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Evaluating the Customer's Benefits of Hourly Pricing based on Day-Ahead Spot Market

Customers with hourly electricity pricing can reduce their electricity cost by shifting their electricity demand in time. However, it is not known how much different customer could gain. As most hourly pricing contracts in Sweden are designed today, customers will know the electricity prices 12-36 hours in advance and will have the possibility to schedule their electricity usage in order to reduce their cost of electricity. In this study, three houses with different load profiles and heat demand are investigated to evaluate the possible savings that could be achieved by adapting to hourly pricing. Heating, laundry machines and dishwashers are assumed to be flexible loads that could be shifted in time. The study results show that the economic incentives to reschedule loads based on the hourly pricing will be limited for customers without electric heating. Even for customers with electric heating, the economic incentives may be too low to adapt to hourly tariffs based on the day-ahead spot market.

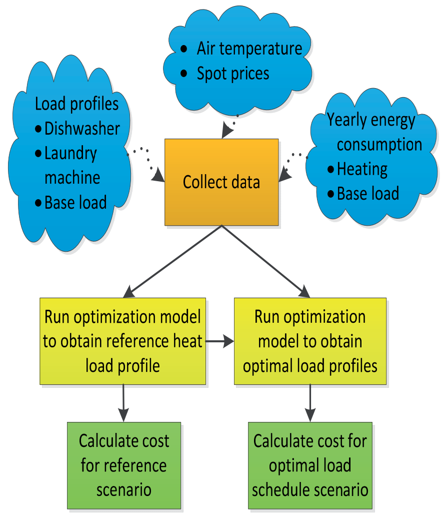

Figure 1: The proposed approach

Introduction

In Sweden customer can purchase their electricity on an hourly contract. This gives the customer incentives to increase their demand when there is a surplus in generation and reduce their demand when there is a shortage in generation. In the long run this could be important to cope with a large scale introduction of intermittent renewable. However, it is not sure how much the customer would gain of hourly pricing or how flexible customers could be. This paper presents the main results from the study [1], aiming to investigate the savings that could be achieved by different customer by adapting to hourly pricing and schedule their demand to reduce their electricity cost.

Approach and assumptions

The proposed approach is presented in Figure 1, where the first step is to gather all data needed to conduct the study. The second step is to compute the load profile for the reference scenario and to calculate the electricity cost for the reference scenario, i.e. without any load management. The final step is to reschedule the flexible loads to minimize the electrical cost for the customer. The optimization model is based on the work presented in [2] and considers the thermal properties of the house as a lumped capacity model. In this study, the model has been extended and consider, in addition to heating of houses, other household loads, e.g. laundry machines and dishwashers, to be flexible. All other loads are assumed to be time critical and are collectively referred to as the base load. The model is implemented in the optimization software GAMS, General Algebraic Modeling System with the objective function being minimization of the electricity cost for the customers by scheduling their flexible loads. The results from the optimal load scheduling are compared with a reference scenario without any load management.

Energy usage and load profiles

The load profiles for the dishwashers and laundry machines are extracted from a measurement project conducted by the Swedish Energy Agency [3], and are used to simulate the reference scenario, i.e. no load management. The load profile for the heating load has been estimated based on the yearly energy consumption for three typical houses in Sweden and air temperature data for the city of Gothenburg. Figure 2 presents the annual energy consumption by the different loads and Figure 4 presents the load profile for a 24-hours period during the summer and during the winter for "House 1" in the reference scenario. As shown in the figure, the energy consumption varies to a large extent between the seasons. The share of flexible load can be below 20% of the total load during a summer day and above 90% during a winter day.

In the optimal load scheduling scenario, the heat loads are limited by the temperature variations inside the house and a temperature deviation of ±1.5 ºC from 21 ºC is allowed. Additionally, the average energy consumption during one day must be equal to the energy consumption in the reference scenario. The installed heat capacity is limited to 10% higher than the peak demand in the reference scenario. The yearly energy consumption and load profile for one program of the dishwasher, laundry and drying machines are assumed to be equal to the reference scenario. Additionally, for the laundry/drying machines, only one machine can start during the night (between 22:00 and 7:00) and during the day (between 8:00 and 17:00). The reason for this constrain is that it is assumed that no one will move the clothes between the machines since most people are sleeping during the night and working during the day.

