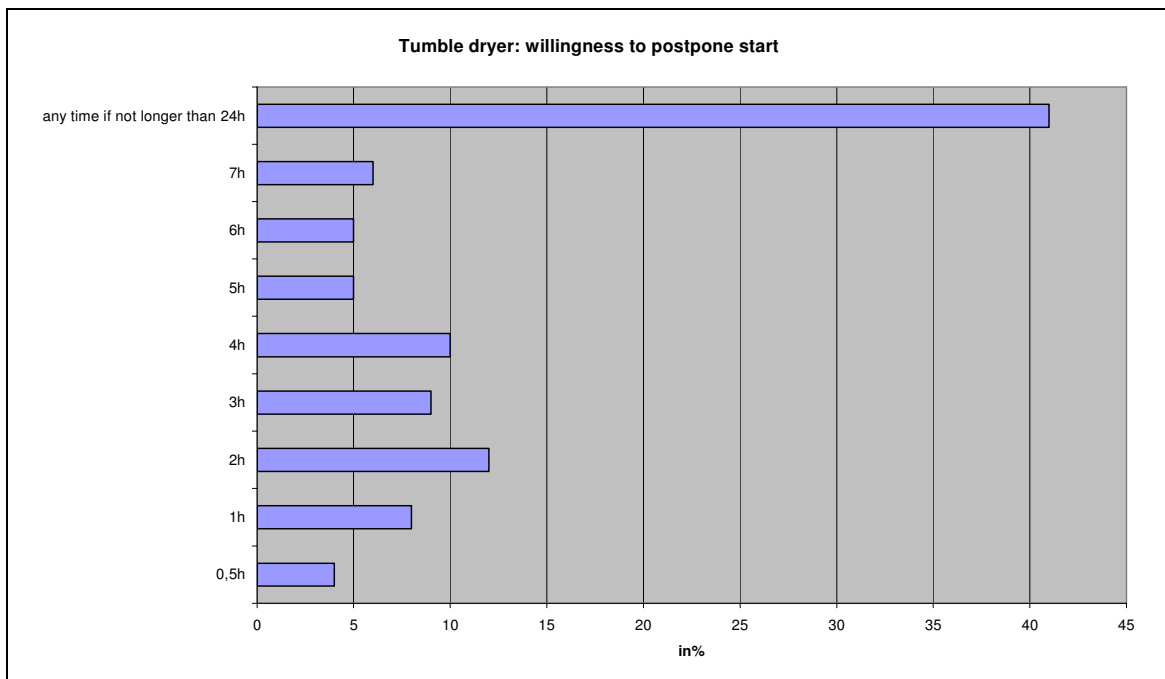
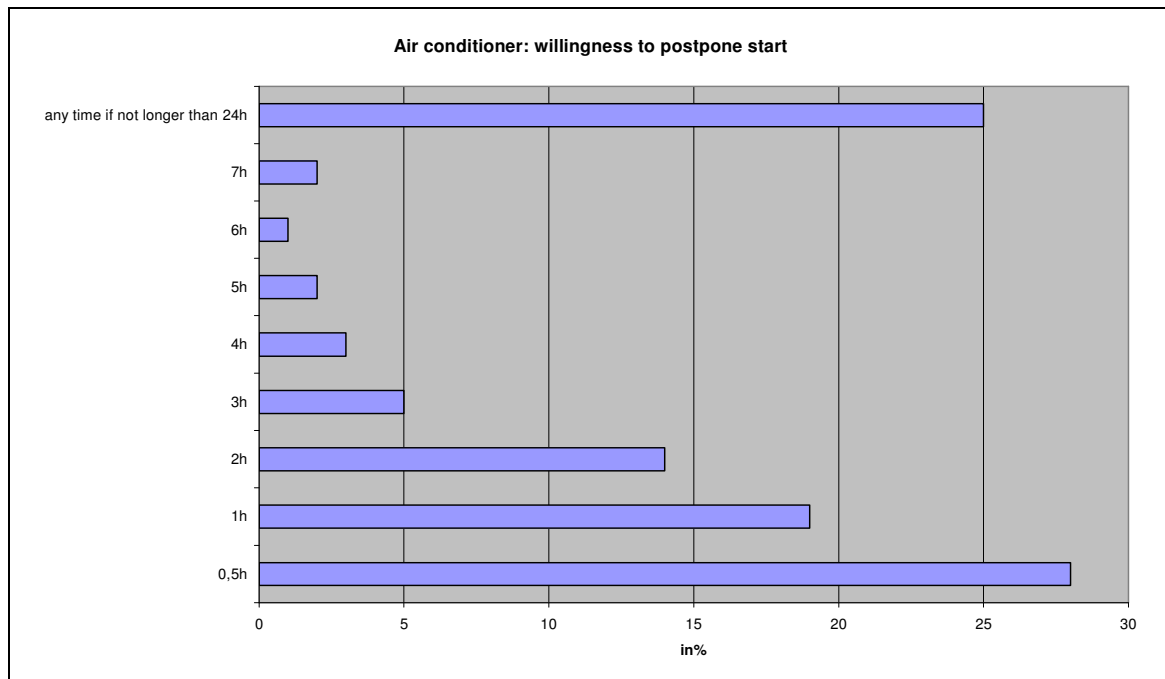


