Turn Me On, Turn Me Off! Techno-Economic, Environmental and Social Aspects of Direct Load Management in Residential Houses

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Abstract

Load management is a techno-economic measure for harmonizing the relations between supply and demand sides, optimising power generation and transmission and increasing security of supply. It can also benefit the environment by preventing use of generators with higher emissions.

This study was performed in collaboration with one electric utility in Southern Sweden, which aims solving peak load problems either with load management or by constructing diesel peak power plant.

The objective of the study was to experimentally test and analyse the conditions and potential of direct load management from customer and utility viewpoint. Techno-economic and environmental aspects as well as customer experiences were investigated.

Ten electric-heated houses were equipped with extra meters, enabling hourly load measurements for heating, hot water and total electricity use. Household heating and hot water systems were controlled by the utility using an existing remote reading system. The residents were informed about the experiment but not about the time and duration of the controls. The experiment was followed up by interviews.

According to the interviews, the residents noticed some of the control periods of heating. Body activity level as well as compensation of sun radiation and heat producing appliances influenced the experiences. After the experiments the households were positive about load control, but they expressed requirements for the implementation of such measures.

The experiments proved that direct load management might be a possible solution for the utility to solve its peak demand problems. The potential hourly load savings for heating varied from 1,1 to 3,8 kW per household.

Introduction

LOAD PROBLEMS AND LOAD MANAGEMENT

Load demand is an important techno-economic issue both for electricity producers and for grid companies. Load problems can occur due to fall in production or the limited transmission capacity in the grid.

The liberalization of electricity markets brought up new problems both in Sweden and in many other countries – many energy generation plants have been decommissioned or preserved for economic reasons and the earlier excessive electricity production capacity has been reduced substantially. This process has however increased risk of notable load problems in the electricity systems.

Load management is defined as a set of objectives designed to control and/or directly or indirectly modify the patterns of electricity use of various customers of a utility to reduce peak demand. It is not – as one may think – a measure to save energy, but to run the power supply system more efficiently. Power is not saved but the load demand is moved from peak hours to times with lower coincident load. Depending on what production mix is used at peak hours, load management might help to reduce the use of power generation plants with relatively higher emissions (such as oil condensing power plants and gas turbines). Expansion of the electricity network might also be avoided due to load management. Table 1 lists different economic, technical, environmental and social interests in using load management measures (Abaravicius, 2004).

LOAD DEMAND IN RESIDENTIAL SECTOR

The residential, commercial and service sector accounts for half of the total electricity consumption in Sweden. Electric space heating currently accounts for just over 30% of the total electricity consumption in the sector. Approximately 104 TWh of heat was used in 2003 to heat homes and premises, of which district heating accounted for 45 TWh and electric heating for 21 TWh (Swedish Energy Agency, 2003). High electric load demand variations therefore occur in winter season following outdoor temperature variations. The increased number and the variety of household equipment also cause risks for load shortages if used simultaneously. Even in households with an alternative heating and hot water systems (district heating or natural gas), hourly load demand reaches very high values. Load demand in the residential sector varies significantly during a day and normally has peaks during morning and evening hours.

Detached residential houses in Sweden comprise a large part of the residential building stock. The dominating energy source for heating and domestic hot water for these houses is electricity. Under current dominating pricing conditions (tariffs, etc.) in Sweden the customer is not encouraged to use load optimally. However, the electricity suppliers, having already to a great extent used the load management potential in the industrial sector, consider the residential one as a significant potential for load management. There are several examples of direct load management systems, used in residential houses both in Sweden and other countries. The division into network and retail companies, as a result of the liberalization of the electricity market, has complicated the situation because normally the grid companies own those systems.

