Reducing Standby Consumption in Households: By Means of Communication or Technology?

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ABSTRACT

This paper deals with standby consumption of information and communication technologies in private homes. The main issue is if more information campaigns are needed or if the focus should be on technologies that help to switch off standby mode. The project reported is a research project with the purpose of investigating households' standby behavior and the project design is thus not directly transferable as a broader program. However, the project is designed to uncover knowledge on households' standby behavior which can inform development of such programs. The paper presents an analysis of a research project where 30 families for one year had standby consumption from information and communication technologies simultaneously measured. In the first phase of the project, consumption was just measured, in the next phase families were informed about how to reduce standby consumption, whereas in the last phase the families were provided with technological solutions to help reduce standby consumption. In the end of the project in-depth interviews with ten of the families were conducted, focusing on practices and understandings in everyday life with relation to standby consumption. Analysis showed that one third of the standby consumption could be reduced by means of communication and another third by means of technical devices. The last third of the standby consumption remained untouched in spite of all efforts in the project. This last third was mainly found in families with older children, where for instance several computers were connected to the same internet access, or other types of connected electronics.

Introduction

As early as 1993 it was predicted that standby consumption would become a pressing challenge, and its size today confirms how difficult it was to prevent standby consumption from growing (Sandberg 1993). In recent years a number of articles and reports on this subject have dealt with how to define standby, how to estimate the size of it, and how to limit it.

Discussion of the definitions of standby reveals that it is difficult once and for all to define standby consumption, as technological development is so fast that the definitions may be outdated before agreements have been reached. Thus the International Energy Agency recommends not wasting too much time on discussing the definitions of standby, but instead countries should actually launch political initiatives to reduce it (IEA, 2001). On the other hand, the lack of a commonly agreed definition makes it difficult to compare results from different research projects, as it may be rather different things that have been measured in the different projects. Some definitions include for instance storage use in water heaters, whereas other definitions restrict it to electronic products (IEA, 2001). Furthermore it has been pointed out that standby can refer to many different modes of the same appliance, and that it therefore may be appropriate to differentiate between for instance active (VCR programmed to record later) and passive standby (just waiting for a remote signal) (Lane & Wajer 1997). Moreover computers

and printers have different types of sleep modes and as a way of summarizing all these different modes the term 'lopomo', low-power-mode, was introduced (Meier, 2005).

There are at least two different ways to determine standby consumption in households: one way is through bottom-up models where market statistics on electronics are combined with modeling of households total electricity consumption. This was done in an American study, which concluded that about half of the total electricity consumption of consumer electronics is consumed while the appliances are in standby mode (Sanchez et al. 1998). The other way to determine standby consumption is to actually measure it. However, following the discussions on different ways to define standby consumption, also, there is no one commonly agreed way to measure it. Another American study is based on spot measurement of watt consumption in ten households of all the appliances in the mode in which the households normally left them in (Ross and Meier, 2002). In this way however the actual behavior of the households is not really measured. The most accurate way to measure standby consumption is to have continuous measurements of both in-use and standby consumption of appliances in ordinary households. The most comprehensive study done in this way is probably the EURECO project that included 100 households in each of four European countries, and including all appliances and lights in all households, measured over one month (Sidler, 2003). The Danish part of these data has been further studied, and it was concluded that standby consumption for consumer electronics in Danish households varies between 0 and 1300 kWh per year, on average 8 % of the total households consumption is used on standby consumption, though in more than 10 % of the households between 15 and 28 % of their total electricity consumption is used on standby (Gram-Hanssen, Kofod and Nærvig Petersen 2004). A recent review study, including both published and unpublished studies, concludes that standby consumption in developed countries ranges between 60 and 110 W per household, corresponding to an average of between 4 and 11 % of the households' total electricity consumption (Meier, 2005). European households are in the lower end with 50-70 W per household, with countries like Denmark in the upper end (Meier, 2005). However, one of the sources for the conclusion is based on preliminary results from the study presented here.

Concerning the question of how to limit standby consumption most of the reports and articles concentrate on how to influence producers of consumer goods to make products with low standby consumption. It is concluded that there is no technical problem in doing this, and the question is, what political tools that are most efficient (IEA, 2001)? Australia seems to be one of the leading countries regarding policies to limit standby consumption with their plans for no appliances to use more than 1 W in standby (Harrington and Holt, 2003). However, while we wait for the 1 W program to be fully realized, it might be relevant to see, to what extent it is possible to persuade consumers to turn off the standby mode of their appliances, either by new routines or with technical help.

