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KEY INFLUENCING FACTORS FOR THE CONSUMER PARTICIPATION IN THE INCENTIVE-BASED DEMAND RESPONSE PROGRAMS

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ABSTRACT Incentive-based demand response program (IBDRP) is one of the most widely accepted methods of demand response (DR) used to achieve the growing peak load demand in the electricity sector. With the introduction of modern technologies related to DR/IBDRP, peak load management has been made easier than before and, hence gaining reliability among the electricity market. Though different ways of incentives are being offered to consumers, financial incentives towards the reduction in the power consumption attract more consumers for enrolling themselves into the programs. This paper examines some of the major factors influencing the participation of consumers in participating in IBDRP, along with the key factors in the perspective of implementers. From the referred literature, formulating an indisputable and flawless customer baseline is identified as the major factor determining the incentives offered to the participants. Miscalculation of it may end up with monetary losses to either electricity provider or the participant.

KEYWORDS : Incentive-based demand response program, customer baseline, demand response

1. Introduction

From the viewpoint of the grid, reduction in electricity demand is not only equivalent to electricity production but more than that while considering the losses in the transmission system. Demand Side Management (DSM) is a well-accepted method for electricity demand reduction and its key element, DR, attracts wide recognition in several electricity markets. By implementing DR programs effectively, an impressive reduction of 28798 MW and 28934 MW was estimated for 2013 and 2014, respectively, in the United States of America (USA). This results in the peak power reduction of 6.1 and 6.2%, respectively, for these years(FERC, 2015).

Price-based demand response program (PBDRP) and IBDRP are the two major sub-divisions of DR programs. In PBDRP, consumers are charged based on their time of usage. Under this scheme, consumers are charged high for using electricity during peak hours and less during non-peak hours. Most commonly used PBDRP are critical peak pricing (CPP), real-time pricing (RTP), time of use (TOU), and peak time rebates (PTR). According to the preference, the consumer may sign a contract agreement with the implementer.

In the IBDRP, for reducing their electricity consumption, consumers are offered with incentives. Implementation of such schemes can be carried out by either by implementers or by participants. In the case of implementer controlled programs, the load reductions will be carried out with the help of control devices, which may be operated locally or remotely. In consumer managed programs, the entire implementation has to be carried out by the consumer themselves.

IBDRP operate in both wholesale markets and retail markets. The commonly used IBDRPs in the retail market is direct load control (DLC), interruptible load (IL), demand bidding/buyback (DBBB), while ancillary services (AS), capacity market programs (CMP), emergency demand response programs (EDRP), etc. operate in the wholesale market.

2. Background

Both implementers and consumers are benefitted with the successful implementation of the DR programs. By meeting the growing demand with the help of DR programs, electricity providers can delay the need for building new power plants or transmission lines (Horowitz, Mauch, & Sowell, 2013; Silver Spring Networks, 2013).

In most of the cases, all efficient power plants will be put into operation during regular time, and the inefficient ones will be used in the worst case to meet the demand during the peak hours. By shifting the loads from peak hours to nonpeak hours with the help of proper DR programs, not only peak power demand can be controlled, but also the running hours of the inefficient power plants can be controlled. This will save operational cost to electricity providers in addition to the enormous reduction the pollution.

Some of the DR programs are also used as a reserve capacity for contingencies in the grid. As an example, by increasing the DLC implementation, PJM, a northeastern grid in the USA, covers 20% of its contingency reserve. In addition to improving the grid stability, DR programs can also be used as a tool to optimize the grid connectivity of renewable energy sources such as solar and wind energy (Horowitz et al., 2013; Silver Spring Networks, 2013). Many electricity providers like PJM, a northeastern grid in the USA use the DR programs to improve their contingency reserve. They managed to cover around 20% of its contingency reserve by proper implementation of DR programs. Improving grid stability and enabling connectivity of renewable energy (RE) sources such as solar and wind energy are some of the other benefits to the electricity providers (Horowitz et al., 2013; Silver Spring Networks, 2013). Additionally, combating climate change, promoting awareness, generating new jobs and expertise, and reducing the reliance on hydrocarbons are some of the other benefits of implementing DR programs(Hoeve, 2009).

As mentioned earlier, IBDRP offers different types of incentives, mainly cash payback to the participants for altering their electricity usage. Every time it is not necessary to reduce the consumption. In certain cases, electricity provider may encourage to use more to avoid shutting down of a power plant. Designing incentives appropriately is a mammoth task as it involves many factors, which eventually attracts consumers to enrol themselves. More energy-conscious consumers who pay less electricity bills are more attracted to such schemes than high consuming customers(Barreto, Mojica-Nava, & Quijano, 2014).