Two of the largest Swedish electricity suppliers, Vattenfall and Sydkraft have performed load management projects in detached houses. For example, Sydkraft project "Topp-Kap", performed at the end of 1980s and the beginning of 1990s focused on developing an electronic load control system for direct resistive heating. The performed tests showed the potential of load decrease of 4 kW per house (at -13°C) with minimal comfort losses for the customers (Sydkraft, 1989). Vattenfall project "Uppdrag 2000", performed in 1990, was focusing on controlling electric boilers in small houses with waterborne heating systems. Average load savings achieved under cold winter days were about 3 kW per household. Many problems, however, came up with recovery load (load demand to reheat the house after the control period – which causes another peak) in those experiments (Levin, 1993). These projects were basically focused on techno-economic performance of the control system and the potential of load demand reduction. Analysis of the consequences for the residents included only indoor temperature drop measurements during control of heating and the residents' experiences during the system installation phase. Neither the customers' view of their heating and hot water

Table 1. Summary of interests in load management at customer and utility sides.

	Customer	Utility		Producer	Grid operator	Society
		Retail company	Network company			
Technical	Avoiding fuse problems		Avoided network capacity problems	Maximum use of base (and cheapest) production units Avoided production capacity addition	Stable operation of power system on national level	Stable operation of power system on national level
Economic	Lower electricity costs Lower network costs due to lower fuse level	Lower risk when purchasing power on spot market	Lower demand subscription fees. Avoided investments in the network	Lower production costs	Stable operation on lowest costs Avoided/postpone d investments in the network	Economically sustainable electricity supply. Maximum reliance on local production
Environmental	Avoiding peak power plants nearby living area	Fulfilling goals established by environmental certification programs	Fulfilling goals established by environmental certification programs.	Avoided use of peak units (e.g. diesel or gas turbines) – which result in high emissions	Avoided new network construction	Least possible environmental effects
Social	Service compatible with the social activities					Power accessibility and equal conditions for all members of the society

comfort nor their opinion and acceptance of load control was analysed.

ASSOCIATED UTILITY AND ITS LOAD PROBLEM

In this paper, the use of load management at a local level, in a specific case of a Swedish utility, Skånska Energi AB is investigated. The utility is located in the south of Sweden, Skåne, and has 16 500 customers, of which 99% are residential customers that account for about 53% of the electricity sale. Skånska Energi AB comprises two subsidiary companies - the grid company Skånska Energi Nät AB (SENAB) and the trading company Skånska Energi Marknad AB. An advanced metering system "CustCom" is installed to all Skånska's customers. The system provides automatic hourly measurements, as well as load control and information services.

Load problems at the utility occur during peaks in wintertime, usually on weekday mornings and holiday (weekend) afternoons. Load demand in the utilities grid is especially sensitive for weather changes, as the majority of Skånska Energi's customers have electric space heating. Daily peak demands (during morning and evening hours) together with higher heat demand due to outdoor temperature drop, cause risk to exceed the subscribed load for the grid company. This results in penalties from the higher level network owner Sydkraft, and thus significant economic losses. The utility would benefit economically by securing the load below the subscribed level and by decreasing it. In year 2002 and 2003 the subscribed load was 76 500 kW.

The utility has some few alternatives to solve this economic problem:

- To apply direct load management using a remote metering and control system CustCom, installed at the utility,
- to introduce a new pricing with a load demand component, or
- to install diesel peak power plant with 2-3 generators with a capacity of 4 MW each.

The construction of the peak plant would have negative environmental impacts both on local and global levels. First of all, the plant has to be located close to the users. This might create significant problems in local environment, as the quality of the environment would be decreased both by emissions and possible noise level increases. From the global perspective, the production of electricity using diesel generators would mean high CO_2 emissions. The efficiency of such a technology is low and the resulting emissions are high. Diesel generation normally has the lowest generation efficiency, reaching only around 25% and also one of the highest emissions factors per fuel, reaching 288 kg C/MWh (1 056 kg CO_2/MWh) (Meyers, et al). For the comparison – the average CO_2 emissions from electricity production in Sweden is 12 kg CO_2/MWh. If the utility would implement load management measures instead of building a new peak power plant, this would obviously be a better solution from the environmental perspective.