Figure 3-3-4 Air conditioner: willingness to postpone start (all countries)



3.4 Motivation to buy smart appliances

In general consumers claimed in the focus groups and interviews that they would not buy smart appliances because of the additional functions, but only if they need a new one anyway.

Within the survey the consumers could indicate whether they would accept smart operation for either “financial reasons”, or “ecological reasons” or “financial and ecological reasons”. The majority of consumers in all countries chose the last option “for financial and ecological reasons”. On one hand this is a social acceptable answer, on the other hand both aspects seem to be important for the consumers. For example energy efficiency and water saving appliances are very popular and actively asked for at the point of sale. This is due to the fact that people are conscious of the operation costs over the life span of the appliance, but also because they want to contribute to environmental protection.

Still the main incentive for the majority of consumers to buy smart appliances is the prospect of a financial benefit. The ecological benefit is viewed as a positive side effect, which makes them feel good and indicates their green conscience, but is not sufficient. Only few consumers would buy smart appliances solely for ecological benefit.

The following conditions have to be met in order to convince consumers to buy smart appliances:

- Technology is considered as mature and experiences are available.
- Acceptable prices and/or subsidies are given.
- They have a financial gain by using smart appliances.
- Feasible cost models are available.
- Comfort is maintained or enhanced.
- Good information about smart appliances is available.
- The appliances have a good usability and attractive designs.

In the experts' interviews it was expressed, that an important aspect in favour of smart appliances would be if they are not only operated because of the optimised electricity system with a correspondent tariff structure but also help to increase the user's comfort. A smart appliance could integrate monitoring features like e.g. to check its own correct functioning. Or smart home features could be realised like e.g. an "all power off switch", so people do not have to worry about a hot stove top or a light left on when they leave home.

3.5 Objections to use smart appliances

As already indicated above consumers are in theory willing to accept smart operation of their appliances, to a higher degree as was anticipated by the interviewed experts. But at the same time they express many objections, varying from safety fears, to potential technical problems to emotional scepticisms.

Regarding the results of the focus groups the following objections can be summarised.

3.5.1 Safety of smart appliances

Major concern of consumers is that they feel uneasy to leave their appliances switched on, if they are not at home or during night. They are afraid of break-downs which might lead to flood or fire. The perception of risk depends to a very high degree on their current use practices and their knowledge about the technology. For example: users are not willing to run the washing machine when they are not at home or during night, but are much less worried about the dish washer, although both appliances work very similar. Obviously they are already used to run the dish washer unattended and they are more concerned about their clothes (e.g. that they might be damaged) than about their dishes. Additionally operation during night raises the problem of noise, which is troubling consumers living in a flat, because they do not want to disturb their neighbours.

Safety issues are linked to smart freezers or refrigerators, people fear that smart operation might damage the food quality or frozen items might defrost. Even if they would get the guarantee that from technological point of view there is no risk they feel uncomfortable about it – mostly because they do not understand how the appliance is working.

3.5.2 Loss of control

A second major concern for consumers is an anticipated loss of control. One background reason of this feeling is a certain mistrust in high tech solutions. Paramount for the consumers is that they can override the smart operation mode any time they want. Also many consumers do not like the idea that the energy utility has control over the devices, as described in operation mode C (see chapter 3.1). Consumers are used to the continuous availability of electricity and to operate their appliances whenever they want. Service on demand is important to them and they are afraid that if operation is influenced by the energy provider there might be a deterioration of comfort. So even in case of automatic regulation they want to keep control over the appliance.

