DEMAND MANAGEMENT PROGRAM FOR LARGE INDUSTRIAL CONSUMERS BY USING THE AMI SYSTEM

Amir Khazaee  MEEDC – Iran  Amir.khazaee@ymail.com
Mehran Ghasempour  MEEDC – Iran  Ghasempour.mehran@gmail.com
Habib Hoseinzadeh  MEEDC – Iran  H.hoseinzadeh@meedc.net
Hossein Hooshmandi  MEEDC – Iran  Hosein.hoshmandi@gmail.com

ABSTRACT
The increasing demand for electrical energy was always a crucial concern for electricity providers, especially in Iran, in which a significant annual peak demand growth is reported. This paper deals with an electricity demand management (DM) program in Mashhad Electric Energy Company (MEEDC) that was planned to be applied in the national level, in order to curtail peak demand growth to delay network augmentation. This program aims to reduce peak demand of day in summer by implementing DM program for large industrial consumers. The DLMS/COSEM based AMI system was utilized in this DM program, enables us for instantaneous and accurate metering. Details of the program and the implementation issues are explored and limitations and problems are addressed. Finally technical and cost analysis results of the program are presented.

INTRODUCTION
The Demand management focuses on actions taken by consumers to alter their consumption of electricity as a reaction to an external signal in the form of prices and incentives in order to curtail peak demand growth to delay network augmentation. This cause improving energy efficiency and optimizing the allocation of power. Such demand management programs usually target specific geographical areas, or periods of time, when the peak demand is nearing, or risks exceeding, the capacity of the network.[1]
Demand response (DR) during peak demand is a far cheaper alternative to the most commonly used solutions. In [2], it is claimed that during critical electricity demand periods, typically characterized by extreme temperatures in summer and winter months, especially weekday afternoons and evenings, the cost of providing such power often exceeds $50 per MW hour, which is more than 10 times the cost of base-load electricity production for the identical unit of power. During extreme peaks, this cost can soar to $1,000 per MW hour or more. Because of DSM benefits, it is addressed in numerous projects around the world in various fields such as Commercial, domestic or industrial consumers (for example in [1], [2], [3]). Some examples of demand shifting have been reported in [4], [5]. According to high energy consumption, the industrial, sectors is the focused sector for energy conservation programs in this project. In [6] multi-Scenarios of Effective DSM for industrial consumers in Thailand is presented.
In comparison with non-criticality of loads at the residential and commercial levels, demand reduction of industrial processes requires a more sophisticated solution. Production constraints, inventory constraints, maintenance schedules and crew management are some of the many factors that have to be taken into account before one or more processes can be temporarily shut down. In order to overcome this problems and limitations in [7] an intelligent system is designed for implementation of demand response at an industrial site. Based on the various operational constraints of the industrial process, it determines the loads that could be potentially curtailed based on Fuzzy/expert systems. After that the authors proposed a system that dynamically ranks loads and workstations within an industrial site as candidates for demand reduction [8].
This paper deals with an electricity demand management program in Mashhad City which has been in progress in summer 2014. The DM Program was carried out in accordance with the Mashhad Electric Energy Company (MEEDC) that was planned to be applied in the national level, in order to curtail peak demand growth to delay network augmentation. Based on national annual demand curves, it was predicted that the peak demand would occur at the interval of 11-15 o’clock in summer, as a result of wide usage of air conditioning systems. Therefore the DM program was designed to move the electricity consumption to off peak times based on Voluntary Load Control (VLC) which is one of DM methods.
The DLMS/COSEM based AMI system was utilized in this DM program, enables us for instantaneous and accurate metering in order to find out the level of participation and to determine the effectiveness of program.

MOTIVATIONS OF PROJECT
The DM Program was carried out by MEEDC that was planned to be applied in the national level, in order to curtail peak demand growth to delay network augmentation.