Thus in this project we investigate to what extent it is possible to limit standby consumption in consumer-oriented approaches, and furthermore we ask what the most efficient way of doing this is: by different types of communication or by installation of technical devices to reduce standby power (e.g. devices which make it easier to manually turn off products or products that are automatically turned off). Technical devices include auto-saver plugs for television and PC, remote control or time switches for power boards.

In the following paragraph the methods of the study is described, and this is followed by a section presenting some of the main results of the study. In the conclusion the policy implications of the results are discussed.

Methods

The project reported here is a research project with the purpose of investigating how households' standby behavior can be changed and the project design is thus not directly transferable as a broader program. One reason is that some of the activities are very expensive and they are mainly carried through because of research interest e.g. the measurement activities. The project is thus not a prototype of a program but a project designed to uncover knowledge of households' standby behavior which can inform development of such programs.

In this project, electricity consumption from information and communication technologies (ICT) in thirty families was measured over more than a year in a way that both standby consumption and in-use consumption could be calculated. Measured technologies included televisions, VCRs, DVDs, playing consoles (in the following called televisions including associated technologies) computers, printers, scanners, loudspeaker (in the following called computers including associated technologies) and hi-fi. The reason for focusing on these types of standby consumption are that other measurement studies in Denmark have showed that more than 85 % of household standby consumption related to these types of end-use (Gram-Hanssen, Kofod and Nærvig Petersen 2004). In this project standby was defined as the mode appliances were left in during nighttime, when not in use. The measurement period were divided into three phases:

- *Reference period*, when the standby consumption was registered before we tried to influence the family to lower it.
- *Communication period*, when the families were influenced by means of different types of communication, including posted leaflets, visits from an energy adviser and the possibility of following their own standby consumption on a web site.
- *Technology period*, when different types of technical devices that made it easier manually to turn off standby or which did it automatically, was handed out. Technical devices included: auto saver ploughs for television and PC, remote control or time switches for power boards.

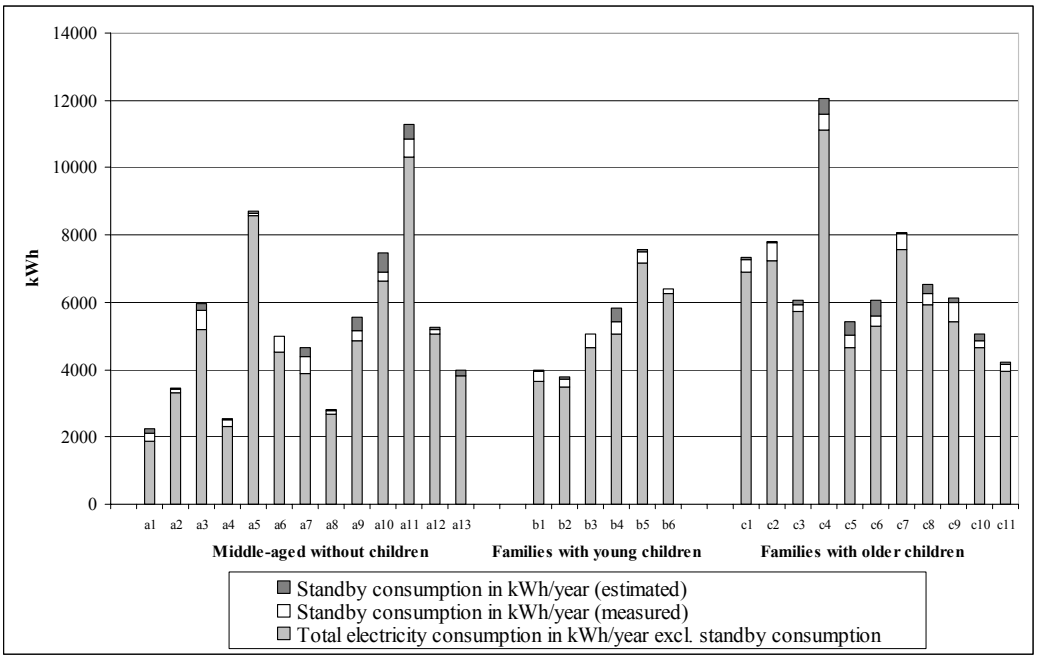
The thirty families in the project all live in owner-occupied detached houses, and their income as well as their energy consumption were slightly in the higher end compared with the Danish national average. Thirteen of the families were middle-aged or older persons without children at home, six families were couples with younger children and eleven of the families had older children at home. As the number of thirty households was too limited to be statistically representative of the Danish population as a whole, we did not seek to find representative households as much as we wanted to find households with a notable amount of standby consumption to make sure that there was actually something to influence. It was the intention to measure all information and communication technologies (ICT) in the households, but the company contracted to put up the measurement devices, failed to find all appliances. The appliances that were not continuously measured, were spot measured for their watt effect in standby mode. By comparing the appliances that were measured continuously and those we only made spot measurements on we found that the continuously measured were representative of the total amount of standby consumption, as regards distribution on different types of appliances.