In fact people do not switch the energy provider very often, but still they feel uncomfortable with the idea that they might be tied up to one company in order to be able to use smart appliances. They do not like to be dependent.

3.5.3 Doubts about technology

Consumers have only a vague idea how smart appliances might work and have to some degree difficulties to understand the underlying technology. They lack knowledge how the electricity grid works and how a higher share of renewable energy will influence it. Consumers are concerned, how limited renewable energy is distributed and that artificial power consumption peaks are created. They want to know how a fair system can be established, so that everyone who uses smart appliances will benefit from cheaper tariffs. They are sceptical about the price of renewable energy in general, as they believe that renewable energy will remain more expensive than conventional energy. They also want to be sure that they are really using green energy.

Consumers also expressed the idea that it would be convenient to be informed about the availability of renewable energy, so they could change their daily routines accordingly. If this information would be broadcasted via radio or internet, they could react, but would not need a smart appliance.

They are also afraid that smart appliances are more error-prone and might easily breakdown because of the additional electronic. They fear that the appliances might have shorter lifecycles because of interrupted operation. Important is for example whether spare parts can be bought or whether the device as a whole has to be replaced. They would prefer solutions with external processors, which can also be attached to other appliances. And they want be sure that a good support and repair service will be available.

3.5.4 Additional costs

In general consumers would be ready to buy smart appliances, if they do not cost more or only slightly more (e.g. 5-25 Euro) than conventional ones. Also higher prices would be acceptable, but this depends on the respective appliance and whether the investment

is paid back. Additional costs have to be viewed in relation to the absolute price of a new appliance (e.g. for expensive appliances additional costs are accepted more easily). A reasonable pay-back time is expected as well as to be able to save money in the long-term. A pay-back time of five years seems too long, some even felt that a three year payback was too long for such a small amount of money.

Consumers are worried that there might be some hidden additional costs, like costs for infrastructure, installations costs or repair costs. They expect cost calculations (e.g. explaining how much a typical family can save over time) to help their decision making whether to invest in smart appliances. Preferably such information should be provided from independent institutions rather than from the energy supplier or manufacturer.

Consumers are aware about additional metering and installation costs. In general additional costs of 100 Euro would be accepted. But for some respondents it would pay off only if several smart appliances are used. It also depends on the overall amount of money which is needed to implement smart appliances in the whole household. The willingness to bear such additional investment costs depends on possible savings.

3.5.5 Scepticism about ecological effects

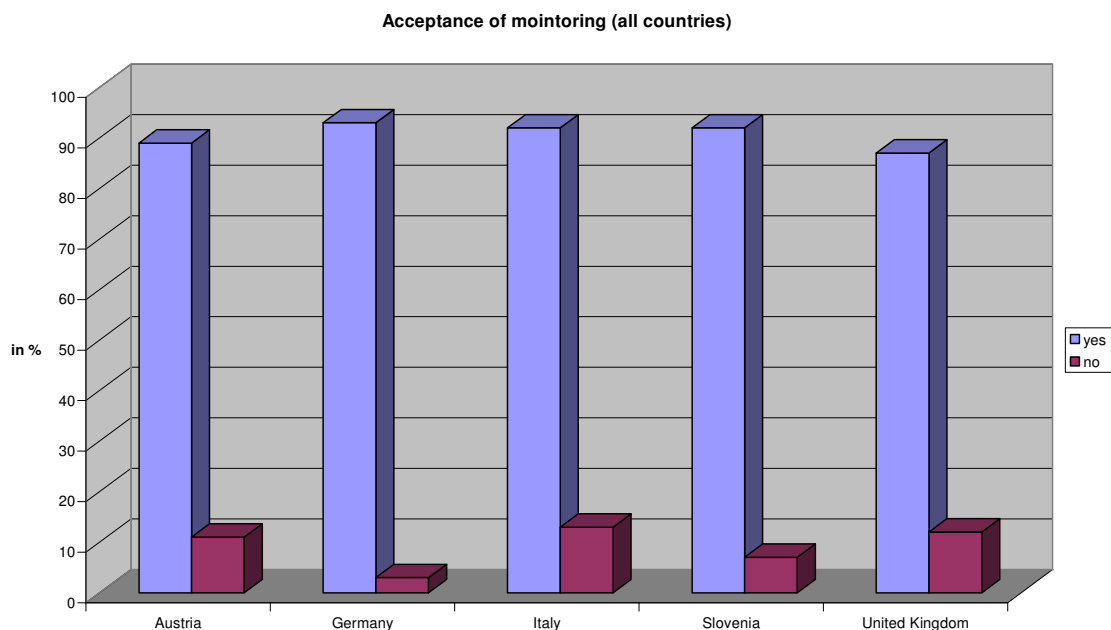
There is a lot of scepticism which ecological benefits can be really achieved. Consumers fear that the ecological benefit is only used as a sales argument. They have doubts whether renewable energy is going to be cheaper and they are suspicious about the motivation of energy suppliers to promote smart appliances. Some suspected that the energy supplier has all the commercial gains, whereas the users have to adjust to new behaviour patterns without high rewards. To overcome their doubts, evaluation of ecological benefits should be done by an independent institution and the promotion of smart appliances should be supported by governmental institutions. As mentioned above good information about the functioning of the electricity grid and the feeding-in of renewable energy is required.