Fig.1: Peak demand of electricity in Iran during 2003 to 2014
Fig. 1 shows peak demand of electricity in Iran during 2003 to 2014. A 7% growth in annual peak demand is indicated. In order to supply the forecasted peak demand of electricity for 2014 (i.e., 50000 MW) requires at least 5000 MW new generating capacity that requires about 5000 million dollars expenses. But this significant cost is only for a few hours, because as shown in fig. 2 only in 3% of times the load meets more than 90% of peak demand. Based on national annual demand curves, it was predicted that the peak demand would occur at the interval of 11-15 o’clock in summer, as a result of wide usage of air conditioning systems. Fig. 3 represents the hourly energy consumption in the peak day of 2014 in Mashhad that occurs in summer and validates the prediction. Therefore the DM program was designed to move the electricity consumption to off peak times based on voluntary load control. Mashhad is the second major city of Iran with more than 1.3 million of consumers. As shown in fig. 4, industrial consumers (which contained less than 1% of whole consumers in Mashhad) consumed 24% of final energy consumption in 2013; therefore, it is the focused sector for DM programs. However there exist numerous limitations and problems which are addressed in the section 4.

**DM PROGRAM DESCRIPTIONS**

**Definitions**

**Participants:** The consumers that accept to participate in the program.

**Participation day:** the days that the participants would ask to have 25% load reduction.

**Details of program**

There are mainly two types of DR programs. Price based and incentive based. In this project incentive based DR program was selected in which utilities pay participating customers to reduce their loads at times requested by the program sponsor. The program was designed by Tavanir for passing peak demand of summer of 2014. The distribution companies were dictated to carry out the program from 2014-06-22 due to 2014-08-22 based on following policies:

- Consumers with demand more than 1 MW are the candidates of participation in DM program.
- Distribution companies must contact with consumers due 2014-06-17 and they must replace meters of participants with AMI meters due 2014-06-21.
- The commitment of consumers is participating in the program and reducing 25% of their electricity demand in participation day for 100 to 200 hours (depending on type of participation)
- The distribution companies should notify request of participation before 14 o’clock of the day before participation day.
- The participants won’t be paid any incentives if they don’t participate more than 2 times in month or more than 3 times in whole program period.

**Incentives**

The proposed financial incentives for increasing the acceptance of candidate consumers to participate in the program were as follows:

1. The cost of consumed energy in the peak tariff of participants in the whole period of agreement (2 months), would be calculated based on shoulder price.

---

1 The supervision organization of Power system in Iran
2- The cost of consumed energy in days of participation would be calculated based on off peak price.

IMPLEMENTATION OF THE PROGRAM

In this project, after identification of curtailable large industries (more than 1MW demand), 89 consumers were selected and negotiated to participate in the DM program. They were asked to have a 25% reduction in demand of electricity in participation days. The participation days would be predicted previously based on load forecasting algorithms and would be notified to the participants before 14 o’clock of the day before the participation day. All candidates agreed to participate in the program.

AMI system

Clearly, employing DM techniques is more efficient if enabled by Advanced Metering Infrastructure (AMI) system. Therefore in this program, after agreements traditional meters of consumers were replaced by smart meters to enable the monitoring features in order to find out the level of participation and to determine the effectiveness of program. The DLMS/COSEM based AMI system was utilized and GPRS was selected as communication system.

AMI networks are categorized as one-way or two-way communications. Two-way AMI networks allow communications between both the consumer and the meter and between the grid operator and the meter. One-way communication networks, on the other hand, only support reporting of customer usage from the meter out to the utility and/or to the grid operator.

In this project most distribution companies utilized external modules to communicate with meters. But MEEDC decided to use two way AMI system because of its greater capacity to support various forms of demand response than one-way AMI. Some other advantages of AMI system are as follows:

- AMI system enables us to implement other DR programs in future.
- Participants would have valuable data about their electricity usage through presented web service and would be able to manage their usage for cost saving.
- Valuable information about power quality of these consumers (which are large industrial consumers) could be obtained for future decision making.

The structure of utilized AMI system is shown in fig.5.

Web service for DR management

In this project, a web service was designed for optimized management of all cases of DSM. Some important duties of the web service are as follow:

1. Notification of participants: based on participation contract, the participants must be notified to the participants before 14 o’clock of the day before the participation day. There were 3 types of notification: email, SMS and web service.

2. Load data of participants: consumption and demand of electricity data for each participant was monitored in order to find out the level of participation.

3. Participant portal: each participant had a password secured portal and participants are able to get their hourly load and consumption data. This opportunity enables the participant for cost saving planning (fig.6).