At the end of the measurement period, ten families were selected for qualitative interviewing. Criteria for selection were variation in how and to what extent the family was influenced by communication or technological devices for reducing standby consumption.

Results

In this section we will first characterize the standby consumption in the thirty households in the reference period, i.e. the period before we tried to change the standby consumption. Then we will explain some about the habits related to appliances in use, and finally we will concentrate on the main results related to the question of how the standby consumption was effected by the different measures.

Figure 1. Standby Consumption (Measured and Estimated) As Part of Total Electricity Consumption in Thirty Households

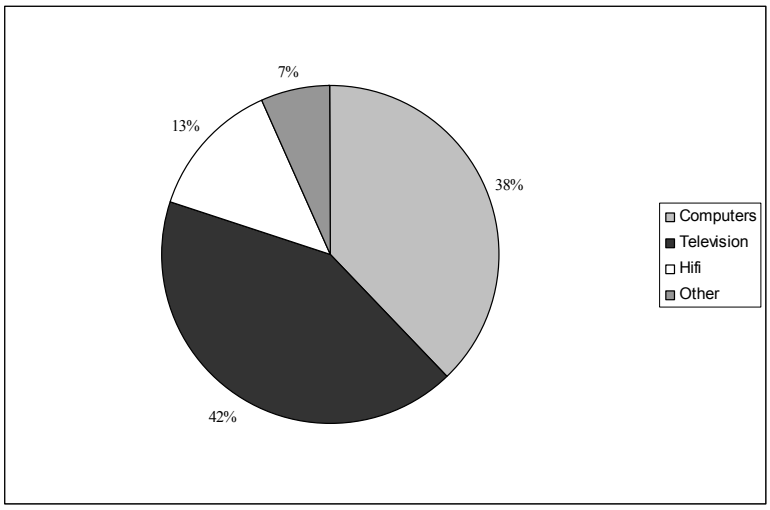


Total electricity consumption as recorded by the utilities, measured standby consumption (reference period) and estimated consumption based on spot measurements combined with estimated use.

Figure 1 shows a big variation in the total electricity consumption as well as in standby consumption in the thirty households. Standby consumption in these households ranged between 2 and 18 % of the total consumption, corresponding to a variation from 120-980 kWh yearly standby consumption. We got detailed measurements of about 65 % of this standby consumption, whereas the rest is calculated on the bases of spot measurements. Effect in standby varied from 17 to 130 W, with an average of 67 W. This was quite comparable with results presented in the introduction, keeping in mind on one hand that these thirty households were expected to be in the higher end of the Danish national average, and on the other hand that we only included standby consumption for information and communication technologies (ICT). The households in Figure 1 are arranged in three groups: middle-aged without children at home, families with younger children and families with older children. This arrangement enabled us to test the thesis that teenagers and middle-aged people have very different use pattern regarding

ICT. The figure show that there was a tendency towards older persons had lower total electricity consumption, which was expected as there were also fewer members in these households. However there was no tendency that the amount of standby consumption was smaller among the families with the oldest members. Analysis of how standby varied with income showed a tendency towards higher standby consumption, as well as higher total consumption, with higher income, but the material was too limited to show any significant results of these types of correlation.