Load management has to be tested in order to investigate the load control system's techno-economic performance. Also, customer's experiences on indoor and hot water comfort has to be analysed when controlling heat and hot water in the customer's houses, as well as the customer's attitudes toward this kind of encroachment made by the utility in the home.

OBJECTIVE OF THE STUDY

The objective of this study is to experimentally test and analyse the conditions and the potential of direct load management in 10 residential households with electric space heating and hot water systems. The study aims to consider both customer and utility perspectives and to cover not only techno-economic but also social aspects of load management.

From a techno-economic perspective the study aims to analyse the technical performance of the control system and customer's equipment, load savings, recovery load, and management costs. From a social perspective – the customer experiences and attitudes influence on indoor climate and social activities as well as control limitations are the primary focus.

Methodology

10 PILOT HOUSEHOLDS

Ten households (in this study called H1…H10) in Södra Sandby, Southern Sweden were selected for a load management experiments. All of them are the customers of Skånska Energi and have electric space heating and domestic hot water systems. The selection was based on the energy survey, performed by the research group in year 2001. The households were asked if they would agree to participate in energy experiments. Of those answering in the affirmative, ten households were selected.

The number of residents is: one person in one household (H3), two persons in five households (H1, H2, H4, H5 and H6), three persons in three households (H7, H8, H9) and four persons in one household (H10). Seven of the analysed houses are detached houses and three are semi-detached houses. The houses are of similar age, since all were built in the period of 1964-1978. Some of the houses (H2, H3, H4 and H9), were extended in the later years. The living area varies from 95 m^2 to 300 m^2. The houses are also of different design (one to two storeys). One of the houses (H5) has a basement, which is used as living area. The dominating construction type of all houses is brick with wooden frame or light concrete frame. In most of the houses the attic insulation was improved after the construction. Four of the houses (H1, H2, H3, H4) have waterborne space heating systems with electric boiler, while the other six (H5, H6, H7, H8, H9 and H10) have direct electric resistive heating. H2 in addition has a heat pump. Electric water heaters work as separate units in all of the houses except H2 and H4 where these are integrated in the boilers.

METERING

The load and outdoor temperature data was obtained via the CustCom system. Total hourly electricity use is normally measured and stored in a database. Two extra electricity meters were installed to measure the load demand for space heating system, and for water heaters in the analysed households. Metering of heating and hot water loads for all select-

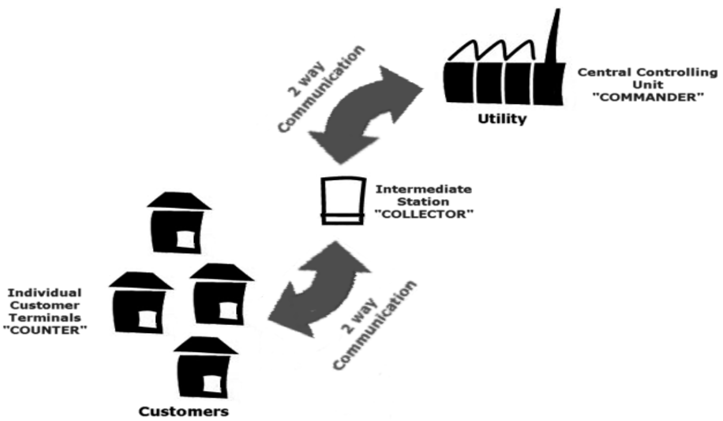

Figure 1. *CustCom's typical system architecture (North, 2001).*

ed households started on April 1, 2003 and continued until February 15, 2004. In two houses with waterborne space heating systems (H2 and H4) it was technically impossible to separate heating and hot water load.

An indoor temperature logger was mounted on the inner wall in the living room in every household at about 130 cm from the floor. Temperature readings were logged every 15 minutes with a precision of 0,5 °C during the test period. Since only one logger was used in each household, the rough assumption is that the temperature is the same everywhere in the house.

LOAD MANAGEMENT EXPERIMENT DESIGN

Experiment period, duration of control periods, time of day and forecasted outdoor temperature were factors that needed to be considered when designing the experiment.

