Get smart! Consumer acceptance and restrictions of Smart Domestic Appliances in Sustainable Energy Systems

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Abstract
Household appliances represent a significant part of energy consumption in the household. Recent technology developments allow a smart operation of these appliances. Demand-side load management, based on coordinated intelligent operation of large numbers of domestic appliances, is a cornerstone of sustainable energy systems with a higher share of intermittent generation, e.g. from wind or solar energy. The underlying concept of smart appliances in energy efficient demand side management is to consume electricity when it is available and not the other way round. A coordinated smart operation of millions of domestic appliances could have a significant effect on energy consumption and load management and save costs and resources and lead to fewer CO_2 emissions.
Simulations undertaken in the "Smart-A" project (in the framework of the programme "Energy Intelligent Europe") show that many European countries can benefit significantly from smart appliances operation. The technological potentials however depend on the user acceptance with regard to load-shifting, including e.g. delay the start of washing cycles, intermediate interruptions of the operation of appliances, or the use of freezers for temporarily storing energy.

Quantitative and qualitative consumer research using questionnaires and focus groups was conducted in several European countries (Austria, Germany, Italy, Slovenia and UK). Detailed scenarios were introduced to identify to what extent and under which conditions consumers are ready to accept smart operations of appliances. Major changes to daily routines, significant additional cost or loss of comfort

will not be accepted easily. The willingness of consumers to adopt intelligent appliances depends on the perception of a mature technology and on financial gains. Ecological benefits are 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. Economic advantage, higher security and good usability will be the key factors to increase user acceptance when it comes to smart operation of appliances.

Introduction

Smart appliances may contribute to a demand-side load management, which is a cornerstone of sustainable energy systems. The underlying concept of smart appliances in energy efficient demand side management is to consume electricity when it is available and not the other way round. This will save costs and resources and lead to fewer CO_2 emissions. Domestic appliances can offer a range of options for load-shifting, including delaying the start of washing or dishwashing cycles, intermediate interruptions of operation of appliances, or the use of refrigerators and freezers for temporarily storing energy. A key benefit of smart appliances for RES integration is their ability to contribute to the compensation of imbalances which occur as a result of the variability of e.g. wind power generation. A coordinated smart operation of millions of domestic appliances could have a significant effect on energy consumption and load management.

The UK government (DTI, 2005) concluded that a valuation of the approximate annual benefit from a Demand Side Management (DSM) programme in the UK (including Commercial Customers) could lead to savings of between 460000 and 1.3M tonnes of CO_2 over a ten year programme. Such systems require smart energy loads that can coordinate their operation with levels of energy supply (Boardman et al, 2005).
An assessment for the UK shows a potential of 2000 MW that could be saved by equipping the nation's household refrigerators with a "dynamic demand control"-technology that helps balancing out supply and demand on a short term basis. The timing of the activity of a number of fridges is altered without letting the fridge go outside the accepted temperature range. Time shifts of seconds up to several minutes occur (Short et al., 2006).

A vivid debate also arose around the potential savings of households that can be realised by giving a feedback e.g. by a display of their consumption data. The EU directive on Energy End-use Efficiency and Energy Services requiring to inform the consumers on their actual consumption has spurred the roll out of smart meters in many EU countries. This was the background of several studies on the involvement of consumers in this context and a possible change of behaviour concerning energy and electricity consumption (Darby, 2006, Darby, 2008, Fischer, 2008, van Elburg, 2009). In any case the relation of consumers and supplier enters a new phase, demanding a "smart consumer" on the one

side who understands a variety of new issues (with the bill as only a summary) and a “fair supplier” on the other side who let the consumer participate in economic savings.

The project “Smart Domestic Appliances in Sustainable Energy Systems” (Smart-A) aimed to develop strategies showing how smart domestic appliances can contribute to load management in future energy systems. The main objective of the Smart-A project was to identify and evaluate the potential synergies that arise from coordinating the energy demand of domestic appliances both with local sustainable energy generation and with the requirements of regional load management in electricity networks. The potential benefits of using smart appliances are the reduction of losses in the energy system as a result of reduced peak load, thus increasing energy efficiency and reducing overall system cost. Smart-A simulations demonstrate that many European countries can benefit significantly from smart appliances operation. The benefits are highest in countries with high shares of wind power and low flexibility of the conventional generation (for further information see www.smart-a.org).