Figure 2. Distribution of Standby Consumption on Types of ICT



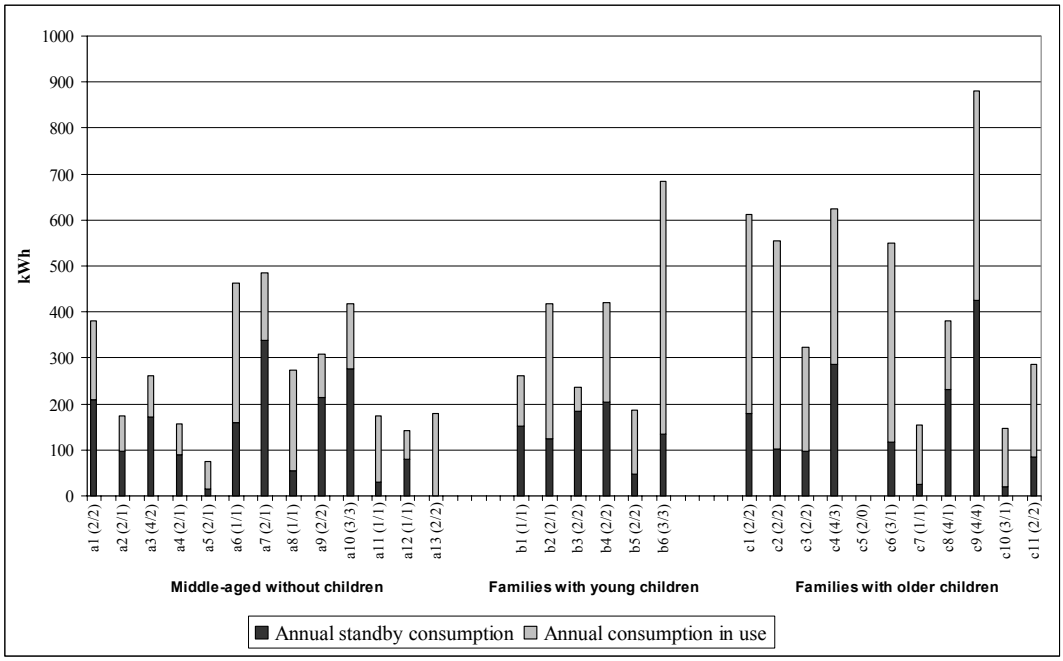
The figure contains both measured standby consumption based on exact measurements and estimated consumption based on spot measurements combined with estimated use.

In this project we concentrate on standby consumption for ICT. However, as seen in Figure 2 the majority of this standby consumption relates to television and computers with their associated technologies, whereas standby consumption relating to music, telephones etc. are of minor importance. The category 'Others' includes: telephone, alarms etc. Therefore in the following we concentrate on television and computers, including associated technologies.

Figures 3 and 4 show that especially in some of the middle-aged families without children at home they used more electricity on computers and televisions when they were on standby compared with when they were in use. Especially we found that several of the middle-aged families almost only used electricity for the computers when they were on standby, while they practically did not use computers at all (Figure 4). In general 42 % of the measured electricity consumption for ICT was used in standby mode, and 58 % for appliances in use. Data analysis furthermore shows that for 20 % of the appliances standby consumption account for more than 90 % of the total consumed electricity.

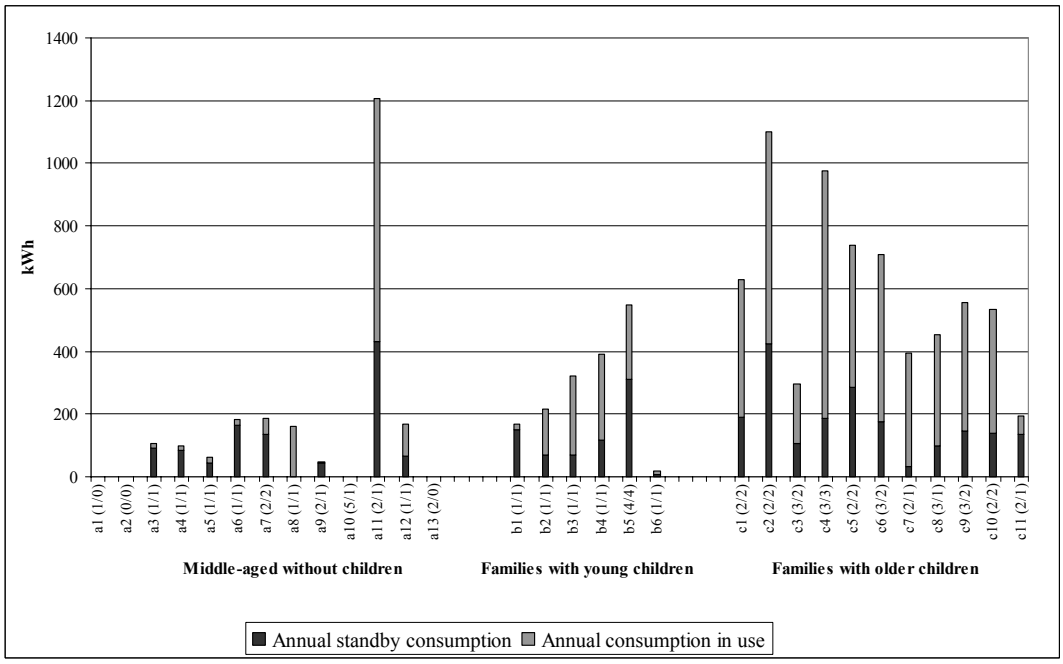
Figures 3 and 4 indicate that there were big differences in the use of appliances in the thirty households. In general families with teenagers watch more television and use their computers more than other families. Even though there were big differences it might be interesting to calculate average hours of daily use, which is relevant for instance if one wants to calculate standby consumption on the basis of spot measurements of the watt consumption. The two figures show a summary of how much electricity each family use for television and computers respectively. For some families this is a sum of several computers or televisions, whereas for others it is just for one of each appliance.

