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THE LESSON FROM DEMAND RESPONSE IN JAPAN

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Abstract

This study aims to contribute to Japanese policy recommendations with using the concept of 'Nudge' aimed at encouraging DR adoption that is scheduled for the wholesale electricity market starting in April 2017. Because consumers have bounded rationality, if the concept of Nudge is added to DR, there is a possibility of expanding the participation in DR more widely. In this paper, we reviewed Japanese electricity demand reduction efforts (the voluntary program) and demonstrated projects with using the nudge concept. The study found that the concept of nudge was useful in both DR trials. However, there was also the problems in these projects. The problem with the voluntary program was that when the consumer believed there was sufficient electricity, they were less willing to cooperate. The problem with the demonstration projects was the relatively low participation rate. Therefore, what the government needs to do is to assist consumers in understanding the importance and the necessity of DR, and in this education process, the Japanese government could use the nudge concept by reflecting on lessons from experiences in Japan and abroad.

Keywords

Demand Response, Nudge, Policy

1. Introduction

As stable and reliable power supplies are very important, electricity generation capacity is usually prepared more than the peak demand. Because it is very difficult to store electricity for peak periods which only occur for a few hours every year, electricity generation is over dimensioned when seeking to match the peak electricity consumption period. In this context, demand response (DR) can be effective in balancing grids and stabilizing the wholesale electricity market price (Bradley, Leach, & Torriti, 2013; Sezgen, Goldman, & Krishnarao, 2007). DR offers time-based rates or other financial incentives to consumers depending on the amount of their reduced peak demand; in other words, DR allows consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods (DOE, 2016).

DR is useful in balancing grids for the following reasons. First, DR is a substitute for conventional methods for balancing power grids (Kirby, 2007; Earle, Kahn, & Macan, 2009; Woolf et al., 2013), which over-dimension the generation capacity to match peak demand periods. Currently, 20% of generation capacity is prepared for peak demand periods that only occur only around 5% of the time (Strbac, 2008). In Japan, the peak period cost is almost 10–15% of the total generating cost, even though peak periods occur only around 1% of the time each year (Nihon Keizai Shimbun, 2015). Because fossil fuel is the primary power generator for peak demand, to maintain peak demand by increasing the generating capacity accelerates greenhouse gas emissions (Shen et al., 2014). Fossil fuel expenses can also rise in the future. Even though energy storage can be an option to balance the grid instead of increasing generation capacity, the cost of energy storage is extremely high and is currently only at a test stage (Kousksou et al., 2014). Consequently, DR, which balances the grid from the demand side, has good value as there is no need for extra fuel or power generation capacity to stabilize the grid.

Second, DR can be a useful tool to mitigate renewable energy generation. The high deployment of renewable energy is causing grid balance challenges because most renewable energy, such as wind and photovoltaic energy, rely on unpredictable weather (Milligan & Kirby, 2010). Therefore, as DR is expected to help mitigate grid balance challenges, it is currently being intensively investigated in some North American and European power systems that have a high degree of renewable energy integration (Cappers, Goldman, & Kathan, 2010; Macdonald et al., 2012).

This study aims to contribute to Japanese policy recommendations aimed at encouraging DR adoption that is scheduled for the wholesale electricity market starting in April 2017. To contribute to Japanese policy recommendations for the deployment of DR, we reviewed Japanese electricity demand reduction efforts (the voluntary program) and demonstrated projects with using the nudge concept. Japanese consumers will be given financial incentives to reduce their peak load when the supply-demand balance is tight. Moreover, the deployment of Smart Meters in Japan will also provide a desirable environment for DR.

The remainder of this paper is structured as follows. Section 2 discuss the usefulness of employing the nudge concept for DR deployment. Section 3 describes the status of DR in Japan using the nudge concept and policy recommendations are discussed in Section 4.