However, 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. The aim of the consumer research within the Smart-A project was to reveal the extent to which 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.
This paper gives 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 and outlines how to increase the consumer acceptance.

Research approach

For a detailed assessment of the user acceptance of smart appliance operation a mix of quantitative and qualitative methods was used. As a first step, a survey with questionnaires was conducted in five European countries. The aim of the survey was to obtain 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 initial costs of smart appliances. The questionnaire was distributed in three different ways. Originally it was planned to distribute the questionnaire to client databases of energy suppliers, but this was only possible for Austria and Germany. In Slovenia and Italy face-to-face-interviews with consumers in shopping malls were performed. In the United Kingdom the interviews were done with an online-questionnaire, which was distributed to a database of 11.000 persons on the university campus. The sample size for the survey differs between the respective countries, as a result of the different methods of distribution.

Table 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

Subsequently phone interviews with selected respondents of the survey were carried out, which allowed a better understanding and assessment of the survey results. From every questionnaire sample ten participants were selected for the phone interviews. Aim was to select primarily those consumers 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.

Finally, focus groups enabled a thorough discussion of consumer attitudes towards smart appliances. Focus groups are well suited to answer questions of social perception and provide results which are in general terms often similar to representative surveys, but allow for much deeper analysis. The approach is effective for the following reasons: It allows a deep analysis and understanding to get to the core of different consumer needs and perceptions and response regarding smart appliances. It furthermore enables to answer the "why" questions behind the evaluated consumer perceptions and goes beyond rational and superficial responses. It allows a flexible research progress as it enables to explore insights emerging during the process. Main questions were whether consumers would adopt smart appliances and which scenarios have to be met in order to accept them. As smart appliances are in the design phase and subsequently no real experiences with such devices are given, it takes time to introduce the concept. To be able to discuss all relevant questions it was decided to do serial focus groups, to have enough room to introduce the concept and to give participants time between the focus groups to think about the implications. The participants were selected according to criteria such as gender, age, occupation, income, household size, living area, regular use of household appliances, technical know-how/interest, environmental attitudes.

The flexibility of smart appliances operation is driven by the penetration, technology and usage patterns of appliances and by the acceptance of consumers to use smart appliance operations. For the purpose of the research three simplified user scenarios of smart appliance operation were presented to the consumers and they had to estimate whether they would accept each and under which conditions. The modes differ according to the extent of user interaction, but also regarding to their costs as can be seen in the table below. These simplified scenarios were developed on the basis of a model by the University of Bonn. The model describes the power demand per household appliance and the average power demand per day of a bundle of household appliances, both local and regional and identifies the

relevant parameters for the possibilities of domestic appliances to adapt their operation to the requirements set by the energy supplier. The technical possibilities for a flexible operation of 10 appliances were investigated, including the impact of the quality of service delivered by the appliance caused by adjustments suggested (Stamminger, 2009).

Table 2 Operation modes

Appliance		**Operation mode**		
		Mode A: The user presses a "smart mode" button and defines by which time the operation must be finished at the latest. Operation starts after the appliance receives a signal (e.g. power-line triggered) from the utility that renewable energy is available.	Mode B: The user is informed 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 delay the operation or not.	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.
Appliance group 1	Washing machine	10-50 EUR	5-25 EUR	
	Tumble dryer	10-50 EUR	5-25 EUR	
	Dish washer	10-50 EUR	5-25 EUR	
Appliance group 2	Air conditioner		5-25 EUR	10-100 EUR
Appliance group 3	Refrigerator			10-100 EUR
	Deep freezer			10-100 EUR
	Electric heated boiler			10-100 EUR
	Electric space heating			10-100 EUR
	Central heating pump			10-100 EUR

Consumer opinions about smart appliances

Whereas the study "Vernetztes Wohnen" (Meyer et al., 2001), in the year 2000 found a rather negative attitude towards smart homes (50% have a negative attitude, only 30% view it in a positive way) and the attitude towards single smart appliances was often labelled with objections like it is "too expensive", "too complicated" or that such technologies are error-prone, this has clearly changed in the meantime, probably due to the broad uptake of cell phones, touch panels, smart devices, etc. The research at hand shows that the consumer acceptance for smart appliances is rather high, with no substantial differences between the different countries.

Regarding the three different operation modes as described above we found that the consumers would accept all three presented options. No clear preferences for one of these operation modes could be distinguished. 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 operation mode B 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 found it difficult to grasp the concept. They could not see the benefits of this solution as many of the respective devices use night tariffs anyway. 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. However, if they are able to override smart operation, if desired, and no loss of comfort occurs, this mode is also widely accepted.

