Recent Survey on Demand Side Management

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Abstract—Average electricity consumption is increasing day by day. Addition to supply side is lagging especially in the developing countries. The major share of generation is by the thermal plants. The CO₂ gas emissions are polluting the climate. Demand side management (DSM) mechanisms are designed to regulate the consumer demand. Addition of electricity generation by wind or solar power along with a storage capacity can be considered an optimal solution of meeting the energy demand.

Key Words: Smart Grid, Demand Side Management, Energy Efficiency, Energy Storage, Different Models, Regulators.

I. INTRODUCTION

Energy demand management, or demand side management (DSM) is the modification of consumer demand for energy through financial incentives and education. Demand Side Management is the process of selection, planning, and implementation of measures intended to have an influence on electricity demand on the customer-side of electric meter, caused either directly or stimulated indirectly by the utility. The most common rationale for DSM in the power sector is that it is more cost effective to reduce the electricity demand instead of increasing the power supply generation or transmission. Demand side management is used to describe the actions of a utility, beyond the customer's meter, with the objective of altering the end-use of electricity. The action could be to increase, decrease or shift demand between high and low peak periods. It is to match demandand supply so as to minimise the consumer bill and utility costs. DSM is the implementation of those measures which help the customers in using electricity more efficiency. The loads can be reduced by improving the efficiency of various end-uses, through a better housekeeping, correcting energy leakages and developing energy efficient technologies. The end users can be tempted to change their consumption behaviour by adopting soft options like higher prices during peak hours or vice versa.

The term “DSM” was introduced to the electricity industry in 1981 by Clark Gellings, a senior executive at the Electric Power Research Institute (EPRI) in the United States [1]. Initially it was to reduce electricity consumption by controlling wastages. Nowadays, the DSM is any action by the utility which results in a modification of consumer demand as per utility’s requirements. It has become increasingly feasible due to the integration of information and communications technology (ICT) with power systems. ICT results in a two way real time communication between the utility and consumer thus coining a new term called Smart Grid. De-regulation of electricity markets is making the utility costs more and more competitive. The utilities require a controlled demand pattern to reduce their cost of generation, transmission or distribution.

II. LITERATURE SURVEY

The general goal of any DSM model is always to reduce average demand, shave off the peaks and improve the load factor. Other than the general energy efficiency and load shifting programs, the present DSM models include options of addition of renewable energy sources (RES). The variable tariffs are an incentive for the consumer to reduce his load during peak hours. These are being studied. Various DSM models have been proposed in literature and are being studied. These have been implemented by different utilities in their area to study customer response. An effective DSM measure can only be a combination of energy efficiency and incentive based shifting of demand. The addition of Wind or Solar energy is the need of future clean energy.

A. Energy Efficiency Models

The consumers of electricity are mainly residential, industrial, commercial and agricultural. The utilities have tried to implement the DSM by making initial investments and giving extra incentives, so that the consumer is tempted to adopt and adjust to these new ideas. The need for energy efficiency was felt more during the 1973 and 1979 oil crisis. The cost of
generation increased with increase of oil prices. The electricity industry then was fully under the state control and the rates were as per the cost of generation. So there was a need to study the alternatives.

The energy efficiency improvement programs were tried out in USA and appliance standards were established at the State level starting with California in 1974. During this period various changes to the refrigerator standards helped in lowering the energy usage of a new refrigerator from about 1,800 kWh per year in 1972 to less than 500 kWh per year presently. For some of the utility implemented programs, the results have been quite encouraging thus justifying the investments in the DSM programs [2].

The building design code was set in USA along with the other policy decisions of energy conservation. It was defined in Energy Policy and Conservation Act in 1975 [3]. The energy audit of a home, an industrial unit or a process can reduce the overall energy usage. The Energy efficiency models are designed to reduce the overall load by minimizing the wastages. The efficiency is improved by using the energy efficient devices. This is achieved by the energy audit of the building, processes or the appliances in use. With well-maintained building walls, windows and sufficient daylight, energy needs for lighting loads will be reduced. The use of efficient electrical appliances can further reduce the overall losses and improve its energy efficiency. The heating and cooling requirements will depend entirely on the construction of walls, ceilings or roofs.

The use of tube lights or CFL by the consumer reduces the load considerably for the availability of same lumens of light. In India, during 1990, the Bombay efficient lighting large scale experiment (BELLE) was tried out. It was a first large-scale demand management program to be sponsored by an indigenous utility in the developing world. BELLE demonstrated the technical and economic feasibility of introducing the state-of-the-art energy-efficient technology into Indian households. The normal bulbs were replaced with the more energy efficient CFLs by the utility in Mumbai area. The cost of replacement was recovered in the subsequent electricity bills at a very nominal rate. The program was co-ordinated between PHILIPS India, BSES and Indira Gandhi Institute of Development Research (IGIDR) [4].