2. Methodology

There has been significant research into the expected consumer challenges and enabling technology as well as on DR's expected benefits in balancing grids and reducing environmental pollution (Shelia & Mark, 2015; Cherrelle, 2016; Haider, Ong, & Wilfried, 2016). There is no doubt that consumer preference analyses and the technological improvements are necessary for DR deployment. However, the problem in the energy sector is that there is little interest in the energy itself. According to a survey by Accenture (2012), consumers spend on average six to nine minutes each year interacting with their utility. Moreover, 54 percent stated that they have not interacted with their electricity provider in the past one year (Accenture, 2012). Therefore, even though there are attractive DR programs from technological and consumer preference points of view, it is also necessary to encourage consumers to take a greater interest in the energy sector and DR.

Moreover, there is a gap between the actions and the intentions in energy consumption (Allcott & Mullainathan, 2010). For example, while in the UK and other European countries 50–90% of respondents favor energy from renewable sources, less than 3% actually buy renewable energy (Momsen & Stoerk, 2014). It has been found that this gap between intention and action is a result of bounded rationality (Thaler & Sunstein, 2008). Behavioral economics and social psychology have examined the influence of values, beliefs, and social norms on behavioral change. Momsen & Stoerk (2014) found that due to limits in their cognitive processes, many people have difficulties understanding situations and fail to act upon their long-term intentions as a result. Sorrel (2015) emphasized that even though consumers are influenced by economic incentives when making decisions about the use of energy, most decisions are made with limited or asymmetric information about energy (service) costs.

In this context, research into behavioral change has used the nudge concept in the energy sector (Asensio & Delmas, 2016; Allcott & Mullainathan, 2010; Costa & Kahn, 2013; Momsen & Stoerk, 2014). Thaler & Sunstein (2008) defined nudge as "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives." The government's role in raising the efficiency of policy implementation is also important (Wijaya, 2015; Maulana, 2015).

Therefore, to analyze the government's role for the deployment of DR, we use the nudge concept as this is a useful tool for analyzing the behavior of electricity consumers. Moreover, in this paper we focus on the residential sector because in Japan, demand in the residential sector is growing and is 20% of peak day electricity (Ministry of Economy, 2011). Social norms, framing, default, priming and feeling of loss are the nudge concepts that this study uses.

Nolan et al. (2008) found that understanding "social norms" was an effective way to change behavior in the energy sector. Social norms from a behavioral science perspective refer to the tendency of people to follow others (Sunstein, 2003). In Nolan et al.'s (2008) research, energy consumers were found to conserve more energy when they were informed that their neighbors were conserving energy. "Framing" has also been found to be effective in changing behavior. Asensio & Delmas' (2016) research found that consumers would conserve energy more persistently when energy conservation was framed as a health-based community concern rather than being framed as a monetary reward. A "default" is when people decide not to switch from the status quo because of switching costs and loss aversion (Spiegler, 2011). According to Momsen & Stoerk (2014), only a default nudge can have a significant effect when residential consumers are given the choice of renewable energy. "Priming" (when people make decisions, they rely on what comes to mind, instead of using all available information (Gennaioli & Shleifer, 2010), "feeling of loss" is stronger than gain (prospect theory (Kahneman &

Tversky,1979), in which the way the information is presented is changed, can be used to change behavior without force.

3. Analysis

In this section we analyze the results and the limitations of DR projects with using the nudge concept such as social norms, framing, default, priming and feeling of loss. Then, the policies needed for DR deployment are discussed in Section 4.

In April 2017, Japan will launch a market for trading unused electricity; therefore, companies and households can receive financial incentives when they reduce demand at times when the supply-demand balance is tight. DR interest has been growing since the earthquake on March 11, 2011 caused a meltdown at the Fukushima Dai-ichi power plant. This power plant, which was subsequently shut down, had supplied 31% of Japan's electricity. To alleviate energy supply shortages, DR began to be more widely understood as a viable alternative. There have been two DR implementation methods: through voluntary DR sign-up and in demonstration projects such as the Smart City projects.