3.6 Monitoring

We had the assumption that consumers will be sceptical about the monitoring of their energy consumption and that they will prefer less invasive communication methods, which leaves it up to them whether to react or not.

It was surprising that most consumers are not concerned about the monitoring of their energy consumption by their energy supplier. A comparison of the survey answers by country shows that older people (over 50 years) seem to be less sceptical, as well as respondents with apprenticeship or academic degree.

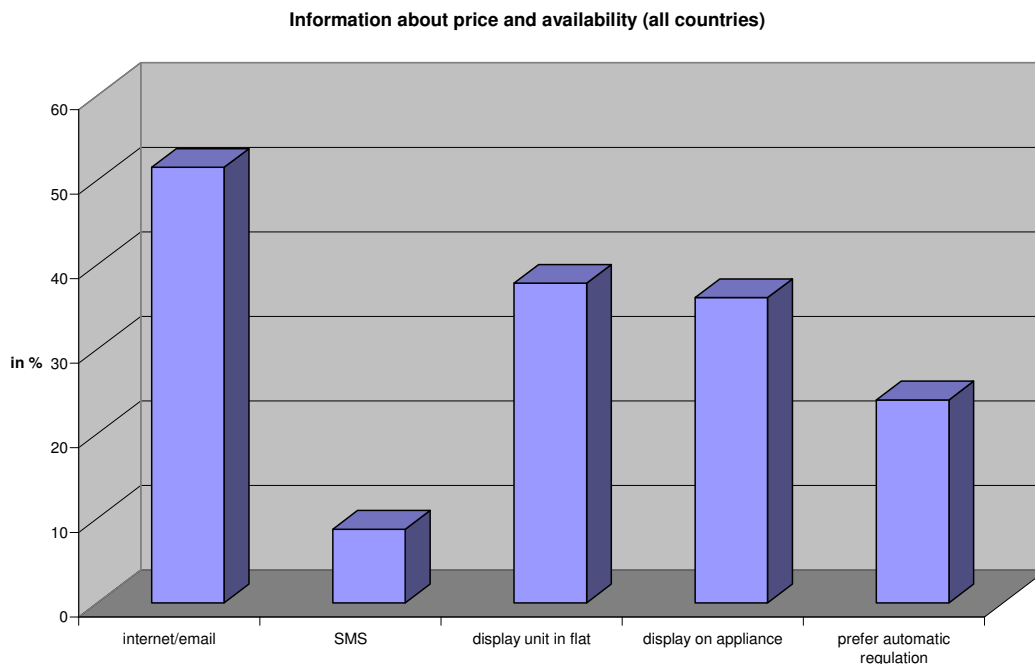
Figure 3-6-1 Acceptance of monitoring (all countries)



The respondents had to indicate in which way they would like to be informed about renewable and cheap energy. More than half of the consumers in every country want to get the information about cheap and renewable energy via internet – this is independent of social factors like gender or age. Especially those who have worked or work in a technical field prefer the internet.

But preferences are distinct in the respective countries: In Great Britain and Slovenia respondents prefer information on the display of the appliance. In Germany two thirds of the people like the information via e-mail or internet. In Austria people also prefer internet or e-mail but the tendency is not so pronounced as in Germany. Younger people seem to prefer it more, also higher educated and self-employed ones. In Italy a little more than half of the respondents like to get information via internet. Least popular is automatic regulation in all countries – except Austria.

