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Is our everyday comfort for sale? Preferences for demand management on the electricity market

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ABSTRACT

In a European perspective, the electricity markets have been experiencing major changes via deregulation, new technologies and changes in the production mix. Together with the daily and seasonal peak hours on the demand side, the changing markets put pressure on increased flexibility to handle and sustain balance in the grid systems. This paper focuses on the demand side and analyzes preferences related to demand management of Swedish households' energy use. In a web-based choice experiment respondents were faced with three hypothetical electricity contracts. The choices of preferred contracts revealed preferences for attributes related to external control of heating, household electricity and information dissemination (integrity). The results show that people put a substantial value on not being controlled, illustrated by compensations up to thousands of SEK for accepting a contract characterized by external control of energy use in various dimensions. In addition, the results show that household composition, age, gender and income play a role for the perceived discomfort from the external control and information dissemination.

1. Introduction

It is fair to say that climate change and energy security are high on the political agenda, in particular in the EU. The European council recently decided on a climate and energy policy framework reaching for 2030 and although the new framework put the climate on a pedestal, the targets for renewable energy and energy efficiency remain central pieces of the EU structural plans. In light of this, large-scale investments in renewable energy, back-up power and transmission capacity are needed to accomplish the targets and aims. As the share of renewables increases the degree of intermittent production increases and investments in local power grids are typically needed for a well functioning power system. Both the internal market in electricity directive (2009/72/EC) and the renewable energy directive (2009/28/EC) suggest that demand response (or demand flexibility) is likely to ease the transition of power markets by improving the interplay between local power demand and supply, and by stimulating energy efficiency. It is clear that a development characterized by demand flexibility would reduce the need for new investments in the power grid and back-up capacity.

This paper elaborates on the economics and potential of smart grids and demand flexibility, which have become keywords in energy policies worldwide (see Joskow, 2012 for a U.S. context). Smart grids are often discussed in a context focusing on the possibilities of new technology, often ignoring the consumers' willingness to accept and use this technology. From an economic perspective cost and benefits of power market reforms are not limited to the energy systems, but will also include end-users in several dimensions. Ignoring the demand-side will severely bias cost–benefit analysis and policy-making. The main objective with the paper is to study potential utility loss, or discomfort, associated with consumer flexibility and demand management. By the use of a so-called choice experiment, households are faced with hypothetical electricity contracts and their choices reveal preferences for different attributes of the contracts. By statistical methods it is then possible to explicitly estimate the compensations needed to be "flexible" in different dimensions at the household level. The dimensions of flexibility considered in the contracts are related to types of electricity use (heating and domestic electricity), time of day and the provision of private information regarding household energy use. As for the latter, one may recall that there is a growing literature suggesting that peer comparisons of electricity use as such is potentially an effective policy instrument for energy saving (see e.g., Allcott, 2011b; Dolan and Metcalfe, 2013).

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In addition to the "main-effects" the paper also elaborates on the importance of socioeconomics and other factors for preferences and flexibility. The size of the reduced comfort (utility loss) caused by restrictions in energy use is potentially related to socioeconomic factors such as e.g., age, gender and income. For example, previous research has shown that men and women engage in different activities during their off-work time, with the activities varying in carbon (and energy) intensity (Druckman et al., 2012). Other studies have made use of time-use data to map different activities to derive load profiles based on "active occupancy" (Torriti, 2012b). Whether or not people are at home during time of restrictions in electricity use is a potentially important factor for the estimation of utility changes.

The method of choice experiments is commonly used in the field of environmental economics and for the purpose of non-market valuation. There are also choice experiment studies related to the electricity market via e.g. load shifting, tariff choice and outages.[1] The method makes it possible to estimate the value of separate attributes of goods opposed to only measuring the value of a specific good (a bundle of attributes). In the present study, it is possible to estimate a value on the discomfort a household experiences from, say, not being able to use the dishwasher, or from a lower indoor temperature during the peak hours and the utility/disutility associated with peer comparisons of electricity use. These values are highly policy relevant by revealing how much money households need to, for example, move electricity use from hours of peak demand.

The paper is structured such that Section 2 gives a background to the discussion on smart grids and demand response. Section 3 explains the method of choice experiment and presents the survey and the experimental design together with descriptive statistics and the empirical specification. Section 4 continues with the results, while the paper is closed with a summary and discussion in Section 5.

2. Smart grids and demand response

Measures to stimulate demand flexibility are commonly referred to as enabling policies empowering the end-consumers' role in the energy markets. Demand flexibility rests on the idea that end-consumers react (respond) to economic incentives like prices or other forms of compensations. This type of flexibility is desirable in unregulated markets where the electricity price changes by the hour, as is the case on the Nordic power market, Nordpool. Given todays advanced electricity meters, it is possible to measure household level electricity use by the hour and charge prices based on the real time spot price on the wholesale market. This type of pricing scheme is referred to as "real time pricing". More generally, when the price facing end-consumers changes at least once per 24 h, it is referred to as dynamic pricing.