It is very obvious that by involving in the IBDRP program, the overall electricity consumption of the dwelling will reduce, which will have an impact on consumer's monthly electricity bills. This is another monetary benefit to the consumers in addition to the incentives they receive as part of IBDRP. As the reduction in consumption is related to the running hours of the electrical equipment, this will lead to substantial reduction in the maintenance expenses also. In certain cases, as previously mentioned, consumers may get the opportunity to use more electricity during off-peak hours without paying extra money (Albadi & El-Saadany, 2008). Incentives paid to consumers are highly dependent on the programs they are enrolled in. As an example, IBDRP with an emergency nature pays more incentives than other programs, due to the high requirement from the generation side(Yoo et al., 2011).

It is very obvious that consumers have to make some compromise on their comfort while participating in IBDRPs. If the provided incentives are not adequate, will lead to dissatisfaction among consumers and eventually they may leave. From the referred literature, the main reason behind dropping out from the IBDRP is found to be the insufficient incentives.

3. Objective

The objective of this work is to identify the key factors persuading the participation of consumers in the IBDRP and role of incentives for the same, both in the implementers and participants perspectives.

4. Methodology

A well-known qualitative data analysis methodology, document analysis, was used in this study to meet the specified objective. Several keywords such as DSM, DR, IBDRP, PBDRP, incentives, consumer satisfaction, etc. were used individually as well as a combination of these to search associated documents in various channels of information. Around 62 documents were referred, which included government reports, company reports, academic article, to include research articles, research thesis, and journal and conference papers, etc. A strict filtering of the documents was conducted to select most appropriate documents addressing the subject, and twenty five documents were selected finally. All the selected documents were analyzed in detail with the help of ATLAS.ti software, a widely used software for document analysis. The results of the analysis are presented in the following sections.

5. Results and discussion

The results of the document analysis are presented in the view of consumers and implementers are detailed subsequently.

5.1. Consumer perspective

Fig. 1 shows some of the major factors related to the user participation in the IBDRP. Broadly it can be divided into two main categories such as compromise and income. By modifying their behaviour and usage pattern, all consumers participating in the IBDRP are making some compromise. The compromises can be related to thermal comfort and disturbances related to shifting the operation of equipment, which are described as below.

As part of the enrolment to the IBDRP, consumers have to make a contract between them and implementers. It is obvious that both parties have to adhere to the conditions agreed as per the contract. In some classical IBDRP such as the DLC and the IL, where operations are controlled remotely, implementers automatically cut down the load of the users during the agreed time period irrespective of consumer's activities. In most of the dwellings, due to its high power consumption, Air-conditioning (AC) units are primarily targeted for drastic power reduction. It is learned that indoor comfort will not be affected if the AC units are switched off for 15 minutes (Crossley, 2003; Horowitz et al., 2013). However, this time differs from case to case, depending upon several factors such as outside temperature, the number of inmates in the house, type of activity during the time of implementation, etc. Even though the timing for load curtailing will be decided after considering above factors, an unexpected event can lead to troubles for the people residing in the house, and they have to adhere to the contractual obligations and take the pain. It is claimed that in most of the cases, the corresponding cost of not using electricity is much more than the incentive they receive in return (Yoo et al., 2011). Repetition of such incidents may force to the nonrenewal of the IBDRP.

To gain the complete benefit of IBDRP, which gives more incentives in peak hours than non-peak hours, consumers shift usage of some of their loads to non-peak hours. It is very difficult to generalise these types of loads as it varies from individuals. Television may be a shiftable load to some people, who can enjoy the programs during the repeated telecast time but may not be acceptable to those who are eagerly waiting for the show. This applies to other appliances like dishwashers and washing machines also. The comfort and other operational difficulties for using such appliances during non–peak hours should be properly compensated to encourage consumers. All these compromises are supposed to be compensated by proper incentives. However, there are also some threats associated with receiving these incentives, which are detailed below.

Collecting instantaneous data of power consumption is mandatory in all DR programs, which cannot be achieved with traditional energy meters. Solution to this problem is the introduction of smart meters. Smart meters can gather data and record it independently and can be connected to a remote server. Even though data collection remotely is not compulsory, to get the complete advantage of the system, it is advised to have it. The collected data can be stored for long duration and can be recalled whenever it is required (Gong, Cai, Guo, & Fang, 2015). Instantaneous data collected by smart meters are used for many analysis purposes, including calculating the reductions achieved, establishing customer baseline (CBL), etc. In many cases, consumers may not show interest to replace their traditional meters with smart meters, as they have no benefit from that, until unless they enrol to DR programs. Electricity providers may educate the consumers about the advantages and benefits of such meters and encourage them to accept the change. From the referred literature, several factors restrict consumers for not installing smart meters were identified. One of the major factors among them was related to the cost associated with the procurement and installation of the smart meters. Without getting a fast payback, consumers will not invest their money for this purpose. As smart meters are mandatory for the implementation of the program, leaving options for smart meter's installation on consumers may influence their interest negatively. This cost will also restrict week communities from enrolling the program, irrespective of their interest (Hoeve, 2009).