The Japanese government launched a voluntary power-saving campaign for industrial and residential sectors from 2011 through 2015. In the summer of 2011, the year of earthquake and tsunami, electricity savings with a target of 15% of peak level were promoted to all electricity consumers in the Tokyo Electric Power Company (TEPCO) and Tohoku Electric Power service areas. In the summer of 2012, efforts to reduce demand were also made, and in particular, a 10% target in the Tohoku Electric Power's service area was promoted. Between 2013 and 2015, no numerical targets were set, but voluntary reduction action was promoted. Because the electricity supply was expected to exceed demand by at least 3%, which is considered the minimum necessary level to ensure a stable power supply, 2016 was the first year that the Japanese government did not ask electricity consumers to reduce their electricity consumption (The Japan Times, 2016).

Voluntary DR promotion, which basically asked consumers to reduce their demand in peak periods to avoid blackouts, was done mainly through website and TV commercials. The Electric power company posted electricity demand forecasts on the site (TEPCO, 2016), also electricity usage levels compared to the peak capacity are being posted on the sites and tips are provided on how to reduce demand to avoid blackouts. "Action to Save Power" is a Japanese government portal site run by the Agency for Natural Resources and Energy (Action to Save Power, 2016). As for the TV commercials, in the Ministry of Economy, Trade, and Industry (METI) commercial, for example, the electricity consumers are asked to "save" the country (METI, 2011). In the commercial by TEPCO, the message focuses on "cooperation to avoid blackouts" with reducing peak loads (TEPCO, 2011). As a result of these efforts, there was a 10% saving after weather normalization adjustments compared to levels in 2010, 2011, and 2014 (Nishio, 2015).

There have also been DR trials as part of the Smart City projects and other DR demonstrations. These promotions have mainly been offering financial incentives and Time of Use (TOU) rates. Smart Cities are expected to grow all over the world because of the economic importance of urban areas and the need to address their environmental problems (Pham, 2014). Additionally, many Smart Cities are aimed at commercialization and exports. The first Smart City project in Japan, which was initiated in late 2009, was primarily for high-tech demonstrators and technological marketing. However, following the Great East Japan Earthquake, these projects have focused more on demand-side management, one of which was the utilization of DR. It was estimated that in Kitakyushu, one of the Smart Cities, the consumption peak periods could be reduced by 20% (NEPC, 2016). In addition to the Smart City projects, there has been the Large HEMS Information Infrastructure Development project (I-ENE consortium) which was subsidized by METI (I-ENE, 2016). In that project, the KDDI implemented a DR program in 3,500 homes, resulting in a 20% participation rate and a 5% reduction in demand (SankeiBiz, 2016).

In the voluntary DR programs, Smart City projects, and demonstration projects, demand reduction was achieved. However, it is unclear which factors contributed to these reductions, what DR implementation problems there were, and what role the government should play in encouraging DR take-up. After first analyzing DR with using the nudge concept such as social norms, framing, default, priming and feeling of loss, then we present some policy recommendations for Japan in Section 4.

First, based on the perception of electricity shortage risk and the need to avoid blackouts, voluntary DR has been a successful initiative. Even though this is not a default position, when presented with a critical situation the priming was successful. The memory of the blackouts after the earthquake encouraged people to participate in the voluntary DR. Consumers were informed that they were saving the country (social norm) through the framing of the issue, so many were willing to cooperate and endure electricity shortages at peak times as this was preferable to blackouts (feeling of loss).

However, when the DR is implemented by focusing on a critical situation such as a natural disaster, after the crisis has passed consumers are often unwilling to continue. According to the research by Mizuho, while 91% of the consumers in 2011 thought that there was a serious lack of electricity, this had reduced to 61% in 2014 with 77% of consumers indicating that their interest in reducing demand was decreasing (2015). Nishio (2012, 2015) analyzed the factors that influenced the demand cuts in the residential sector each year between 2011 and 2014 using a follow-up questionnaire. It was found that in 2011, the focus on social responsibility influenced households to accept the uncomfortable and inconvenient conditions during off-peak hours, but social responsibility became weaker gradually in 2011-2014.