Averaging over all countries up to 90% of the respondents would accept different options for smart operation of appliances. But the acceptance depends on the respective device and can not be generalised over all appliances. Smart operation for washing machine (see Figure 1) for example is highly accepted. Depending on the country, 88 to 97% of the respondents would accept smart operation. Similar results where obtained for smart dish washer and tumble dryer. However the potential for a smart tumble dryer is only agreed, when the tumble dryer is integrated in the washing machine, as users are usually not willing to wait for this service. As one respondent put it:
"[…] I have a four persons household, if the weather is bad and you need clothes, then I need the dryer immediately. A smart operation is difficult, although I believe that the dryer in comparison to the other appliances, because it needs a lot of energy, would profit the most from a smart operation. But in real life, at least for me, I would not use it. If I have time to dry the laundry on the line, I wouldn't need a dryer."

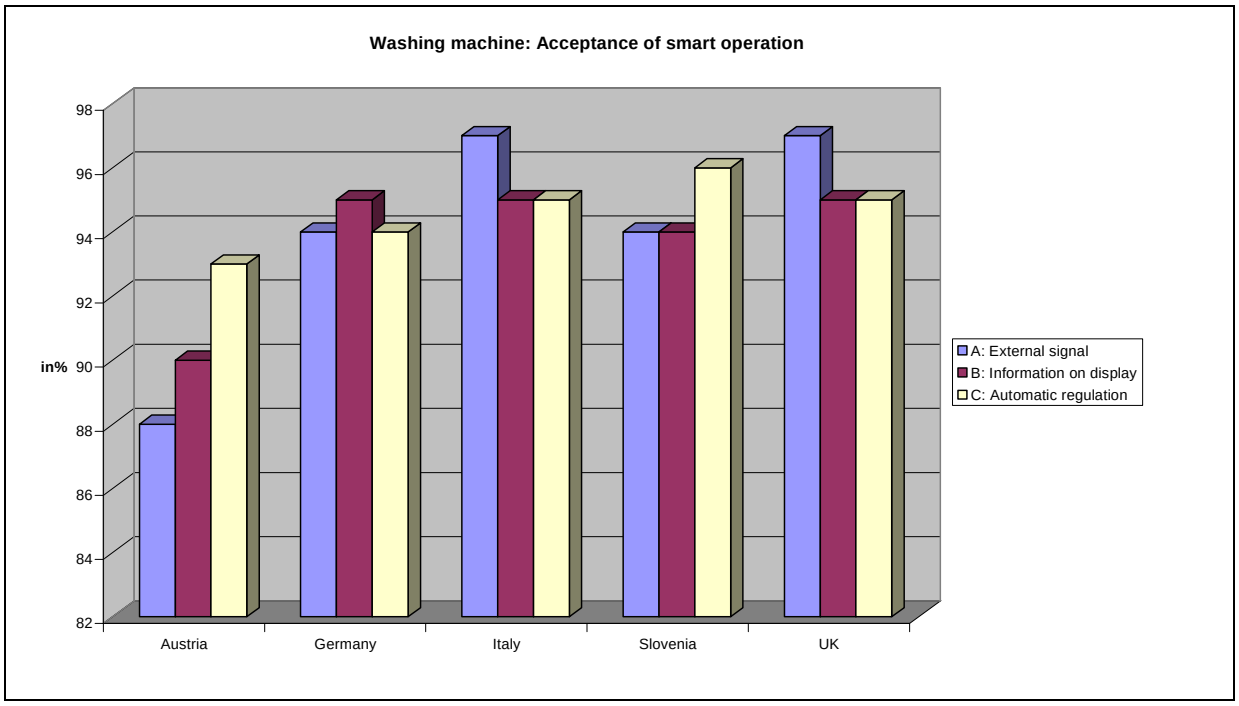

Figure 1. Washing machine: Acceptance of smart operation.

Smart (automated) regulation of devices such as air conditioner, refrigerator, deep freezer, central heating pump is accepted, but only if comfort is not lost.

"As long as a correct service is guaranteed no consumer would care if the smart-story is running. If you can save some money – so much the better."

"You'd never know about it, perfect."

According to the survey up to 98% of the respondents would accept for example the smart operation of a refrigerator and deep freezer (see Figure 2).