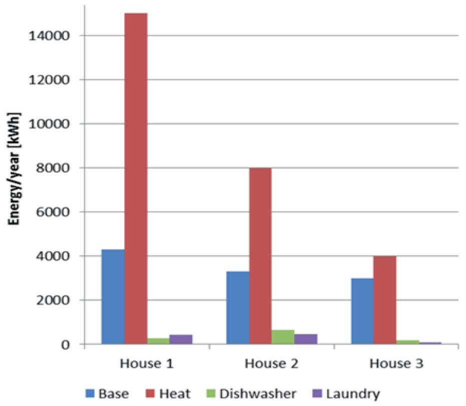

Figure 2: Energy usage for the investigated period for the studies houses

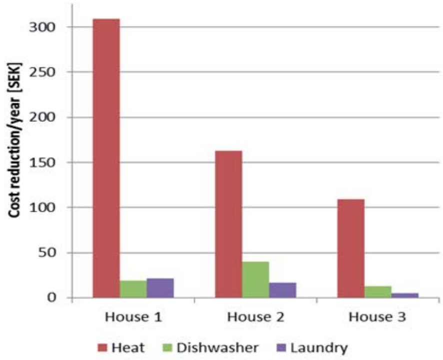

Figure 3: Cost reduction for the houses in the case study for the simulated period

Case Study results

The cost reduction achieved by the optimal load scheduling is presented in Figure 3 as compared to the reference scenario. As can be seen in the figure, the major cost savings are achieved by shifting the electric heating loads. Compared to the reference scenario, the electricity cost could be reduced by about 1.7%, if all loads were to be shifted. For all houses, the savings achieved by scheduling the dishwashers or laundry machines were relatively small. For customers without electric heating, the rescheduling of the dishwashers and laundry machines would lead to a cost reduction of about 0.5-1.2% of the total electricity cost.

The load profile achieved by the optimal load scheduling is presented in Figure 4 for the selected day during the summer and during the winter. As can be seen in the figure, the peak demand has increased both during the summer and during the winter, although it has been shifted in time. For all three houses in this study, the peak demand has increased substantially compared to the reference scenario, especially during the summer. The reason is due to the fact that the heating system is operating at its maximum power for a short period and that the dishwashers and laundry machines would likely start simultaneously.

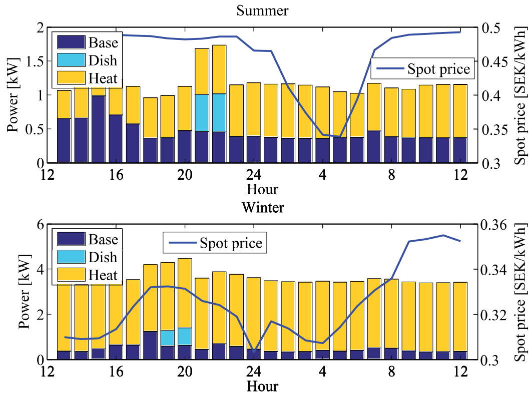

Figure 4: Load profile for "House 1" in the optimal load scheduling

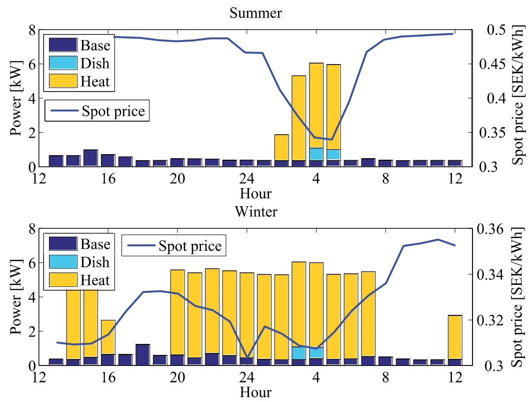

Figure 5: Load profile for "House 1" in the reference scenario

Concluding remarks

The results from this study indicate that the savings that could be gained by customer (re)scheduling their laundry and dishwasher loads are rather limited. It is assumed that the inconvenience this might cause the customer may be higher than what they are actually gaining in monetary terms to encourage the customers to participate. Customers that are using electricity for heating could gain somewhat larger reduction on their electricity bill by adopting the hourly spot price scheme, especially customers with a high heating power installed. Additionally, the results indicate that there is a risk that the electricity demand might increase during low price periods, which in turn could require reinforcements in the electrical distribution systems if the hourly tariff gets widely spread.

References

[1] D. Steen, L. A. Tuan, O. Carlson and L. Bertling Tjernberg, "Evaluating The Customers' Benefits Of Hourly Pricing Based On Day-Ahead Spot Market," Paper accepted to be presented at CIRED, Stockholm, 2013.

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[3] J. P. Zimmermann, "End-use Metering Campaign in 400 households In Sweden Assessment of the Potential Electricity Savings," (Report), ENERTECH, 2009.

For further information: David Steen,Anh Tuan Le, Ola Carlson, Lina Bertling Thernberg, Chalmers