Figure 3. Electricity Consumption for Television Including Associated Technologies, Distribution in Use and in Standby Mode, Reference Period



Numbers in parentheses (x, y): x: number of televisions in the home, y: number of televisions measured.

Figure 4. Electricity Consumption for Computers Including Associated Technologies, Distribution in Use and in Standby Mode, Reference Period



Numbers in parentheses (x, y): x: number of computers in the home, y: number of computers measured.

The measurements allowed us to investigate use pattern of televisions and computers. The average daily use time might for instance be relevant if standby consumption is to be measured based on spot measurement. In Table 1 the average daily use of computers and

televisions are calculated in two different ways. The item 'Per family' includes the sum of how many hours each *type of appliance* was used, irrespectively of how many appliances the family owned. The item 'Per appliance' is a simple average of how many hours *one appliance* were used, regardless of whether the television was the only television in a family or if it was the third or second. Further analysis showed that there were variations over the year in the use of especially television. During the summer month from June to September, the average of daily televisions hours per family was only about 6 hours a day, July only 5 hours a day, whereas the top of average television use per family was almost ten hours a day, in January.

Table 1. Average Daily Use of Televisions and Computers, Per Family Including All the Televisions and Computers in the Home, and Per Appliance

Average hours of use	Televisions	Computers
Per family	6.8	6.2
Per appliance	4.4	4.3

In the previous paragraphs, we described the households' standby consumption before any attempts to change it as well as some aspects of their use patterns. Now let us move on to see what happened with standby consumption during the different phases of the project. The first phase was the reference period. The second phase was the communication phase, which could be divided into three sub-phases.

- First, the distribution of written material, on how to reduce standby consumption.
- Second, a visit by an energy adviser, using a measuring device to show the family their actual standby consumption on each appliance in both money and kWh.
- Third, password to homepage where they could follow their standby consumption.

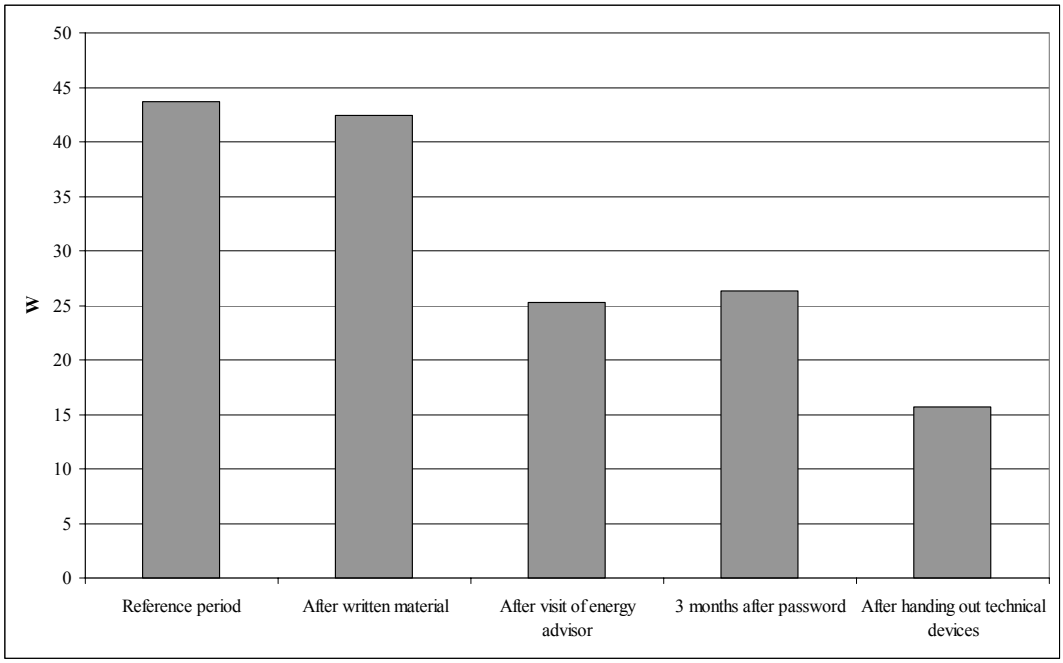
Finally the last phase of the project was the technology phase, where energy advisers again visited the families, this time to offer them technical devices that made it easier to reduce standby consumption (for a more detailed description of these devices, please see (Gudbjerg and Gram-Hanssen, 2006)). For each of these five steps the mean standby could be calculated, to see which of the initiatives that had measurable effects.