Figure 3-6-2 Information about price and availability (all countries)



Also the qualitative research showed that consumers would accept a permanent monitoring of their energy consumption and they do not expect any incentives for it. However there are also many who did not like the idea and are worried about misuse. Good data protection and deletion after some time as well as the possibility to have access to ones own data is expected. On the one hand the possibility to view the own energy use in real time is perceived as interesting and could be used to optimise one's energy consumption, on the other hand also some fears were expressed that people with a high energy consumption might be denounced.

3.7 Feedback

Consumers would be interested to get information about their energy consumption and the price. Also comparisons of costs (with/without smart mode) would be interesting. Information about ecological impact is also desired. Some consumers would prefer to get the feedback directly, via display on the device, because then they can react accordingly (e.g. green light flashes up to indicate that renewable energy is available now). Data about energy consumption and use patterns should be saved for a longer time period. The online availability of data would also be interesting for some users. Others only demand an overview of consumption on the yearly invoice in terms of saved money, saved energy, saved CO₂ equivalent and possible savings when smart operation is used more comprehensive. The possibility to review current consumption, for instance on the internet, was not attractive for them. All in all the information should be provided in a simple, easy understandable way.

4 Strategies to raise consumer acceptance

The results of the consumer research show that consumers have a positive attitude towards smart appliances and would be willing to adopt them. Whether this positive attitude will lead to a market penetration depends very much on whether it will be possible to overcome the objections which are existing. Partly this will depend on the manufacturers and whether they are able to provide solutions which are comfortable, secure and easy to handle, and partly on the utilities – whether they will be able to offer attractive tariffs. Also important will be the support of national and European institutions to promote smart appliances. An information and communication strategy to build trust in this new technology is necessary. Foremost the consumer benefits in using smart appliances have to become clear.

Based on the above described results of the consumer research the following aspects could help to overcome barriers and increase the acceptance of consumers.

4.1.1 Build trust in technology

Major objections of consumers are based on safety issues in a broad sense also covering any possibly greater strain on household items. Clearly use patterns play here a big role, consumers are for example not used to operate washing machine and tumble dryer when they are not at home. Also insurances are a problem, as usually insurances do not cover damages, if appliances are operated while not being at home. These are major obstacles which have to be overcome to convince consumers to invest in smart technologies.

Instead of special guarantees for the appliances users expect a high tech solution which prevents any damages. Some claim that even if insurance compensates for the smart appliances they would not operate them when they are not at home, because in case of breakdown the user still has the annoyance. It won't be entirely possible to meet this consumer expectation, as no appliance will be 100% safe. But additional safety mechanisms may convince those who have objections to leave an appliance unattended. For many consumers higher safety would be a unique selling proposition which would be more convincing than money savings or ecological benefits. Besides technologies which are already available on the market, e.g. water stop for washing machines, consumers would appreciate functions like:

- Information about faults: In case of a break down of refrigerator or deep freezer consumer is informed by phone or via SMS.
- Information about deterioration of material: Appliance informs user about e.g. attrition, calcifications, parts which have to be exchanged in the near future.
- Self diagnosis: The appliance gives information about the kind of break down, so user can communicate it to service team.

But also an additional insurance which covers damages caused during unattended operation will increase consumers trust in smart operation. The guarantee should at least last for the length of time which is needed for payback.

Also monitoring devices which show data such as temperature and status of working process might help to overcome barriers, as well as the information that service is guaranteed (e.g. conventional energy will be used if not enough renewable energy is available).

4.1.2 Support of Smart-A concept by independent institutions

There is a lot of consumer scepticism whether the technology will be leading to the desired effects and whether ecological benefits can be met. Consumers fear that the ecological benefit is only used as a sales argument. They have doubts whether renewable energy is going to be cheaper and they are suspicious about the motivation of energy suppliers to promote smart appliances. Some expressed the suspicion that the energy supplier has all the commercial gains, whereas the users have to adjust to new behaviour patterns without high rewards. There exists a certain mistrust towards energy suppliers and also manufacturers and the impression that economic goals are hidden behind a “green washing” attitude. As consumers pointed out information provided by the main beneficiaries will be met with reluctance. To overcome their doubts, the promotion of smart appliances should be supported by independent institutions, like governmental institutions on national and European level and by consumer organisations. Also the maturity of the technology and the assessment of ecological benefits should be verified by independent institutions. This can develop in parallel with energy efficiency labelling.