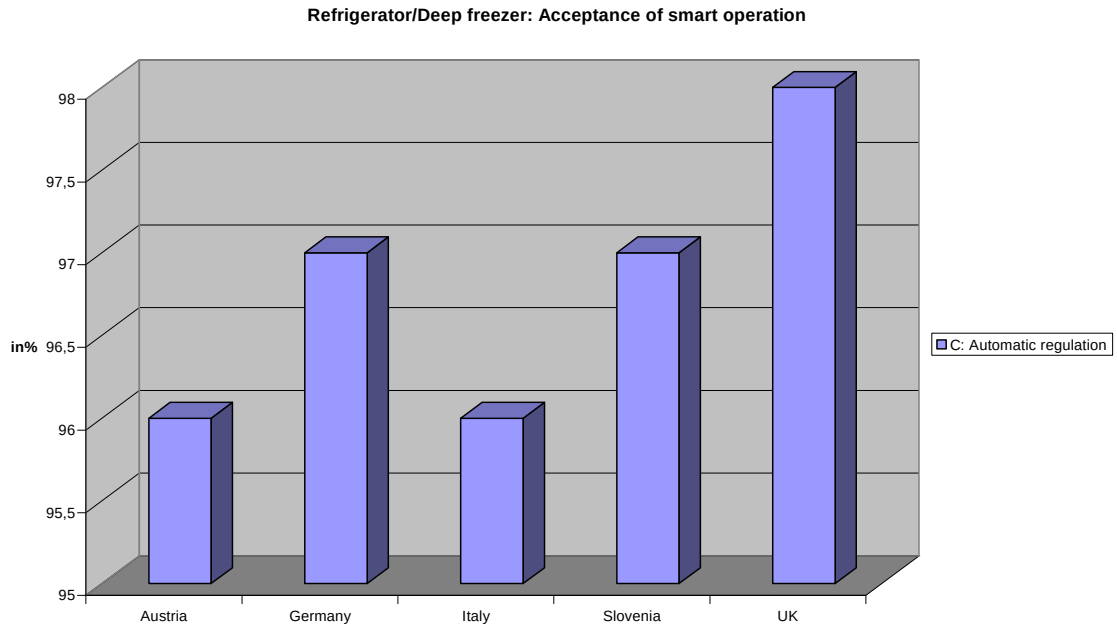

Figure 2. Refrigerator/Deep freezer: Acceptance of smart operation.

However a key factor for consumer acceptance is the maintenance of control. One background reason for 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. Service on demand is important to them and they are afraid that if operation is influenced by the energy provider comfort might decrease. So even in case of automatic regulation they want to keep control over the appliance.

"I want to keep control, the way I imagine it now there are several possibilities, either there is a huge regulation behind it, because many appliances have a certain cycle and when it is turned off in the middle of the cool down than it is bad for the appliance. I want to be able to control the cycle – I don't want the energy supplier to control it. In any case I want some kind of emergency button or something."

"To me it's an outside company dictating what you do in your own home...this is just one step too far."

Overall no significant correlations between age, gender, income, education and user 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. For more details see Smart-A report D 5.2 Evaluation report – consumer survey on smart appliances (Suschek-Berger & Mert, 2008).

Willingness to change user 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.

"It would be a problem for me to change my habits. I am used to do my laundry and to take washed clothes out in about an hour. Maybe some extra stimulation would convince me to change my habits in order to use smart appliances. We don't change our habits just like that, someone or something has to push us – some financial benefits for example. I think 10% lower bill for energy every month is ok."

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. A shift of between half an hour and three or four hours is realistic, precondition is that comfort is not lost.

This corresponds to results of the study "Preis, Verbrauch und Umwelt versus Komfort – der mündige Energieverbraucher" (Thieman et al., 2007) which showed that in case of differentiated tariffs with cheaper energy (e.g. during night) a majority would be ready to do the housework during these times, as long as comfort is not reduced. This is especially the use of washing machines, dish washers and dryers as well as the recharging of rechargeable batteries. An adaptation of habits and time management is refused.

Motivation to buy smart appliances

The 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 for buying smart appliances. Only few consumers would buy them solely for ecological benefit.

“The point is... if you replace something, it's effort. You have to care for the disposal or sell it. And the installation etc., it all causes big efforts. The incentive has to be really big to bring oneself to buy a new one.”

“I would buy it, no matter if price of smart appliance is higher. If price of energy stays same and there are ecological benefits, I would buy it.”