Figure 5 shows that sending out written material and leaflets had almost no effect, nor had access to a homepage where they could follow their own consumption. Visits from an energy adviser who through a measurement device illustrated how much money and energy the household wasted on nothing, combined with personal advice, however, reduces the standby consumption with more than one third. Furthermore visit from energy advisers who installed technical devices to make it easier to switch off standby additionally reduced standby consumption to one third of the original size of standby consumption. From this figure the conclusion seems rather simple: public campaigns and continuous visualizing of consumption are of no use, whereas personalized advice and technical devices are a solution. However, analyzing the interview and measured data in greater depth allows us to frame our advice somewhat differently

The first question to discuss is to what extent the reference period represented the 'normal' standby consumption or if already the fact that the measurement devices were installed influenced the habits of the households. Two things indicate that the reference period can count as the normal standby consumption: first from the interviews we hear that many of the families were conscious of not changing habits as they knew we would like to have measurement of their

normal behavior. Second we found from our later attempts to change the households habits, that this was not very easily done, which indicated that just putting measurement devices up are not likely to influence a lot. The next question relates to the influence from the written material including a leaflet sent out to the families one to two months after start of project. As we see in Figure 5 there is almost no positive effect on standby consumption from this initiative. However, from the interviews we hear that some of the families were confused about this material, e.g. they did not know if they were still in the reference period or if they were supposed to react to the material. So in this phase the families' behavior was clearly interrupted by being part of a project. The interviewees themselves evaluated the effect of the written material in the following different ways: some thought that it was one of many small inputs pushing them towards doing something, others (the majority) read the material carefully both because they were part of the project, and others again just threw it out without reading it. The project thus did not indicate any effect of sending out written material, however it can not be rebutted that there might be an effect from campaigns etc.

Figure 5. Development in the Average (Measured) Standby Consumption in Different Phases of the Project



The first visit of an energy adviser took place one month later and was highly appreciated by most of the families. It was an eye opener to plug in the measurement device to all their different appliances and see a small digital number with the exact amount of money that they used every year just for standby. Even though the families had heard about standby, they had somehow thought that in their case it could not be that much. For some of the families this information and the advice they also got at the visit, meant that they reacted immediately to lower their standby consumption, as it is also seen in Figure 5. In this we hear that visualization of consumption as well as information is important for action. However as we see in Figure 5 the possibility of following their consumption on a homepage had no extra effect. Approximately one and a half months after the visit of the energy adviser, a password was mailed to them, allowing access to a homepage showing them ongoing results from the measurement in their own

home. From the interview we learned that very few have used this option, and those who did, only did so once or twice. From the day they received their password they had to wait a few days before access was possible, and this delay had the result that several households forgot everything about this possibility. For those who actually did visit their homepage, we learned that they did not find the information very interesting, some because they found it difficult to get a simple overview, others because they didn't think they got any new information. From this we learned that visualization of consumption may have an effect; however it needs to be very simple and very direct for the customer to get the information, as standby consumption is not given high priority in most families. So the simple and direct method with a measurement device might be better than a webpage, especially when comparing the economy, as the web based solution is much more expensive than the simple measurement device. The question however remains, how to get people to use the measurement device themselves without the visit of en energy adviser?