Moreover, there were bigger challenges than just reducing demand. The participation rate was a real problem that needed to be countered. Generally, as mentioned previously, consumers spend around 6–9 minutes each year interacting with their utility, with 54% having not interacted with their electricity provider in the past one year (Accenture, 2012). This low interest in electricity was also noticed in the utility switching. After electricity deregulation in EU countries, the switching rates were much lower than expected. Therefore, this lack of interest in electricity deregulation and the possibilities of cost reductions (feeling of loss) were highlighted as the main reasons for the low switch rates (Ariu et al., 2012). In the U.S., the percentage of customers who chose to participate in the TOU rate was also lower than expected (Federal Energy Regulatory Commission, 2015). The interest of the Japanese in electricity is no different from other countries. From August to November 2011, the year of the earthquake in Japan, Goto & Ariu (2012) surveyed consumer preferences for the TOU rate as a tool for reduction of demand. It was found that only 4% were interested in TOU, and even though they would be provided with information about their consumption patterns, only 7% indicated that they would choose TOU.

To increase participation, a social experiment was conducted as part of the Yokohama Smart City project in 2014 (Japan Smart City Portal, 2015). The possible participation rate was 16% after the invitation, 31% after being provided with information about the expected financial gain, and 48% after being provided with information about the expected financial gain and incentives which focused on expected future cost reductions. However, even though the participation rate increased, the reduction amount was reduced. The average peak cut effect decreased from 26% for the 14% who had been told about the expected savings, to 16% for those who had accepted an incentive fee of 6,000 yen for expected future cost reduction.

These investigations indicate that consumers do not want to change their utility or to use TOU mainly because they are not sure of the extent of the loss (feeling of loss), of how many people are changing their utility, and of the benefits of TOU (social norms).

4. Discussion

DR can generate significant benefits if it is widely adopted; however, to date, there has not been sufficient engagement with consumers. Behavioral science and social psychology have tried to explain the gap between consumer action and perception, and some research has attempted to use the nudge concept to change electricity consumer behavior. A nudge is a slight change in the information given to a person when they need to make a decision. In this paper, we reviewed Japanese electricity demand reduction efforts and demonstrated projects with using the nudge concept to aim at accelerating the deployment of DR in 2017 when reduced demand will be traded on the wholesale market.

Two DR waves were examined. The first was a voluntary DR program actioned by the Japanese government and the utilities and the other was a DR demonstration project. For the voluntary DR, consumers were asked to save the country by reducing the peak loads to avoid blackouts, while the demonstration projects mainly focused on financial incentives and TOU rates. There was no significant difference in the reduction volumes between these two methods. Moreover, we found that the concept of nudge was useful in both DR trials. However, the problem with the voluntary program was that when the consumer believed there was sufficient electricity, they were less willing to cooperate. The problem with the demonstration projects was with increasing the relatively low participation rate.

What the government needs to do is to assist consumers in understanding the importance and the necessity of DR. In this education process, the Japanese government could use the nudge concept by reflecting on lessons from experiences in Japan and abroad. People are more persistently conserve energy, if they were informed about health-based concerns rather than the monetary rewards (Asensio & Delmas, 2016). In Japan, also, people who received financial incentives for expected future cost reductions had a lower peak reduction than those who participated in DR without financial incentives. Therefore, the Japanese government should be careful when framing the DR in Japan. Secondly, as Japan produces only 11% of their own domestic demand needs peak demand is supplied by imported fossil fuels (EDMC, 2014). Therefore, the Japanese government could use priming methods focused on energy security. People may also have a greater feeling of loss from the trade deficit losses of importing fossil fuel than from demand cuts. Default was an effective way for choosing renewable energy in the residential sector (Momsen & Stoerk, 2014). The U.S. has also been studying the impact of opting out (default) in energy sector (Federal Energy Regulatory Commission, 2015). The Japanese government need to examine the possibility of using default in Japan. Finally, sharing more information with Japanese consumers regarding the DR movement abroad could help to change Japanese consumer behavior toward DR take-up (social norm).

Increasing consumer engagement for DR is important for the future of Japanese energy provision. The technological environment for DR has been improving and many electric companies are trying hard to provide attractive electricity rates to consumers after deregulation. Therefore, the Japanese government needs to focus on raising awareness to encourage consumers to take a greater interest in the energy sector in order to increase the efficacy of DR adoption with using the nudge concept, and for achieving this purpose, a closer and more detailed analysis of Japanese electricity consumer behavior is necessary.

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