4.1.3 Provide coherent and comprehensible information

The complexity of smart operation seems high, whereas the corresponding savings seem rather low for the consumers. Most consumers have difficulties to understand the underlying concept of smart operation, therefore good information about the functioning of the electricity grid and the feeding-in of renewable energy is required, which should be provided by the energy utilities. Consumers need to understand the bigger picture and the concrete implications of using smart appliances, to be motivated to adopt them. Also the tariff structure combined with smart appliances has to be easy understandable. The information should help the consumer to get an idea what is his load curve, what is his saving potential and what are appropriate actions like peak load reduction.

On the other hand there is always the danger of information-overload. In the expert interviews a new actor was proposed: someone who helps the consumer to save energy, to filter and interpret the relevant information smart metering provides. There arises the question whether this service could be commercially successful. At least each customer is needing time-consuming support.

4.1.4 Provide attractive financial benefits

There are two main reasons why consumers will adopt smart appliances: either to gain an economic benefit or to contribute to reduce the environmental burden. As the results of the research show consumers clearly expect an economic benefit in order to use smart appliances. They are not prepared to change their behaviour without good incentives. Only a small percentage of environmentalists will be ready to buy smart appliances solely for environmental reasons.

Following this logic the main trigger to buy smart appliances will be attractive tariff offers of the utilities to their customers. The opinions and expectations about the savings differ: Possible savings for the single smart appliance will be rather low. For some consumers even such small savings would be a motivator, under the condition that technology is working safely and no loss of comfort occurs, others expect more substantial gains to accept smart operation. But consumers are aware of the fact, that in case several smart appliances are bought the sum of savings would have a bigger impact.

In case savings for smart operation are small it might be a feasible strategy if additional costs are sponsored by the energy utility, but in this case the motivation to use smart operation frequently would be lower.

In general a financial reward for each smart operation cycle is viewed positively and would also motivate consumers to use smart operation frequently. Though respondents do not have any clear ideas how high this amount should be. In any case information about energy and money saving should be part of the energy bill. Consumers are also open to accept a general cheaper tariff, instead of a reward for each smart cycle. Another model would be that the consumer gets a premium if they buy a smart appliance. But for these scenarios the motivation to use smart operation for each cycle will be lower. In general consumers think it is up to the energy supplier to provide an attractive cost model to convince them to use smart appliances. And as already mentioned above recommendations and evaluations of consumer organisations or independent institutions will be crucial for trust-building.

All in all consumers want convincing reasons and benefits to accept intervention and monitoring by the energy provider. In the current study we only estimated the overall tendencies. Further research is needed, when detailed cost models are available to assess whether consumers will accept them.

4.1.5 Provide options for consumers

One of the main questions of the consumer research was to assess whether consumers are willing to give an external party (energy supplier or network operator) insight in the use pattern of their appliances and the possibility for intervention. It depends on this acceptance whether the potentials of smart appliances can be fulfilled. Consumers generally agree to let the provider run the appliances and they would also be ready to accept a permanent monitoring of their consumption, a good data protection provided. But it became quite clear that users want to maintain control.

Many expressed the preference of solutions where they react to information of the network operator about price and availability of renewable energy. At least for appliances such as washing machine, dryer and dish washer which need a direct user interaction. They asked whether the availability of renewable energy would follow a regular pattern, so they could change their daily routines accordingly. This shows again, as already discussed, that consumers need relevant information about the background of the system to ensure their cooperation. It is very unlikely that users will spend time to think about load management and shape their user behaviour accordingly. The more automatic the systems work, the higher the comfort for the users, but at the same time automation is rejected because users feel uncomfortable with it. To overcome their concerns about loss of control consumers should have the option to actively decide whether to operate their appliances in a smart mode or not and overrule smart operation any time they want.

To increase consumer acceptance European standards for smart appliances will be helpful, as consumers want to have the choice to change the energy supplier whenever they want. They do not want to be forced to stay with one supplier, to be able to use their smart appliances.

4.1.6 Provide additional consumer benefits

It is a prerequisite that smart appliances should not only operate in a demand side energy management system but also show its strengths to increase the user's comfort. Smart appliances have to be beneficial for the household, so that consumers will be ready to adopt them.

The use of smart appliances is not imperatively associated with higher comfort, on the contrary inconveniences are expected, but they would be accepted for financial savings. Financial benefits therefore seem to be the crucial point to accept smart operation, as already stated above. But consumers also stated that possible savings are rather small and might not be very attractive to convince them, especially if they have doubts about the technology and might have to put up with less comfort. Thus, it is necessary to find additional benefits for smart appliances to make them attractive.