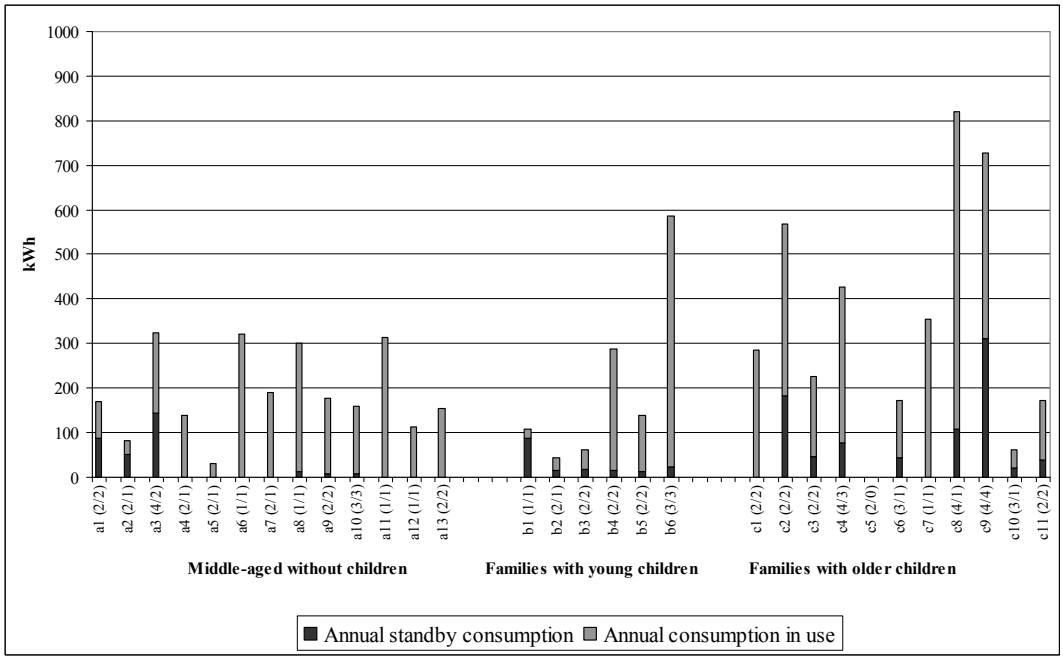
Figure 5 shows an average of how the families reacted to different initiatives in the project; however, this average covered big differences between the families. In some families most of the decrease in standby consumption followed right after the first visit of the energy adviser, whereas in other families there was almost no reduction in this phase of the project. The families who responded to the first visit had something in common: they found that standby consumption was a waste, primarily of money but for some also of natural recourses, and they find it very easy to do something about it. Some families started to use the on-off bottom of the appliances instead of the remote control, whereas others rearranged the cords and plugs making it easy to turn of many appliances at the socket outlet in one push. In these cases often one of the persons in the household did an evening walk through of the house, turning off all the lights and at the same time the standby consumption. The families who did not respond to the first visit also had something in common. Typically they did not find the amount of energy or money that they use for standby very alarming even though it was at least the same size as in the families that found it very high. Furthermore these families do not in general care very much about saving either money or energy: As one apparently rather wealthy woman expressed it: 'after all it is only 100$'. Thus not finding it interesting to save this amount of money, they find it difficult to do the same kind of things, which other of the families, for whom 100$ is an appreciable amount of money, found very easy to do.

The last phase of the project, when technical devices were handed out to the families, occurred almost half a year later. This was because we wanted to see if the effect of the communication had a long-time effect or whether it faded out. The data thus showed us that most of the changed habits from the communication phase lasted, and this was also supported by the interviews. When we asked people if they would continue with their new habits, they typically expressed it like this man: 'Of course, because now it has become a routine which I just do without thinking'.

In the technical phase an energy adviser walked through the house with the household, and proposed different types of technical devices for the different types of standby consumption. In some of the families, who did not respond to the communication initiatives in the first phase, these technical devices and the fact that someone gave them to the family and maybe even installed them for them, really helped to turn down standby consumption. Further analysis showed that standby consumption from televisions to a larger extent than from computers was influenced by communication, whereas standby consumption from computers was more influenced by the technical devices. From the interviews we furthermore understood that especially the families less inclined to do something about standby consumption find the