The experiment strategies were developed based on the analysis of available measurements and considering both the utility perspective and the household perspective. From the utility perspective, the control periods were adjusted to the times when the utility usually would have problems – few peak hours on weekday mornings and holiday (weekend) afternoons. From the customer perspective – the control time was limited from 1 to maximum 4 hours when controlling heating in order not to deteriorate the customers' comfort too severely.

Before the experiment started, the households were given a prepared form to make notes about changes in indoor climate and in hot water comfort. The household members were also asked to note times when nobody was at home. The reason for this was to see if the residents missed out on some of the load controls. These notes make a clear indication on whether the controls are noticed or not, since the residents' experiences in this way are stipulated in time and afterwards can be compared with the actual control schedule.

The experiment was carried out during period of three weeks Feb 16, 2004 – Mar 7, 2004. Customers were not informed about the exact experiment periods in order to discover if the control periods were actually felt by the customers. The essence of the experiment was on/off control of space heating and hot water systems in houses according to the schedule prepared by the research group and sent to the utility. The utility personnel set the control for the given channels in the CustCom system. Load for space heating was switched off for the periods of 1, 2, 3, 4 hours and load for hot water was switched off for the periods of 1, 2, 3, 4 and 16 hours.

The time, chosen for the experiment was within the statistically coldest period in the region. Nevertheless, relatively high outdoor temperatures this particular year did not allow to make the tests under the most sensitive conditions. (Hourly outdoor temperature data for one place, at Skånska Energi headquarters area, is also provided via CustCom system.)

LOAD CONTROL METHOD

The architecture of a complete CustCom system (see Figure1) typically incorporates three main items: individual customer terminals (counters), intermediate stations (collectors) and a central controlling unit (commander) located at the utility. Two-way communication signals transmit the information between the customer's terminal and the utility by the use of either radio, GSM, fibre or control cable. The information that is transmitted includes meter readings, various control signals and additional features such as alarms (North, 2001).

The CustCom system provides several technical possibilities to control load. One of them is "object control", which was used in this experiment. The Counter 1000, one of the constituent units of the CustCom system, was extended with an additional card, which created the possibility to control load for specific devices (objects). These additional load control cards and extra relays were installed by Skånska Energi in all the ten houses.

INTERVIEWS

Immediately after the test period, interviews were carried out with the household members in the ten houses. The interviews were typically semi-structured interviews with opportunities for the household members to talk about different themes decided by the researcher. The themes covered:

- Residents experiences of the on/off regulation of heating and hot water, that is indoor climate and changes of hot water comfort during the test period
- Experiences of the normal indoor climate and hot water comfort
- Thoughts about energy use in the household
- Opinions of load management measures; how would these measures have to be designed in accordance with the interviewees' requirements?

The interviews took place in the respondents' home and lasted for 45 to 90 minutes. They were recorded and subsequently transcribed. Both interview answers and notes about changes in indoor climate and hot water comfort were later analysed together with the indoor temperature data in order to compare the physical temperature changes with the residents' experiences of the indoor climate.

Results

TECHNO-ECONOMIC ASPECTS

Performance of the control system, load demand savings, recovery load and costs are the major techno-economic parameters considered by the utility.

Load demand savings for space heating

Load savings for heating are calculated in the following way:

$$LS = \frac{P_{bc} + P_{ac}}{2}$$

Equation 1

where:

LS – Load savings

P_{bc} – hourly load before the control period

P_{ac} – hourly load after the control and recovery period (it is assumed that the recovery load period lasts for one hour after 1-2 hours of load control, or 2 hours after 3-4 of load control. The assumption is made based on actual readings of load curves)

Figure 2 summarizes the results for all households and shows that H2 and H4 have highest hourly load savings on space heating. It is important to consider, however, that the data from H2 and H4 also includes load for hot water, since these houses have boilers with integrated hot water system. The results for other households show that the savings in principle depend on house area. H3, H5 and H1 have larger living area and thus larger demand for space heating than the remaining ones. Households 6, 7, 8 and 10 have "soft heating" systems and load guards that keep the load demand below a specific level. The basic feature of "soft electric heating" system is the pulsing of the electric energy to the specific radiators in specified time intervals. Since the pulses are shifted, the radiators are never switched on all together, which decreases the load demand.