As already elaborated above higher security might be for many consumers a convincing argument to buy smart appliances. In general reasons to buy smart appliances could be more convenience, easy use and attractive design. In detail the following aspects were named by the consumers to make smart appliances attractive:

- Washing machine:
 - Control, if washing machine is overcharged
 - Possibility to operate washing machine with unsorted cloth (no discoloration)
 - Washing machine produces some kind of “predictive report” that allows owner to replace key parts before they cause a breakdown
 - Feedback about user behaviour, e.g. washing machine warns “do you really want to wash your delicates with 90 degrees?” or washing machine knows the weather forecast and gives feedback “not sensible to wash your laundry now, as it is going to rain and you can not dry it on the line”
 - Possibility to fill in soap powder/tablets for many cycles for washing machine and dishwasher
 - A raised washing machine to avoid bending down
 - Ironing function/anti-crease function for washing machines
- Refrigerator
 - Refrigerator records the level of stock and automatically places an order with the local supermarket
 - Information to optimise food purchase: e.g. the refrigerator gives recommendation which amount of food is required according to use pattern or gives recommendation about healthy nutrition
- Security
 - Monitoring and error reports (e.g. shows correct functioning or whether there are some calcifications, shows costs per wash)
 - Protection against overheating of appliances
 - Connection with supporting facilities (e.g. if TV runs non-stop for a long time period, check whether something happened to inhabitant).
- Good usability
 - Appliances reflect personal living habits (e.g. washing machine automatically chooses usual wash temperature)
 - Possibility to regulate the appliances from outside, e.g. with an digital wristband, computer

- Manual override for emergencies, safeguards against power cuts
- Standardisation and possibility that different appliances communicate with each other
- User-friendly operation (especially for older people) with big displays or displays with pictures
- Design
 - Appliances should “blend in” with the existing environment and they should be unobtrusive
 - Possibility to integrate appliance in fitted kitchens
 - A range of sizes for different sized households including a small unit for single people
 - Appealing design, e.g. new look to promote the fact it is a new idea
- Feedback
 - Record a household’s consumption and savings in terms of energy and financially
- Noise reduction

4.1.7 Different sales arguments for different consumer groups

Smart appliances might be particularly attractive for people who are fond of innovative products and “last generation” products and who appreciate electronic functions and interfaces. These represent a certain consumer group of so called early adopters. In our research we could not find significant differences between these consumers in comparison to others. The only difference seems to be that for early adopters the costs of smart appliances play a minor role and they have a better understanding of how the technology might work. However, from experts view it is likely that this consumer type will be the first to buy smart appliances. For them smart appliances and their utilisation should be associated with a “new” “modern” and “progressive life style”.

For a broader public it will be essential that people have the feeling that they are doing the right thing, that smart appliances are perceived as mature and experiences exist that they are working satisfactorily, so for them safety and reliability will be the keywords to promote smart appliances.

Consumers remarked that smart appliances might not be suitable for older people, as they are less flexible. Also families with small children might be less attracted to smart appliances, as they have a tight time management. For younger people or people with low income the appliances might be too expensive. On the other hand it was assumed, that smart appliances might be attractive for people who spent a lot of time at home and can wait for the service or react to incoming signals. But in fact, people who spend a lot

of time at home, are likely retired persons, persons with small children or students. In promoting smart appliances such implicit estimations have to be addressed.

The current research only superficially touched this topic, further investigation will be necessary to match smart appliances to the demands of different user groups.

Although no significant correlations between education, profession, income and acceptance of smart operation could be found, the high participation of academics in the current survey indicate that consumers with higher education and higher income will be more interested in this topic, as well as people with ecological motivation.

4.1.8 Main actors to foster implementation

The interviewed experts put it clearly that the major benefit of smart appliances is for the utilities, which most often operate also a network and the transmission system. And the most profit of smart appliances controlled by utility requirements is drawn by an optimisation of the whole chain from generation, to transmission and distribution, to the consumer. Also consumers view it partly this way and expect from the energy utilities to provide attractive offers.

