[*PEAK LOAD HABITS FOR SALE? – SOFT LOAD CONTROL AND CONSUMER PREFERENCES ON THE ELECTRICITY MARKET*]

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Overview

The increased interest in demand response in Sweden and many other countries can be traced to the ongoing transition of the electricity system towards more renewable and intermittent power, in combination with fast development of information and communication technology. Power consumption is now commonly measured in real time and prices and requests can be timely communicated to the customers at low costs. The ongoing digitalization of machines, devices and installations will bring new business models to the power market. The customers will no longer only serve as the lender of last resort, but will provide services to the power market in competition with the traditional supply side actors.

So far, demand-side management (DSM) in Sweden has focused on exploiting large industrial electricity consumers at moments of imminent power shortages, which typically occurs on days with high power consumption due to exogenous factors. The balancing of intermittent power production, however, requires more adaptable resources that can be activated at short notice during all times of the year. The household sector in general, and detached and terrace houses in particular, may have a large potential in this context. At the household- and appliance level, demand response can work through automatic response or through ”manual” behavioral changes. Sometimes these strategies are referred to as efficiency and curtailment activities (see, e.g., Gardner and Stern, 2008). Because many single- and two-dwelling buildings in Sweden are heated by electricity, an automatic response of heating systems has a significant potential to help balance fluctuations in the power system. When it comes to demand response working through curtailment activities, however, the story may be different, as such activities are dependent on behavioral changes.

Besides passive use of electricity, households use appliances and installations sporadically and actively as part of their daily routines. To achieve demand response in this part of the household’s electricity use, the household has to change its behavior by planning its time and possibly by breaking old habits. In this part of the household’s electricity usage, the devices ”themselves” cannot optimize the electricity consumption to maximize the utility of the household members. This is because the utility of the service/benefits from consuming electricity depend to a large degree on the timing of the production of energy services. In other words, the production cost of these energy services largely consists of the opportunity cost of the households’ use of time and attention. As the energy cost constitutes a small share of the total production cost, the price of electricity has to increase by a relatively large amount to create a significant demand response. Technical measures may to some degree reduce this barrier but do not have as much potential as the automatization mentioned above.

Previous research (see e.g. Broberg et al., 2014, and Broberg and Persson, 2016) suggests that people demand substantial economic compensation to engage in demand-side management (DSM) programs. For example, people were found to very much dislike restrictions on the use of household appliances during the evening peak hours (Broberg and Persson, 2016). In the present study, we work with a hypothetical DSM-program focusing on soft load control. We use the term soft load control to denote a temporary restriction in the maximum possible load (in watt) that a household can use to run high-power appliances and installations. The experimental setting contributes to previous research in several distinct ways. Instead of focusing on specific appliances and restrictions lasting for several hours, we now focus on shorter restrictions (0.5-3 hours) for high-power appliances at specific times during the typical peak hours of the day and year. A form of flexibility is also introduced in the restrictions. The experiment also elicits the willingness to accept complete black-outs at the time of peak load electricity use. This approach links the soft load control to the most extreme case of restriction – the full black out. In this way, we obtain measures of several levels of restrictions and, in addition, we are able to make comparisons to the related literature.

The hypothetical DSM programs are characterized by controlling the maximum level of load at the household level. That is, instead of a strict focus on VOLL, we report on values of potential lost load (VOPLL). In essence, VOPLL captures the value of a secure and sufficient power supply to the household customer. From the household customer perspective, VOPLL is the disutility of not being able to use all of their loads as they are used to. The disutility stems both from actual load shifting, but also a loss of option value. The option value could be interpreted as the possibility to use an appliance or installation when needed. Using the method of contingent valuation, we also separately estimate, the average monetary compensation required to accept a DSM program that includes five 30 minutes black-outs during the winter season. Given the specific design, we estimate VOLL while also assessing the relative importance of different categories of household appliances and installations.

Methods

In a choice experiment context, we apply a survey approach eliciting people's preferences concerning a hypothetical demand-side management program (DSM) involving load control. The DSM program includes load control on a number of occasions during the peak hours in the winter season. By varying the attributes of the DSM program, we elicit people's preferences for these attributes and attempt to place a monetary value on them. The load controls, or attributes, are: (1) maximum high-power loads, (2) duration of load control, (3) number of occasions of load control and (4) degree of self-control over available load. To estimate the relative value of having full access to high-power loads compared to other loads (e.g., heating, lighting and TV) we also designed a continent valuation scenario involving a complete black-out. The difference between the compensation required to accept the black-out and the compensation to accept a DSM program with a softer load control but with similar duration and number of occasions may then reveal something about the relative value of different loads.

Results

The results reveal that households would require minimum compensation ranging between SEK 2000 and SEK 3700, depending on how stringent the control is with respect to maximum load, duration, and number of days. This is a large amount of money, considering that the annual electricity bill for a homeowner household is approximately SEK 15 000 on average. This number can also be compared to the actual potential saving on the electricity bill for that particular load saving, which is about SEK 3 – 5. An additional way to show the significance of the compensation that households demands for load controls is to relate it to the value of lost load. Given some specific assumptions concerning the potential loss of load resulting from the various scenarios, households on average value the potential lost load, VOPLL, to at least SEK 20 – 40 per kWh, which should be compared with the actual electricity consumer price of about SEK 1. This simply means that the value the consumers, or households, attribute to secure access to electricity at the afternoon peak hour is way above the marginal cost of providing electricity.

Looking more specifically at the minimum compensation for accepting a 30-minute black-out in the afternoon peak hour reveals an even higher value than the less restricted load control, which is expected. According to the results, compensation in the range of SEK 3000 – 4600 is needed, where the upper limit is more probable, which corresponds to a value of lost load, VOLL, of approximately SEK 400 – 600 per kWh. This indicates a huge difference between the value of the load that was controlled in the choice experiment and the remaining load (e.g. heat, lighting and TV). Compared to previous literature on VOLL our estimates fall in the higher range, especially compared to Swedish studies. A possible explanation for the high values of VOLL in our case is the scenario they are conditioned on. Compared to today's rather safe power supply, a scenario of five random black-outs in the peak hour winter period mirrors a highly unstable power system. Our setup is however highly relevant considering future power systems and markets.

Conclusions

The overall conclusion from our empirical analyses is that demand response relying on behavioral change is expensive. In other words, it is very costly from the consumers' perspective to change their behavior during the hours under consideration. The "cost" for the consumer can in this case be interpreted as the opportunity cost of time. That is, the risk of not being able to make dinner at the usual time may be very disruptive for the household, and according to our results this disruption is very costly. A policy implication that follows immediately from the results presented here is that specific policies aiming at stimulating behavioral changes probably are very ineffective and/or costly. As a result, policies to affect demand response should focus on automatization and passive response. First, such measures seem to be the low-hanging fruit, not least in the sense that relatively large effects can be achieved without so many negative effects on households. Second, a significant share of homeowners' use of electricity is related to more or less passive use, such as heating, refrigerators, ventilation, etc. This means that the load that could be subject to passive response is relatively large, and hence a relatively large potential for load-shifting follows. A related policy implication is that it is far from obvious that demand response is more cost effective than supply response, i.e., increasing production of electricity. We saw that the value of the load lost is far above the marginal production cost, which means that there is a potential for using fairly high-cost production for some hours of the year.