Consumers were aware about additional metering and installation costs with regard to smart appliances. In general additional costs of 100 Euro for smart meters and installation would be accepted in order to be able to use smart appliances. The willingness to bear such additional investment costs depends on possible savings.

All in all, consumers expect low additional costs for smart appliances. 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. Higher prices might be acceptable, depending on the specific 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.

“[…] the promise of payback within three years is a bit shady for me. Because washing practices are different. I assumed, washing twice per week, and calculated 15 Cent for reward. How should this reward look like, so it works? That is a shady promise, which can not be kept. This means someone who washes everyday – I don’t know three, four small children – and someone in a single household who washes once per week will have different payback times. That’s not working. So much can’t be rewarded.“

“50 Euros is not a lot, but if it’s 50 Euros more than another product I would still want a measurable benefit.”

“This is not a selling point – 50 Euros payback over three years is nothing – I would just buy it for environmental reasons.”

Consumer objections

Studies about smart homes (e.g. Haines et al., 2005) showed that the successful introduction of smart technologies into the home is related to a number of challenges: Consumers may be resistant to the new concepts that the smart home presents, they may have limited technical experience to operate the system effectively which may reduce their motivation to use it, etc. Despite the overall high acceptance of smart appliances in the current study, consumers also expressed many objections, varying from safety fears, to potential technical problems to emotional scepticisms when it comes to smart operation of appliances.

One major concern of consumers is that they feel uneasy leaving their appliances switched on, if they are not at home or during night. In the words of a respondent: *"Well, it sounds highly interesting, but I personally do not like to leave an electrical appliance turned on, when I am not at home. For a washing machine, there is a risk. These appliances would need sufficient security mechanisms, so I can be sure, nothing might go wrong. I don't leave my home when an appliance is working."*

Consumers are afraid of break-downs which might lead to flooding 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 the night, but are much less worried about the dish washer, although both appliances work very similarly. Obviously they are already used to running the dish washer unattended and they are more concerned about their clothes: *"I'm not bothered about dishes, but clothes are quite personal things – we express ourselves through them."*

Safety issues are also 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 works.

In a study in Switzerland (Devine-Wright, 2005) experts from demand side and suppliers were asked how their own customers would like "smart living", they said that 93% are too less informed. When asked what they themselves are experiencing or missing, 85% criticize that too many and confusing terms are used, 59% stated that information search is too time-consuming, 56% criticised that suppliers for information were missing and 49% stated that the existing information was incomplete. The Smart-A study confirms the need for good information, at least for the consumer side. Consumers have only a vague idea how smart appliances might work and have to some degree difficulties in understanding the underlying technology. They lack knowledge of 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.

"What is for example at noon, the sun shines brightly, the signal comes that renewable energy is available, and people start millions of washing machines. How is it controlled? First come, first serve? Or is it distributed evenly? Do I know if I am using renewable energy or is energy supplied from elsewhere, because millions of washing machines are running?"

"Maybe it is smart to have some important organization standing behind this project... I don't know…EU maybe or some other institution with good reputation. People would have more trust that smart appliances are ecological and consumer friendly and would buy them in a higher degree."

In the survey only 36% of the respondents were afraid that smart appliances are more error-prone (see Figure 3), but the interviews showed that some concerns exist that smart appliances might easily break-down because of the additional electronics or have shorter lifecycles because of interrupted operation. Consumers consider it important to know for example, whether spare parts can be bought or whether the device as a whole has to be replaced. They want be sure that a good support and repair service will be available.