In 1994, the then electricity regulator for England and Wales commenced an initiative known as the Energy Efficiency Standards of Performance. Under this initiative, the regulator wanted the electricity suppliers (i.e. retailers) to spend GBP1.00 per customer on household energy savings measures. It had set the energy savings targets to be achieved by the suppliers. This program was further extended to electricity suppliers in Scotland in 1995 and Northern Ireland in 1997. In 2000, the program was extended by the regulator to all electricity and gas suppliers in the United Kingdom with at least 50,000 customers. The program became the dominant vehicle through which energy efficiency measures were delivered to residential customers in the United Kingdom [5].

The Ahmedabad Electricity Company (AEC), presently part of the Torrent Group, is located in the state of Gujarat and is engaged in generation, transmission and distribution of electricity. In March 1994, AEC was identified as a site for a Demand-Side Management (DSM) Technical Assistance Program under the USAID-funded, three-year Energy Management Consultation and Training (EMCAT) Project. It was targeted at high rise apartment water pump installations, flour mills, municipal wells, motor testing and industrial audit. The results showed that the DSM can be more successful if it is designed with economic returns in mind. In this case the program also included the shifting of load by displaying the time of use rates. The electricity meters were replaced at the consumer premises and the response was appreciable [6].

B. Load Shifting Models

The aim of load shifting is normally to shave the peaks and fill the valleys. The peak load management is important because at times, the additional capacity or an extra purchase is needed, just to meet the peak load demand. The extra capacity will remain idle at other times. The peak loads take the transmission and distribution networks also to their peak capacity. So peak load reduction is needed for a cost efficient and reliable power supply to the consumer. The valley filling maintains the base loads and can bring the load factor closer to unity. The load shifting DSM models in any industry or a household will reduce the overall bill of the customer by reducing the overall connected load.

An example of an early network-driven DSM program is the Sacramento Residential Peak Corps
program in California which was initiated in 1979 to address needle peaks on Sacramento’s electricity network. These peaks occurred on summer days. The program provided peak clipping and load shifting through the remote cycling of central air conditioners during the selected summer afternoons. Residential customers were to apply and become Peak Corps members. By this they allowed the utility, Sacramento Municipal Utility District (SMUD), to install a cycling device and send a radio signal to cycle their central air conditioners by switching off and on as per times determined by the utility SMUD. The cycling device was installed and maintained by SMUD at no cost to the customer. In return, Peak Corps members received discounts on their June to September electricity bills. The Peak Corps program has now been operating for 36 years [7].

The report by Frontier Economics and Sustainability First submitted to the Department of Energy and Climate change UK in Aug 2012, has shown the results of various Load shifting programs in different countries and found that consumers do shift electricity demand in response to economic incentives (such as the application of higher prices during peak demand periods) even if these incentives are accompanied by only basic information on the prices being applied. The size of the shift could vary significantly. Also the Interventions to automate responses deliver the greatest and most sustained household shifts in demand if consumers have certain flexible loads, such as air conditioners or electric heating [8].

The GoodCents Select program implemented by Gulf Power Company in Florida is an example of a recently-developed network-driven DSM program which uses short-term demand response. Gulf Power pays for the installation of the energy management system and the communication gateway in residential customers’ dwellings. Customers can program the energy management system to automatically turn off or turn down selected appliances when electricity prices reach set levels. The gateway facilitates communication between the system components, records energy usage and communicates this information to Gulf Power [9].

C. Buyback programs

To some of the consumers have installed small emergency generators to meet their emergency demand in case of a power failure. Also the solar and wind power plants installed with the individual consumers can be integrated into the grid with a buyback program in which the consumer is compensated to add his generation. Commercial and industrial electricity users in the service area of the New England Independent System Operator (ISO) can receive incentive payments if they reduce their electricity consumption or operate their own electricity generation facilities in response to high real-time prices in the wholesale electricity market or whenever the reliability of the region’s electricity network is stressed [10].

D. Renewable Energy Sources and storage of Electricity.

Due to their climatic advantages and free availability the Wind, Solar and other natural forms of energy are being converted to electricity. However their availability is not continuous. The consumers could have surplus power at times and the grid should be integrated to accept it from consumer. The generated power could also be stored in batteries for a future use by the customer. The batteries of electric vehicles are a good storage medium and these could be charged in a parking area during the day time[11]. The availability of the wind and solar power needs to be accurately forecasted for its optimum utilization as a DSM measure. The matching of the variable loads and variable RES is a challenge for designing a DSM model [12].

E. Planning and Implementation of DSM

A lot of research has already gone into the various models which can be effective for managing the demand. The load reduction and load shift needs to be achieved by the utilities. For the successful implementation of a DSM model, an accurate data needs to be available regarding the demand and supply curve in that area. So the essential steps of an effective DSM programs are load research, load shape objectives, program implementation strategies and its actual implementation [13].