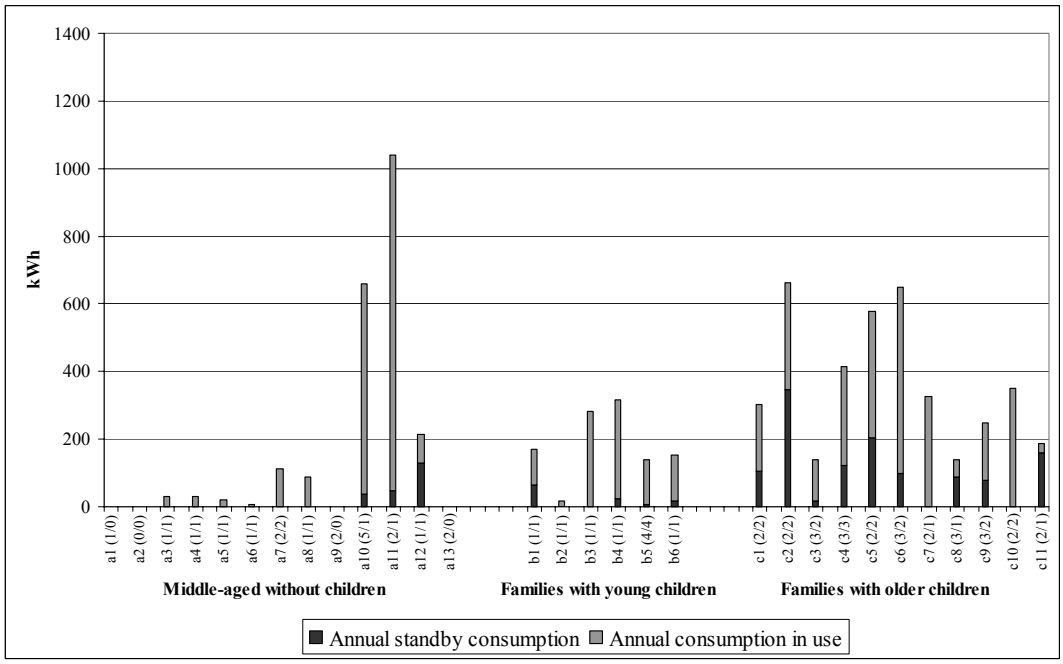
technical devices helpful. The question however is how to persuade families, who are not very interested in standby consumption, to buy and install such technical devices if they were not a part of the project?

Figure 6. Standby Consumption for Televisions (Including Associated Technologies) at the End of the Project



Numbers in parentheses (x, y): x: number of televisions in the home, y: number of televisions we measured.

Figure 7. Standby Consumption for Computers and Associated Technologies at the End of the Project



Numbers in parentheses (x, y): x: number of computers in the home, y: number of computers we measured.

As we saw in Figure 5, even with all our efforts it was only possible to reduce standby consumption in these thirty households to about one third of the original level. It is therefore relevant to examine the character of the last third of the standby consumption which we did not succeed in reducing. In Figures 6 and 7 we see standby consumption for each of the thirty households respectively for televisions and computers. In general we found that it primarily was in households with older children that it was difficult to reduce standby consumption. This could lead to a conclusion that teenagers don't want to save energy, but this might not be quite fair to the teenagers. Other research has shown that teenagers actually do consume more electricity than grown ups (Gram-Hanssen, Kofod and Petersen 2004). However this is the result of social pressure from friends as well as from parents who want their children to be up-to date as regard possessions of electronics (Gram-Hanssen 2005). From the interviews in this project we also realized that the reason for not eliminating the last third of the standby consumption is a question not so much about lacking interest as a question about practical problems with the technical solutions especially families with teenage children had. In these families parents as well as teenagers typically use both televisions and computers individually of each other in both time and space. However, often these appliances were connected with each other for internet access or for satellite television. Because the family members used the different appliances in different rooms at different times of the day, it was very difficult to turn off for instance routers and satellite disks.

Conclusion

In this project we have shown that it is possible to reduce standby consumption in ordinary households to one third of the normal level, by means of communication and help from technical devices. This holds true for an average of the thirty households, but analysis also showed that some households could easily reduce all their standby consumption just by being aware of it, whereas other households reduced all their standby consumption by means of technical devices. Whether the family found it easy to reduce standby consumption or not, relates to on one hand how interested the family in general was in energy savings, and on the other hand to technical details as how easy it was to turn of the standby either at the appliance or by reaching the socket outlet in the wall. One third of the standby consumption in the thirty households was not affected by any of the efforts in the project. This was not mainly because of lack of interest from the households' side, but primarily a result of different appliances being connected to each other and used by different persons at different times of the day.

These results emphasize on one hand the need for improved pressure on the producers to develop electronics with much lower standby consumption, for the kinds of appliances which may be difficult to turn on and off. But they also revealed that many people would like to turn off the appliance, if it was just possible to do so. However, often both socket outlet and appliances are without a switch, which seams very inconvenient, and a problem for the producers to think about.

Even though the production side may look as the most promising and obvious way to solve the standby consumptions problem, this is a long-term solution and until it has succeed, households has to be considered as relevant actors also. Here this project suggests that a continued effort by awareness rising in the public together with developing and marketing of technical devices is relevant. Even though the same success rate as in this project cannot be expected to be achieved with much less resources, it still shows that parts of the standby consumption are quite easily reduced.

Acknowledgement

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