The potential hourly load savings for space heating varies from 1,1 to 3,8 kW per household, which is a similar result as obtained in previously described studies carried out by Sydkraft and Vattenfall. As it can be seen the potential load savings are lower at the households with "soft heating" systems.

Recovery load for heating

Recovery load occurs when the system is reheating the house after the control period. It is an important issue since it can result in another, even higher, peak after control, which, in turn can cause problems for the utility and customers. Figure 3 shows the recovery loads for space heating after the implemented control periods (during the first hour after the control period). A dependency on the duration of the control period can be observed here

Households 6, 7, 8 and 10 have "soft heating" systems and load guards, which is reflected in the recovery load levels for those households. This system can be recommended as a good solution to protect the grid from high recovery peaks. For the household it could mean a longer deterioration of indoor comfort, specially during more extreme winter weather conditions. In this particular experiment the indoor temperature drops were very small as the outdoor temperature was relatively high.

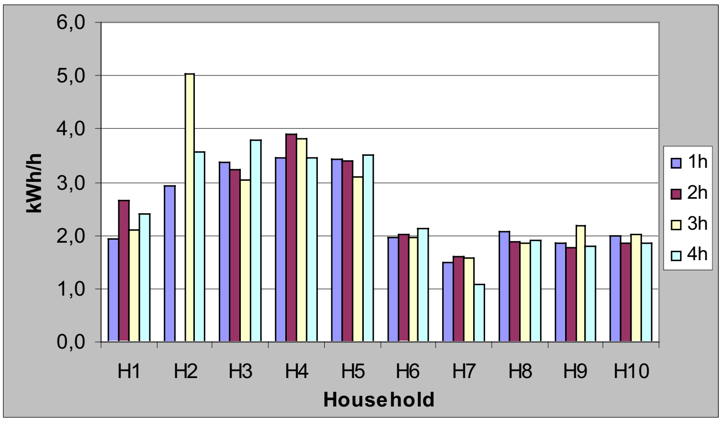

Figure 2. *Average hourly load savings on heating (In H2 the 2-hour control was not performed).*

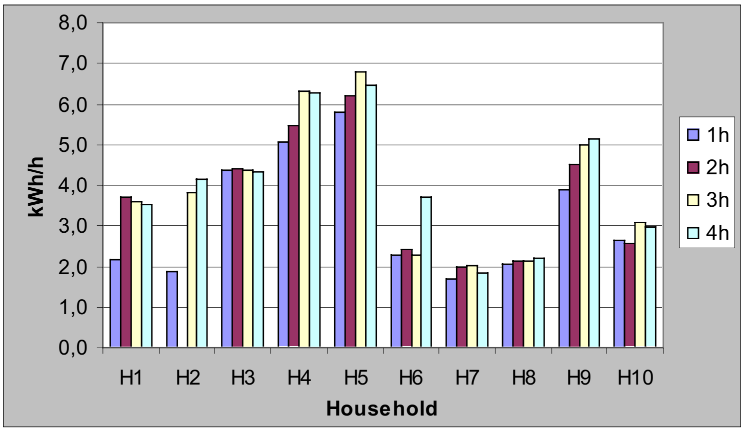

Figure 3. *Recovery load for heating.*

Load savings for hot water preparation

Domestic hot water systems have a potential for load savings (for 1-4 hours control) without serious negative consequences. However, it is difficult to say how big the savings are, as water use measurements were not performed in this study. The water heaters normally have installed capacities of 3 kW, which actually could be considered as a maximum switchable load.