4. Real-time price management: this web service is also has the ability of real-time calculation of incentives and it is accessible for both participants and operators.

Problems and Limitations

Demand reduction of industrial processes requires a more sophisticated solution. There exist some problems and limitations in this project as following:

- Some of participants were in places with poor GPRS status. This was an important limitation, because without hourly data, financial incentives wouldn’t be calculated. For this problem, local reading of meters and importing them to database was a solution. But for future years some participation with GPRS service providers are going to make. Also in some cases DSL could be used as the communication system.
- Production limitations, inventory constraints, maintenance schedules and crew management are some of the many factors that have to be taken into account.
account before one or more processes can be temporarily shut down. But in most cases the participants were satisfied and willing to participate in future DM programs. Specially using AMI system features made them able to manage costs and leads to financial benefits.

**RESULTS**

Finally 9 participation days were occurred. These days were predicted based on load forecasting algorithm. Table 1 represents results of participation and success rate of the program in each day. This was the first year of implementation of this DM program, however acceptable but not completely satisfactory results were achieved. Based on the results an average of about 10 MW reduction was achieved that leads to a significant cost saving. Also participant satisfaction was another outcome for this program. Fig.7 represents the effectiveness of the DM program for demand reduction in peak times. It is indicated that a significant demand reduction is achieved in the participation hours (red curve) while in a non-participation day doesn’t show this reduction (green curve). The dotted curve represents the demand estimation of selected participation in the absence of DM program. Note that in order to have a better comparison per unit values are indicated.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of participation (kW)</td>
<td>9000</td>
<td>17000</td>
<td>19000</td>
<td>18000</td>
<td>10000</td>
<td>7000</td>
<td>22000</td>
<td>20000</td>
<td>10000</td>
</tr>
<tr>
<td>NO. of notified consumers</td>
<td>7194</td>
<td>13085</td>
<td>9711</td>
<td>6825</td>
<td>11333</td>
<td>8271</td>
<td>14187</td>
<td>12987</td>
<td>9200</td>
</tr>
<tr>
<td>NO. of participated consumers</td>
<td>22</td>
<td>68</td>
<td>87</td>
<td>87</td>
<td>45</td>
<td>46</td>
<td>89</td>
<td>89</td>
<td>27</td>
</tr>
<tr>
<td>Participation success rate (%)</td>
<td>17</td>
<td>36</td>
<td>51</td>
<td>44</td>
<td>33</td>
<td>27</td>
<td>51</td>
<td>61</td>
<td>21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>25% of existing demand (kW)</td>
<td>9000</td>
<td>17000</td>
<td>19000</td>
<td>18000</td>
<td>10000</td>
<td>7000</td>
<td>22000</td>
<td>20000</td>
<td>10000</td>
</tr>
<tr>
<td>Rate of participation (kW)</td>
<td>7194</td>
<td>13085</td>
<td>9711</td>
<td>6825</td>
<td>11333</td>
<td>8271</td>
<td>14187</td>
<td>12987</td>
<td>9200</td>
</tr>
<tr>
<td>NO. of notified consumers</td>
<td>22</td>
<td>68</td>
<td>87</td>
<td>87</td>
<td>45</td>
<td>46</td>
<td>89</td>
<td>89</td>
<td>27</td>
</tr>
<tr>
<td>NO. of participated consumers</td>
<td>17</td>
<td>36</td>
<td>51</td>
<td>44</td>
<td>33</td>
<td>27</td>
<td>51</td>
<td>61</td>
<td>21</td>
</tr>
<tr>
<td>Participation success rate (%)</td>
<td>80</td>
<td>77</td>
<td>51</td>
<td>38</td>
<td>113</td>
<td>118</td>
<td>64</td>
<td>65</td>
<td>92</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

In order to curtail peak demand growth to delay network augmentation a DM program has been designed and implemented in MEEDC. This project aimed to manage industrial consumers and was enabled by AMI system. It was indicated that about 10 MW peak reduction was achieved that leads to a significant cost saving. Also participant satisfaction was another outcome for this project.
This program will be held in coming year with a few reformations to prevent mentioned limitations and improvement of consumer willingness and their acceptance to stay in the program.

REFERENCES