Since 1993, the International Energy Agency (IEA) has been working to develop and promote various tools for DSM applications. It is a collaborative work between countries in Asia, Europe and North America. The whole program of IEA is in the form of tasks. After completion of each task a report is made available to all the member countries for their further use. Each country need not reinvent the wheel. Since 1993, there have been a total of 25 tasks and 21 have been completed. The
task number 16, 17, 24 and 25 are still ongoing. In task 16, the experts from Energy Services Companies ESCos around the world contribute towards the market development of performance-based Energy Services. Task 17 is for the integration of DSM, Energy efficiency, distributed generation and the generation through renewable energy sources. Task 24 and 25 are to study the practical business model of any DSM program. The detailed study is carried out for each of the designated tasks and results are published for its cost and effectiveness. The task results have become a tool box of information for governments, utilities and energy companies in shaping the DSM measures in their energy policies [14].

The U.S. Energy Information Administration (EIA) is a principal agency of the U.S. Federal Statistical System responsible for collecting, analyzing, and disseminating energy information to promote sound policymaking, efficient markets and the clean environment. EIA programs cover data on coal, petroleum, natural gas, electric, renewable and nuclear energy [15].

F. Green House Emissions

The Kyoto Protocol is an international treaty which was negotiated in 1997 and came into force in 2005. It extends the United Nations Framework Convention on Climate Change (UNFCCC) 1992 [16]. It is based on the acceptance by the developed countries that the rapid industrialisation over the past 150 years has given rise to global warming and excessive CO2 emissions. Presently a larger share of the electricity generation is based on thermal plants and the CO2 is produced due to coal burning. The reduced thermal generation and increase of RES share will ultimately reduce the greenhouse gases for a better climate. The Kyoto Protocol is a legally binding agreement, under which the industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990. A UNFCCC meeting was held for the member countries in Lima (Peru) in December 2014 to review and move further [17].

G. Barriers to DSM

For all these steps the funds are needed. The electrical supply has always been under the state control. The willingness of the state plays a crucial role in its actual implementation by setting it as a task for the utilities. From the mid-1980s to the mid-1990s, DSM became a major business in the US electricity industry. State-based regulators imposed stringent requirements on electricity utilities to implement broadly-targeted, environmentally-driven DSM programs. From the mid-1990s, electricity regulators in the US began to turn their attention away from DSM and towards electricity market reform. Consequently, policymakers in many US states that adopted electricity industry restructuring also created public benefits funding mechanisms to help ensure the continued implementation of broadly-targeted, environmentally-driven DSM programs. [18]

For any DSM model to be successful it should not only have its technical feasibility but also a financial benefit. The technical feasibility may exist for its implementation but there is a necessity of a financial support or benefit to meet its initial investment cost. The actual cost benefit does not appear immediately. Over the years, the utilities have been functional under the state control. For implementation of any effective DSM measure, a firm goal needs to be set by the state regulators along with a detailed administrative infrastructure to plan, implement and verify the program. Also the funds are to be allocated accordingly [19].

The rich and developed countries have invested in these programs but the developing countries are far behind or to say are still fulfilling the basic deficiency of electricity for their masses. One of the reasons is the concern for the climate change occurring over there. The Kyoto protocol has given a further impetus to the addition of RES especially wind power to the member nations. The developing nations must adopt the DSM for ensuring the supply availability to all the consumers and for a clean environment. The rapid development activities being undertaken in developing countries will add up the similar problems as being faced by the developed nations today.

H. DSM in India

In the Indian context there is an Energy Conservation Act 2001 by which the Bureau of Energy Efficiency (BEE) has come into being [20]. The Electricity Act 2003 (EA 2003) defines the various provisions of supplying the electricity by the utilities after restructuring of the electric industry. With EA 2003, the earlier relevant Acts, such as Indian Electricity Act 1910, Electricity Supply Act 1948 and Electricity Regulatory Commission Act 1998 have been repealed [21]. The state Regulatory Commissions have been given the task of tariff determination. The National Electricity Policy 2005 gives the future
direction to the electricity industry to meet the mandate of EA 2003. The section 5.9 deals with energy conservation [22]. In India, Energy Conservation Building Code (ECBC) was launched in July 2009 which sets minimum energy standards for a new commercial building having a connected load of 100 kW or more. [23]. As an energy efficiency measure BEE has given the star rating to the electricity appliances like Air Conditioners. A few of the DSM programs have been experimented as in AEC Ahmedabad. At state level some of the rebates are being given for adding solar power. As a dedicated program it still needs to take off with some specific target.

III. CONCLUSION
In a present day scenario of ICT with a real time two way communication between consumer and utility, the necessity of providing electricity supply to maximum consumers at a competitive cost and the concern of climatic changes, the DSM measures are a must without any other option. The state regulators must plan and implement the short and long term measures to ensure a voluntary control of the consumer demand.

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