An interesting question when analyzing hourly load control potential for hot water, is when the water heaters are on full power. Having this knowledge it is easier to create load management strategies, as it gives a suggestion when to control the heaters in order to get a maximum load savings. Using the daily load curve and the hourly data, the following methodology for finding the probability if the water heater is on full power was developed:

It was assumed that heater is on full power if its hourly load exceeds 2,5 kWh/h (exception was H7, where the maximum load is limited. In that case the assumed value is 1,5 kWh/h). Every hour of the day through the period April 1, 2003-February 15, 2004 is analysed. Number of

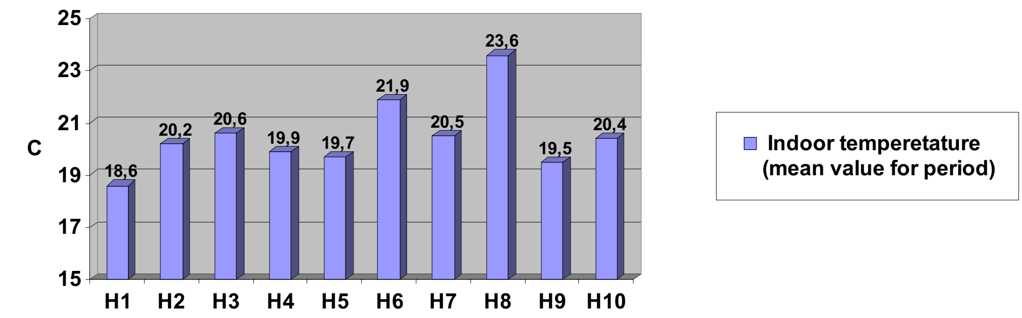

Figure 4. *Average indoor temperature in the ten houses during the test period.*

hours when the full load value is reached is divided by the total number of recorded hours. The results show that the pattern of load demand for hot water varies from household to household, presumably depending on the behavioural factors. There is a tendency, though, that the highest demand occurs during morning and evening hours, therefore these periods could have the highest potentials for load control.

Measurements and control costs

When it comes to economic issues, the costs for extra equipment for measurements and control purposes (meters, relay, control card, labor, etc.) appeared to be relatively high, reaching 1 100 Euro per household.

Would it be economic for the utility to implement direct load control? Some few rough estimations can give us an indication about it:

There are two reasons to implement load control: to avoid penalties and to decrease the subscribed load level. Penalty differs on weekdays and weekends - it is twice as higher on weekdays. If a subscribed load demand is exceeded, for instance, on weekday morning (a typical time when the utility risks to exceed the demand) by 3 000 kW during one hour, the total penalty for the utility would reach 117 000 Euro. If, the utility would implement the control measures in 1 000 households, assuming that average expected load saving is 3 kW/house, the penalty could be avoided. Additionally, expected savings for decreased subscribed load by 3 000 kW would be 88 700 Euro /year. The installation in 1 000 households, however, could cost around 1 090 000 Euro .

In year 2002 there was 1 hour exceeding of contracted load with 355 kW. In year 2003 there were no exceeding. In year 2004 there were three hours and exceeding was 3 887kW, 3 021kW and 1 107 kW respectively.

From the technical point of view, the system CustCom proved to be a good technical tool to implement load control objectives. Few technical problems though were recorded during the experiment in some households (communication problems, fuse went off, circulation pump stopped), but it is not evident that the control actions was the reason for these problems.

SOCIAL ASPECTS

Indoor comfort

Thermal comfort is, according to the standard ISO 7730, defined as "that condition of mind which expresses satisfaction with the environment". Physical measurements of thermal comfort are thereby not practicable but to ask users about their opinions about the thermal comfort (Bengtsson, 2003). In this study, the indoor temperature as well as the residents' perception of the indoor climate is considered.

The average indoor temperatures for the three-week period differ a lot between the ten households. In Figure 4 we can se that temperature levels differ between 18,6 °C to 23,6 °C. When asked in interviews, it is evident that some households like to keep the temperature low while others prefer to keep a much higher temperature in their homes.

Turning off the heating for 1,2, 3 or 4 hours naturally means that there will be an indoor temperature drop that depends both on the length of the period that the space heating is switched off and on the outdoor temperature. Figure 5 shows the result of indoor temperature drop in our experiment.

