TOWARDS FLEXIBLE ENERGY DEMAND – PREFERENCES FOR DYNAMIC CONTRACTS, SERVICES AND EMISSIONS REDUCTIONS

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Overview

Flexibility is a key element for reliable operation of energy systems as the levels of variable renewable energy sources increase. Generally, flexibility as a term refers to energy system's ability to maintain continuous service during rapid and large changes in energy supply and demand. Demand side flexibility is an essential part of the overall system level flexibility. In order to achieve necessary levels of demand side flexibility, households must become more active participants in the market.

Many aspects of households' motivation to provide flexibility are not well understood and thus the mechanisms to promote flexibility among households are still inadequate. This study contributes to existing literature (see e.g. Broberg and Persson (2016)) by examining households' willingness to participate in dynamic pricing and flexible load control services. To successfully implement demand side flexibility, household behavior and preferences should be appropriately analysed. Furthermore, required compensations and other possible value creating elements should be determined and examined in detail.

Methods

We conduct a Choice Experiment (CE) to examine households' preferences for characteristics (i.e. attributes) of demand side flexibility in Finland. CE is a widely applied quantitative statistical method to analyze individual's discrete choices (see e.g., Johnston et al. (2017) and Ruokamo (2016)). The main goal of the CE method is to determine how individuals construct their preferences for services and goods, and what are the trade-offs between different attributes describing them.

The CE covers several important aspects of demand side flexibility. The CE is employed using six hypothetical choice tasks presented to each respondent. Respondents are provided with three choice alternatives and asked to choose their preferred alternative among them. One of the alternatives corresponds to the benchmark situation (i.e. status quo) without flexibility characteristics, whereas the two other alternatives present possible choice scenarios with flexibility characteristics. The choice alternatives are described by six attributes: electricity distribution contract, electricity sales contract, remote control of heating, remote control of electricity use, system level emissions reduction and annual savings.

Electricity sales contract has two possible levels: fixed price contract and real-time price contract (where price fluctuates from hour to hour). Electricity distribution contract has three possible levels: fixed price tariff, two-rate tariff (different prices for day and night) and power based tariff. Power based tariffs are introduced to create an incentive for households to limit their peak power usage and smooth their consumption profile. The remote control of heating and remote control of electricity usage are defined in terms of time. As the load on the electricity system appears to be highest during the morning and early evening, we assign these attributes to have three possible levels: no remote control, control between 7 am and 10 am and control between 5 pm and 8 pm. Power system level emissions reduction in CO2 has three possible levels: 0%, –10% and –30%. Generally speaking, electricity markets can be made more efficient by matching the demand and supply better. If households start to adjust and/or time their electricity usage, that in turn reduces the load during traditional peak-hours and decreases the need of running conventional power plants utilizing fossil fuels. The annual saving in electricity bill is set to vary between 0€ – 350 € for individuals living in detached and semi-detached houses, whereas for individuals living in smaller flats, e.g. in terraced houses and apartment buildings, annual savings potential is lower and set to vary between 0€ – 200€ in the choice tasks.

The target population for this study is randomly drawn from a group of Finnish homeowners and we have 380 respondents in the final sample. To analyze respondents' choices we use the Mixed Logit model in willingness to pay (WTP) space (see Train and Weeks (2005) for model description).

Results

Results show that respondents require, on average, 54€ [±12€] compensation in their annual electricity bill to choose real-time price over fixed price. This indicates that uncertainty in the monthly energy bill is linked with considerable discomfort. Regarding electricity distribution contracts, the two-rate tariff is the least favored alternative with 43€ [±21€] compensation requirement. The WTP for power-based tariff is not statistically different from zero suggesting that respondents are indifferent between fixed rate and power-based tariffs. This implies that there is likely some room in the market for new dynamic distribution fees.

Results reveal that respondents' sensitivity to restrictions in electricity usage are greater than comparable restrictions in heating. There are also considerable differences in their perceptions between load control in the morning and in the evening. The most disutility is attached to constraints imposed on both heating and electricity load controls in the evening. Required compensation from electricity load control is 115€ [±24€] in the evening and 42€ [±14€] in the morning. A possible explanation for this finding is that everyday household tasks (e.g. doing laundry and dishes) usually take place in the evening. Required compensations for accepting load control in heating are 46€ [±19€] and 37€ [±16€] respectively. This indicates that for many households the load control in heating is acceptable in principle, at least within tight bounds. Load control in heating offers flexibility with sacrificing only little comfort of living.

Results show that as the levels of emissions reduction and annual savings increase, the probability of choosing respective alternatives increases among respondents. Interestingly, respondents are willing to pay on average 86€ [±13€] annually for 30% emissions reduction, however, less significant emissions reductions (-10%) do not attract respondents. This demonstrates that there exist, on top of monetary savings, also other value creating elements to increase demand side flexibility. Power system level emissions reduction, however, needs to be large enough to activate this potential.

To investigate preference heterogeneity we introduce interactions between the status quo and other covariates. From attitudinal characteristics we find that positive perception of RTP contract (i.e. the respondent either had RTP or had considered such contract) is associated with higher probability for choosing flexibility alternatives. This indicates that understanding the potential benefits of dynamic pricing is likely linked with higher willingness to participate in demand side flexibility. Moreover, respondent's interest in own energy consumption is associated with higher participation in flexibility alternatives compared to status quo.

Conclusions

Demand side flexibility is expected to take an increasing role in the future power system. Households should adjust their electricity consumption based on price signals and other incentives in order to facilitate efficient use of generation and network infrastructure and functioning of the overall electricity market. By investigating carefully the determinants of demand side flexibility, we can support the development of the future energy system to meet households' and society's needs. In order to increase the participation of households to flexibility services and contracts, it is necessary to examine which characteristics make the participation less or more desirable.

References

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