Threat related to consumer's privacy is identified as one of the other reason for keeping consumers away from adopting smart meters. As the occupancy pattern of inmates can be predicted with the help of their power consumption in a house, many consumers fear that by hacking this data from the network, thieves can easily identify their presence in the house and plan accordingly. It is the responsibility of the implementers to take extreme care to secure the data on their network to avoid such threats.

There is no direct way to measure whether the users curtailed the committed amount of electricity in the agreed time period or not. This is done by subtracting their consumption during the event from the CBL of that particular time. CBL is the base power consumption of any facility, prior to the DR implementation. Hence, calculation of CBL is identified as the most crucial factor to be considered while implementing IBDRP in any electricity markets. Since CBL is the basis of calculating the money given to consumers, accurate calculation of it is vital for implementers also.

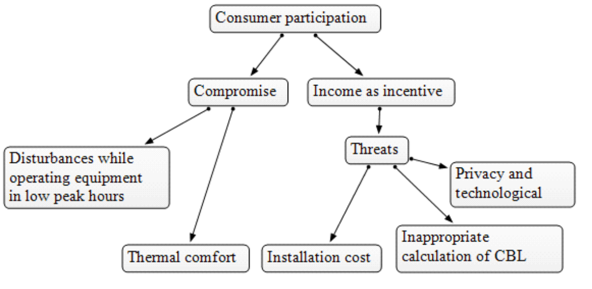

Fig. 1. Key factors influencing consumer participation

5.2. Implementer's perspective

Fig. 2 shows the major factors related to IBDRP implementation in the view of the implementer. It is advised to conduct a detailed cost benefit analysis prior to its implementation. Costs can be broadly divided into capital, administrative and incentive payments. The capital cost will be huge in places where necessary infrastructure is not available, which may play a vital role in the cost benefit analysis. The main infrastructure changes include replacement of traditional meters with smart meters, optimizing the communication system, installation of control devices, etc. —(Pedrasa, Oro, Reyes, & Pedrasa, 2014; "Task 15 Case Study ETSA Utilities Air Conditioner Direct Load Control Programe Australia," n.d.).

Other than maintenance cost, expenses towards data collection and transfer, the cost of marketing and awareness, evaluation, measurement and verification (EM&V), etc. are coming under the administration cost. This can be called as operational expenses also. Due to its high importance, E&MV may have a higher cost for the newly implemented programs than an established program (Woolf, Malone, Schwartz, & Shenot, 2013). Currently, marketing is very easy due to the availability of many channels. Television, newspaper, community events, radio, door-to-door canvassing, word of mouth, media events, direct mail, and telemarketing are some of the effective channels —(Faruqui, 2012; KEMA, 2010; "Task 15 Case Study

ETSA Utilities Air Conditioner Direct Load Control Programe Australia," n.d.). Among them, telemarketing and direct mails may have more impact on consumers as they interact to consumers individually(KEMA, 2010).

Incentives play a major role in the IBDRP, and the success of these programs depends highly on the incentives that consumers receive in turn for their participation (Charlie Hewitt, 2015). Timely distribution of financial incentives also influences consumer's interest to continue with the program. The payment can be made in different ways such as monthly credit, one-time payment, yearly bill credit, etc. (Charlie Hewitt, 2015; Faruqui, 2012; KEMA, 2010; Wisconsin Public Service, 2012). Many implementers provide free hardware to participants for controlling their loads to reduce the financial burden of the participants. However, if the calculation of CBL is not done properly and if it is higher than the actual one, may have to pay additional money to consumers for more than their reduction. Hence accurate calculation of CBL is one of the major challenges for both implementers and participants.

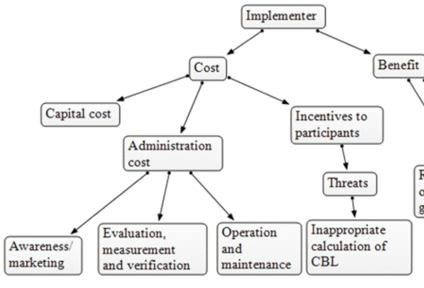

Fig. 2. Factors influencing implementers for adopting IBDRP.

6. Conclusion

IBDRP is getting popular among the utility companies, and many of them are planning to implement such programs. Prime factors affecting the success of such programs are the effective calculation and distribution of incentives. Error in calculating the incentive will be a risk for both implementers and consumers. By calculating the CBL in a foolproof manner, these errors can be eliminated. Even though CBL can be verified by continuous E&MV, the repetition of such activities make consumers restless, and they feel that they are not trustable, which may lead to drop out. By introducing social media based campaign may attract more consumers towards enrolling themselves for the program. Data security can be attained by using encrypted data transfer between smart meters and data centres, which will gain confidence among the participants on their privacy issues. Introducing IBDRP in markets where proper infrastructure available is found to be very cost effective for implementers. By considering the financial and environmental benefits, the government should take the initiative to provide proper infrastructure, wherever it is required.

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