The Figure 5 is showing moderate temperature drops due to the switch off of the space heating system. For longer control periods the temperature drops reached down to 2,5 °C at most, but in general the temperature drops were lower. Radiation from the sun through the windows, as well as activities in the household including use of electricity (for example cooking), seem to have compensated for the temperature drops in some control situations. The outdoor temperature for the test period was relatively high for the season, between –0,8 °C to 6,1 °C (in average 2,1 °C). A lower outdoor temperature would most likely have resulted in larger indoor temperature drops when turning off the heating system.

Now, knowing the indoor temperature drop during the test period, how did the residents react to the temperature changes? Household notes from the test period show that some of the controls went unnoticed because the residents were simply not at home. For controls where people were present at home, many controls actually has been noticed and noted on the "comfort sheets". These show that some households noticed the controls more than others. One interesting result is that the households with generally higher indoor temperature are as sensitive to indoor temperature drops as the others. Although a temperature drop from 23 to

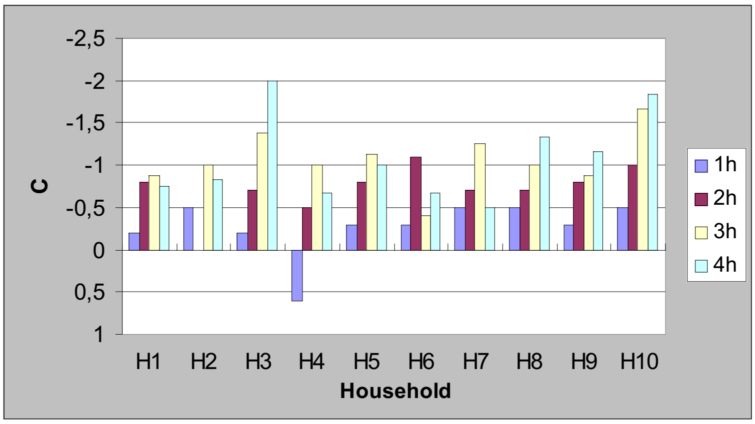

Figure 5. *Average indoor temperature drop due to the switch off of the households heating systems.*

22 degrees doesn't constitute in a low indoor temperature level, these households have been able to detect the change in temperature. This might imply that the rapidness of temperature drop is of great importance to the thermal comfort. Also, it came clear that the residents make adjustments in their way of clothing to match their general temperature level: with high temperatures, the residents tend to wear thinner clothes and walk barefooted inside the house, with lower indoor temperature they usually wear an extra sweater or suchlike. Therefore the ones with higher indoor temperatures may actually be more sensitive to draught from windows since especially the feet are sensitive to cold (Ronge, 1970). Other factors that seemed to be of importance for the thermal comfort experiences of the test was time of day and body activity level of the residents when the heat was shut off. More households have reported inconvenience to the temperature change in the mornings than in the afternoons. This could probably be explained by the fact that the residents undertook more sedentary work in the mornings (i.e. working at the computer) and that there were often some activities of cooking in the afternoon that raised the indoor temperature. Although quite a few of the controls of the heating were noticed, this was not expressed in the interviews as something particularly unpleasant (Sernhed, 2004).

Hot water availability

For the controls of the water heaters, only one control was noticed and only by one household. It was the 16-hour control that was noticed by the household that had the most household members (four persons). The water heater was shut off from 7 a.m. to 11 p.m. – at 4 p.m., the family was about to wash the dishes when they realized that there was only cold water in the tap. It is rather remarkable that no other household did the same discovery! This could possibly be explained by the fact that the size of the water heaters in these test houses are rather big (200-300 liters) and the number of residents is rather low (1-3 persons), which makes the dimensions of the water heaters quite ample of size. This condition is due to the move out of grown up children from these houses.