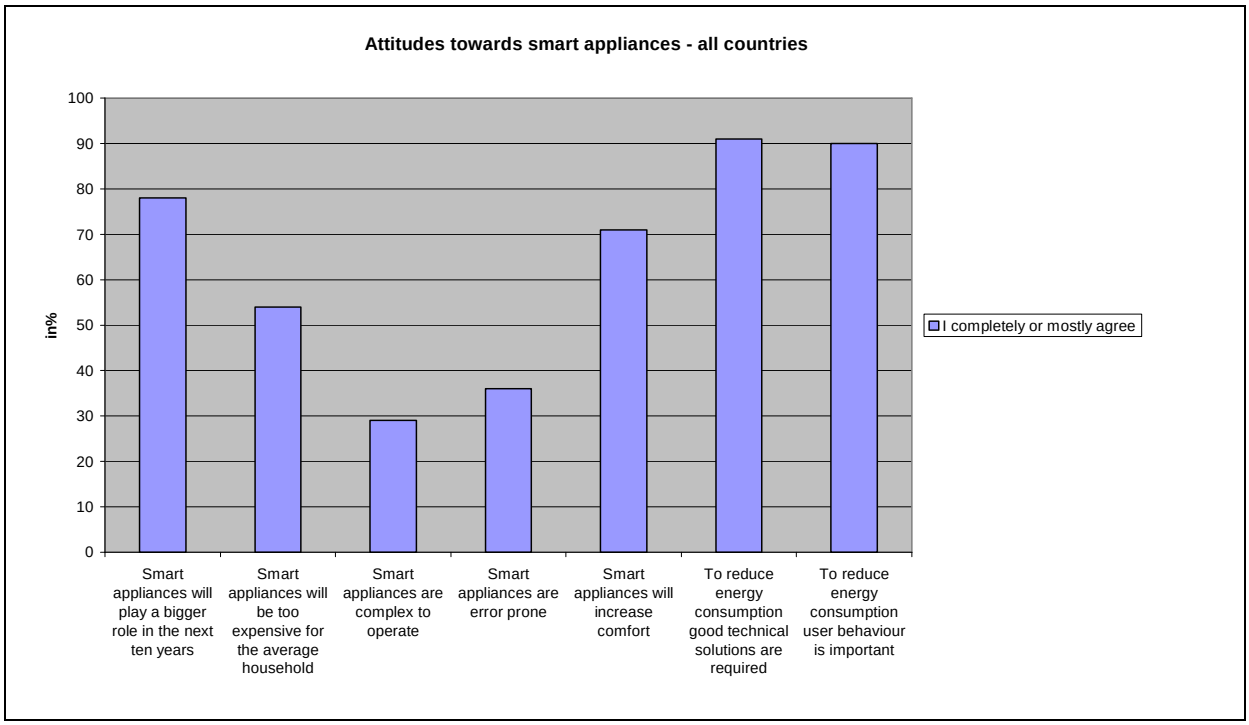

Figure 3. Attitudes towards smart appliances (all countries).

Feedback

Studies showed that on one hand consumers view consumption information as useful, as it helps them to save money. On the other hand they are afraid of a big brother effect and they fear that data recording might be misused. Younger generations were more open-minded towards the connection to external networks than older generations (Meyer et al., 2001; Haines et al., 2005).

In Germany the project Intelliekon investigates how smart meters might provide a feedback on energy consumption which meets household expectations. A study within the project shows that the majority of consumers is interested in feedback information about their own energy consumption. But during the process of exploration of smart metering and feedback systems, especially those group of consumers, who in principle had a positive attitude, expressed concern because of lacking data and privacy protection. A minority rejects feedback because of various reasons such as fear that one owns behaviour might be monitored, indifference or refusal to deal with the topic, or expecting too little reward from feedback. During the discussion process questions of data protection are raised at those point of time, when consumers realise that feedback on energy consumption also means that data of the household is generated, which might fall into wrong hands or make the customer "transparent" (Birzle-Hader et al. 2008).

In the study at hand most consumers were not concerned about the monitoring of their energy consumption by their energy supplier. 93% of all respondents would accept this (definitely or probably), 54% say definitely yes. A comparison of the survey answers by country showed that older people (over 50 years) seem to be less sceptical, as well as respondents with apprenticeship or academic degree. Also the qualitative research showed that some consumers would rather accept a permanent monitoring of their energy consumption and they do not expect any incentives for it. *"I would just be one tiny digit out of 10 million people."* 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.

"The energy distributor should protect my data, they should have it in some codes or something…only authorized person can use that data and only for internal needs."

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 reprimanded.

"It would be great to have some kind of insight into how much money is saved and also how much energy is saved. It is nice to know what mine contribution to cleaner environment is."

We asked the respondents 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 in Austria (see figure 5).