Dynamic pricing in general, and real time pricing in particular, is rather uncommon today although the interest is growing with the technology development and with the change in the production mix toward more intermittent sources. In the EU, the rollout of smart meters has advanced furthest in Finland, Italy and Sweden (COM, 2014). In Sweden more than 90% of firms and households have advanced meters (Sweco, 2014). Since October 2012, the Swedish electricity suppliers have to, upon request by consumers, offer real-time contracts. So far however, the interest in these contracts has been limited among customers. By the spring of 2014, only 8 600 households (about 0.2% of all households) had signed real-time contracts (Swedish Energy Markets Inspectorate, 2014).[2] To have more consumers opting for real-time contracts, the incentives for such contracts need to increase. It is not known, however, to what degree increased price volatility will affect demand flexibility, which is ultimately an empirical question. In all cases, it is urgent to examine how households are likely to act under various circumstances. To some degree, the high hopes of an untapped potential of demand-side flexibility is contradicted by the vast literature on the so called energy efficiency gap arguing that consumers are rather price-insensitive and may react inefficiently to price signals due to informational, organizational and behavioral failures (for an overview, see Broberg and Kazukauskas, 2015). With this in mind, empowering end-consumers by enabling dynamic pricing (or other compensation mechanisms) and the provision of detailed information about their energy use may turn out to be ineffective. Still, a number of studies have shown that dynamic pricing affects households' electricity consumption (Faruqui and Sergici, 2013). In a field experiment on electricity customers in the U.S. it was found that real-time pricing does not primarily lead to load shifting, but rather decreases electricity consumption in peak price hours, amounting to an energy saving of approximately two percent of a households total electricity use (Allcott, 2011a). A potential problem in such studies is that the consumers participate on a voluntary basis, which may cause a selection-bias (see e.g. Goulden et al., 2014). For example, Torriti (2012a) found that when Italian households were involuntarily exposed to dynamic pricing (time of use) total electricity use actually increased by approximately 13%. The study also found that the introduction of time of use pricing succeed in, to some degree, lowering the morning peak, while worsening the evening peak problem.

In contrast with real-time pricing and active responses, demand flexibility can be increased through agreements on power reductions. Contracts can be designed to compensate households if they reduce their power demand when supply is stretched, or to allow an external actor to control parts of their electricity consumption remotely (Babar et al., 2014). In the latter case, the contracts mean that households waive the right to control parts of their own electricity use.[3] The contracts hand a central role to aggregators brokering "demand flexibility" between power trading companies, grid operators and consumers. In this context one can refer to power reductions, battery storage and micro-production of wind and solar power as virtual power plants (Medina et al., 2010). The aggregator's role is to pull together the fragmented demand flexibility and design products that can be sold in the spot or regulating market. Given peak demand in time, both through the year but also through the day, aggregators may curb and control consumption by simply performing effect-control on given households. The direct and exact control of the demand side is very attractive from a practical perspective, although potentially imposing disutility and discomfort at the household level. Direct load control (DLC) makes it simpler to optimize the available capacity, as the power demand becomes more predictable compared to the case with active response through real-time pricing. The idea of contracts allowing for DLC among households is not new, although typically practiced in warmer climate countries, such as Australia, and relating to air conditioning (see e.g. Strengers, 2008 for research on the implementation of DLC and household comfort).[4]

In addition to paving the way for demand flexibility, smart grids increase the opportunities for monitoring and evaluating household electricity use via e.g. so-called energy service companies. The improved flow of information via smart metering potentially enables energy system operators and energy service companies to improve their businesses and end consumers to lower their costs for energy. Moreover, alluding to social norms may be an effective way to induce behavioral

[1] See e.g., Buryk et al., 2015; Pepermans, 2011; Carlsson and Martinsson, 2008a; Abdullah and Mariel, 2010; Goett et al., 2000.

[2] Critics may argue that there is a substantial status quo, or default, bias in electricity contracts and, for example, in a US pilot with dynamic tariffs as default it was found that only 10% opted out (Herter, 2007).

[3] The demand response is implemented externally and may therefore be classified as a "passive" demand response.

[4] There are significant differences between a produced and a reduced MWh in terms of its underlying value. In order for a 1 MWh power *reduction* to be worth as much as 1 MWh produced power, it has to be guaranteed that it is additional, i.e. it must be proven that power demand really would have been 1 MW higher without the power reduction. This is a challenge and, as long as the problem persists, it constitutes an advantage for measures relying on active demand response through dynamic pricing.