Customer attitudes towards load control

In the interviews the different limitations of load control and requirements from the customer point of view were discussed:

- Limitations: How and when may the utility control the customer heating system and water heaters?
- Need for information: Do the households now why the utility is interested in load management?
- Signal: Do the households want to be alerted before space heating and water heater is controlled?
- Compensation: Do the households experience a need for economical compensation if they agree to load management?

Most of the households think that there ought to be a limitation on the length of the control for heating for two, maximum three hours. The length of control should also be adjusted to the outdoor temperature, so that the control periods would be even shorter in cases of very cold weather. Only the household that experienced problem during the 16-hour control of water heater had opinions about limitations of the length of these controls, which it would like to limit to three hours at most.

Few households could imagine what are the utility incitements using load management. Some households thought that they themselves would save energy by letting the utility turn off the heating system and the water heater for shorter periods. In this way these households thought that they could save money. When realizing that load management isn't about saving energy but rather power, the issue of load management sometimes was questioned. It seems that there is a great need for information explaining the difference of energy savings and power savings, and what purposes the utility and other actors have to conduct these measures with household costumers.

In the interviews the respondents were told that the need for load management isn't necessarily existing on a daily basis but can arise rapidly so that the utility might not be able to tell the customers in advance. The question raised was then: Would the customers want to have some kind of signal (for example signal lamp) that shows when load management is on? Half of the households replied in the affirmative and the other half in the negative. Those who said yes presented different reason to this:

- To have the possibility to take measures to indoor temperature drop, for example light a fire or to put on a sweater.
- To be able to help the utility yet more by being more cautious about other domestic electricity use.
- That it would be honest of the utility to show when they are controlling.
- For the control of the water heater it would be good to have information in advance, so that the household members could plan for it.

For those who didn't want to know, there were also several reasons to this:

- If the utility adjusted the control periods somewhat to the household's routines, there would be no need for more information
- It is not necessary to know when as long as the control periods are short
- It is better not knowing since if one did, one would probably get irritated about it.
- If the controls would just occur on rare occasions, there would be no need to know.
- A couple of household with waterborne space heating system had already found a way to see if the heating or hot water was controlled on the boiler.

Nine of the ten households say that they would agree to "real" load management if it was carried out in the range of the experiment. The question of compensation was raised to the households. Here, seven of the ten households answered immediately that there should be some recompense, otherwise they would not be interested. The other three households had a more "collectivistic" opinion, meaning that if these measures could decrease the electricity price for all the customers, this would be good enough. The oldest households also talked about the importance of supporting the small local energy company in the competition with the industry giants (Sernhed, 2004).

Concluding discussion

Load management in the residential sector is not a new phenomenon neither in Sweden nor in other countries, however in Sweden many utilities were not interested in using load management after the deregulation of the Swedish electricity market in 1996. Conditionally, the deregulation has resulted in a decrease in reserve capacity, which means that the value of load management measures is even greater today.

The load management measures used in this study are using an existing remote meter system at the utility Skånska Energi AB, adding extra control cards and some installations to turn off and on the space heating system and the water heater in the ten pilot houses. In Sweden, there is a governmental promulgation for the utilities to read the customer electricity meters for at least four times a year. This promulgation is actually an incitement for the utilities to invest in new remote meter systems that facilitates more frequent readings and that may have features of load management possibilities like Skånska Energi AB has. This study shows that the function of this system works sufficiently for load management purposes and that there is a potential to decrease total load demand thanks to controlling heating and hot water systems in residential houses.

The behavioural part of this study proves that one can expect that there is a proclaimed willingness to entrust heating and hot water systems to the utility to control. Most of the households would probably demand some kind of compensation on the electricity bill. In case of agreement about load control, there is a need to consider resident's domestic hot water comfort and indoor climate. Households investigated in this study have stressed that the load controls should be limited in time and adjusted to outdoor climate conditions. Ideally, the load control activities should not be noticeable for the customers.

In order to summarize the results from the study it can be claimed that both load management and peak diesel plant are the solutions to solve the load problem for the utility, however, with completely different environmental effects. If choosing load management, the increase in CO_2 emissions, as well as other negative environmental effects can be avoided.

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