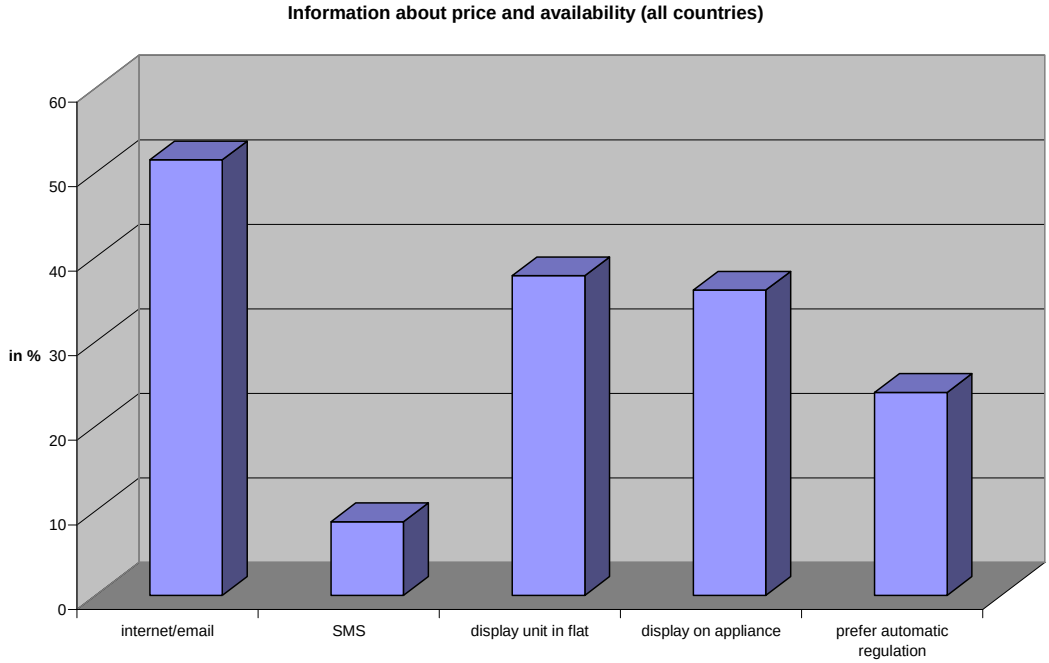

Figure 4. Information about price and availability (all countries).

Conclusions

Despite the overall positive attitude towards smart appliances for the interpretation of the results one has to keep in mind 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 live in a house, without children (60%). These 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. But 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 foresee using them. Consumers are estimating their future behaviour using appliances, which are unknown to them. Consequently the high acceptance level and readiness to change their user behaviour in order to be able to use smart appliances must be judged with a certain cautiousness.

The phone interviews and focus groups give a more sophisticated picture about the underlying conditions for consumer acceptance. The qualitative results suggest that consumers reconsider the issue and raise more concern when they start dealing with the subject in more detail, subsequently also their acceptance level changes. All in all, the findings of the quantitative and qualitative research correspond with each other and help to draft starting-points to optimise scenarios for the use of smart appliances.

Concluding consumers would be ready to buy smart appliances if

- the technology is perceived as mature and safe,
- they need a new appliance anyway,
- handling is easy,
- comfort is maintained or enhanced
- and consumers maintain control over the appliances.

Strategies for increasing consumer acceptance

The results of the consumer research show that consumers have in general a fairly 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 that exist. This will depend partly 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. The support of national and European institutions to promote smart appliances will also be important. An information and communication strategy to built trust in this new technology is necessary. Detailed information on possible strategies for increasing consumer acceptance is available in the Smart-A report D 5.5 Consumer acceptance of smart appliances (Mert et al., 2008).

Build trust in technology

Major objections of consumers are based on safety issues in a broad sense but also relate to any possibly greater strain on household items. Clearly use patterns play a big role here. Consumers are, for example, not accustomed to using the washing machine and tumble dryer when they are not at home. Instead of special guarantees for the appliances, users expect a high tech solution which prevents any damage. 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 inconvenience. 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 leaving an appliance unattended. For many consumers this 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 e.g. temperature and working process might help to overcome barriers, as well as the information that conventional energy will be used if not enough renewable energy is available.

Support of Smart-A concept by independent institutions

There is a lot of consumer scepticism that economic goals are hidden behind a "greenwashing" attitude. As consumers pointed out, information provided by the main beneficiaries (energy suppliers, manufacturers) will be met with reluctance. To overcome their doubts, the promotion of smart appliances should be supported by independent institutions, like governmental institutions at 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.

Provide coherent and comprehensible information

Most consumers have difficulties in understanding 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 easily

understandable. The information should help the consumer to get an idea of his load curve, his saving potential and what are appropriate actions, such as peak load reduction.