All in all a market penetration of smart appliances implies the collaboration of many actors: informed consumers, utilities and grid operators, which ensure a standardisation, programmes on European and national level that promote smart appliances. A prerequisite for a synchronised supply and demand is to distribute the advantages to all actors. As one of the experts put it: “In the end, the interest is not for the consumer who could save e.g. 40 Euro per year with a very efficient new water heater. But 6 million of water heaters saving each 400 kWh per year in terms of 2020 target, this is another story.”

5 Conclusions

For the introduction of smart appliances the acceptance of consumers is a key factor. The quantitative and qualitative consumer research using interviews, questionnaires and focus groups, which was conducted in five European countries, namely Austria, Germany, Italy, Slovenia and UK, shows a very high basic acceptance level of consumers towards smart appliances.

For the interpretation of the results it has to be considered that the sample for the quantitative research has some specifics: We have a high rate of academics (40%), the majority of respondents (62%) are male, middle-aged (between 36-50 years) and work or have worked (53%) in a technical field, with an income between 2000-3000 Euro (30%). The majority lives in a house, without children (60%). Thus, the high acceptance of smart appliances as found in the survey might not be directly transferable to other social strata. Furthermore it also has to be considered that there is a gap between real behaviour and attitudes. The questionnaire did not ask how respondents really use their appliances, but how they can imagine to use them. Consumers are estimating their future behaviour using appliances, which are unknown to them. Subsequently the high acceptance level and readiness to change their user behaviour in order to be able to use smart appliances has to be evaluated with a certain cautiousness.

For the qualitative research the samples were chosen according to defined criteria. The phone interviews and focus groups give a more sophisticated picture about the underlying conditions for this acceptance.

All in all the findings of the quantitative and qualitative research correspond with each other. The research shows that the consumer acceptance for smart appliances is high, with no substantial differences between the different countries. Overall no significant correlations between age, gender, income, education and acceptance could be found. Only energy saving behaviour seems to have an influence: The more people engage in energy saving behaviour the higher is their acceptance of smart appliances.

The acceptance depends on the respective device and can not be generalised over all appliances. Smart operation for washing machine and dish washer is highly accepted. The potential for a smart tumble dryer is only given, when the tumble dryer is integrated in the washing machine. Time shift of operation is realistic between 0.5 and 3 hours.

Acceptance of smart (automated) regulation of devices such as air conditioner, refrigerator, deep freezer, central heating pump is given, but only if comfort is not lost and users keep full control over the devices.

Main motivator for the majority of consumers to buy smart appliances is the prospect of a financial benefit. The ecological benefit is viewed as a positive side effect, which makes them feel good and indicates their green conscience, but for most people they are not sufficient as the sole reason to buy smart appliances. Only few consumers would buy them, solely for ecological benefit.

The following conditions have to be met in order to convince consumers to buy smart appliances:

- Mature technology
- Maintenance of control
- Acceptable prices and/or subsidies
- Financial incentives for smart operation
- Feasible cost models
- Maintenance or enhancement of comfort
- Good information
- Good usability
- Attractive design

Despite the overall positive attitude towards smart appliances there are many objections which have to be solved before a market penetration is feasible. The objections can be summarised as follows:

- Doubts about the safety of smart appliances
- Doubts whether technology is mature
- Fear to loose control
- Concerns about additional (hidden) costs
- Doubts that ecological effects will be met
- Scepticism about motivation of main actors

To overcome the objections the consumer benefits if using smart appliances must be clear and smart appliances should contribute to increase users comfort. Whether a market penetration of smart appliances will be successful or not will depend on appliance solutions which are comfortable, secure and easy to handle and are combined with attractive tariff options.

If smart appliances e.g. would be safer than conventional ones, this would be for many consumers a USP, which would motivate them to buy these devices.

Important will be the support of national and European institutions to promote smart appliances. The maturity of the technology and the assessment of ecological benefits should be verified by independent institutions.

An information and communication strategy to built trust in this new technology is necessary. But consumers also need to understand the underlying concept of smart operation.

Strategies to raise the acceptance of consumers can be summarised as follows:

- Built trust in technology by equipping appliances with additional safety functions
- Support and promotion by independent institutions
- Provide information about the underlying concept and functioning of the electricity grid
- Offer attractive tariffs
- Let consumer keep control over appliances
- Provide additional services or functions to increase consumer comfort

The current consumer study gives a first insight in consumer attitudes and opinions. Further research about desired tariff structures and handling and operation of smart appliances in real-life situations (e.g. pilot houses) as well as which degree of information consumers need and want are feasible.