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 reducing the environmental burden. As the results of the research show, the majority of consumers clearly expect an economic benefit before they would 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 a single smart appliance will be rather low. For some consumers even such small savings would be a motivator, under the condition that the technology works 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, 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.

Provide options for consumers

The consumer research assessed 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 thinking about load management and shape their user behaviour accordingly. The more the systems work automatically, 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 decide actively whether to operate their appliances in a smart mode or not and overrule smart operation any time they want.

European standards for smart appliances will be a helpful way of increasing consumer acceptance, 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.

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 necessarily 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 attractive enough 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.

To sum up, 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

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. Also aspects of data protection and privacy issues need further investigation.

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.

References

Birzle-Hader, B. Deffner, J., Götz, K., 2008), Lust am Sparen oder totale Kontrolle? Akzeptanz von Stromverbrauchs-Feedback. Ergebnisse einer explorativen Studie zu Feedback-Systemen in vier Pilotgebieten im Rahmen des Projektes Intelliekon

Boardman B., Darby S., Killip G., Hinnells M., Jardine C.N., Palmer J. and Sinden G., 2005, 40% House, Environmental Change Institute, Oxford University, p. 77 -81

Darby, Sarah, The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays, Environmental Change Institute, Oxford, 2006

Darby, Sarah: "Why, what, when, how, where and who? Developing UK policy on Metering, Billing and Energy Display Devices", ACEEE 2008, 17-22 August 2008, Asilomar.

Devine-Wright H., Devine-Wright P., 2005, Representing the demand side: 'deficit' beliefs about domestic electricity users, De Montfort University Leices-ter, p. 1343 – 1348

DTI, 2005, A Scoping Study: Demand Side Measures on the UK Electrical System, UK Department of Trade and Industry.

Energy Saving Trust, 2008, Domestic Heating by Oil: Boiler Systems – guidance for installers and specifiers (2008 edition), p. 60

Fischer, Corinna, "Feedback on household electricity consumption: A tool for saving energy?, Energy efficiency 1 (2008), pp. 79-104

Haines V., Maguire M., Cooper C., Mitchell V., Lenton F., Keval H., Nicolle C., 2005, User Centred Design in Smart Homes: Re-search to Support the Equipment Management and Services Aggregation Trials, Ergonomics and Safety Research Institute, Loughborough University, p. 1- 110

Hinnels M., 2008, Technologies to achieve demand reduction and microgeneration in buildings, Energy Policy,Volume 36, Issue 12, December 2008, Page 4429

Mert W., Suschek-Berger J., Tritthart W., 2008, Consumer acceptance of smart appliances. D5.5 of WP5 report of Smart-A project.

Mert W., Pozzi D., Hogan S., 2008, Consumer acceptance – Summary report of the results of phone interviews. D5.3 of WP5 report of Smart-A project.

Mert W., Pozzi D., Pirotte C., Watts M., Hogan S., 2008, Consumer acceptance – Summary report of the results of focus groups. D5.4 of WP5 report of Smart-A project.

Meyer S., Schulze E., Helten F., Fischer B., 2001, Vernetztes Wohnen – Die Informatisierung des Alltagslebens, p. 129 - 217, Berlin

Shafiu A., Watts M., 2008, Communication and Control Requirements, D4.4 Part III of WP4 report of Smart-A project

Short, Joe; Leach, Simon, Using smart appliances to provide peak-load management and increase the efficiency of the electricity network, EEDAL '06, 21-23 June 2006, London

Stamminger R. (ed.), Synergy Potential of Smart Domestic Appliances in Renewable Energy Systems, Schriftenreihe der Haushaltstechnik Bonn, Band 1/2009, Shaker Verlag, Aachen 2009

Suschek-Berger J., Mert W., 2008, Evaluation report – consumer survey on smart appliances. D5.2 of WP5 report of Smart-A project.

Thiemann R., Passenberg I., Suer S., Krüger T., Schmitz M., 2007, Preis, Verbrauch und Umwelt versus Komfort – der mündige Energieverbraucher. Verbrauchsverhalten und neue Möglichkeiten zur Kundenbindung und Kundengewinnung für Energieversorger, p. 1 – 16

Tritthart W., Mert W., Reindl K., 2008, Working paper on general consumer preferences and restrictions. D5.1a of WP 5.1 from Smart-A project.

van Elburg, Henk, Smart metering and in-home energy feedback; enabling a low carbon life style, ECEEE 2009, 1-6 June 2009, La Colle sur Loup, France