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Load Management Techniques and Pricing Model for Demand Side Management – A Review

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ABSTRACT: With the increase in population the demand of electricity is also increasing proportionally. Changing the conventional interconnected system into Smart network would be the key to fulfilled increase in demand. In view of increasing load demand, the necessity of controlling the demand side management of available resources of energy become prominent. In this work we presented the different technique and algorithms–used in DSM. Apart from techniques we also focused on different pricing model for cost minimization. The different load management techniques are the foundation step for the researcher for employing DSM to bridge the gap between supply and demand of energy. In addition, the pricing models will encourage consumers to take part in the demand response (DR) program of utility for minimization of the cost of energy.

Keywords: Demand Side Management, Demand Response, Smart Grid, Load Shifting

I. INTRODUCTION

A progressive nation has a energy demand on the climb. Fast advancement as of late and shortage in fundamental fuel sources make it hard to keep balance among demand and supply of electrical energy. Although the residential, commercial and industrial consumers are major contributors to most utility peak loads, there is comparatively less information on the peak load impacts and resource potential of the demand management system. To overcome this gap between consumer and utility end, the utility introduces demand management by encouraging consumer to take part in demand response (DR) and demand side management (DSM) programme. The benefits of DSM and DR are potentially categorize as; reduction in cost of energy of consumption by initiating in DR program and utility implements the load management techniques for the shifting of peak demand from peak to off-peak hours.

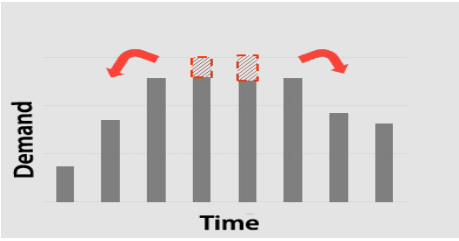

Fig. 1. Illustration of Smoothing Out Peak Electricity Demand.

The DSM is employed in the distribution system for load energy management, demand response, automated load management [1,2].

Extensive assortment of DSM methods have been given in the literature. Normally, DSM concentrated on just a individual or multiple parameters having potentially various target capacity, for example, limiting energy cost, crest to average extent (PAR) as well as augmenting consumer comfort index [3]. Exchange of demand side administration advancements to the growing world requires the most extreme consideration, since the latest trends is not applicable to all conditions. Absence of two way communication of data on power demand by different type of load and end-utilizes are one of the serious issues experienced in actualizing DSM approach. For instance, if apparatus power use can shift to off-crest periods, peak load demand can be decreased along with a lot of extra cost of power generation.

There are a various demand side administration strategies and evaluating mechanisms. The primary objective of the load management techniques in demand side management along with different pricing models by controlling the consumption of energy during peak hours while the utility receives the advantage of reduction in load factor and minimizing the cost of extra energy generation during peak hours.

II. DEMAND SIDE MANAGEMENT TECHNIQUES

To mitigate system instabilities brought about by increasing electricity demand, the suitable objective of DSM is reshaping the load demand curve, during peak periods, and shift the increased load during peak period to off-peak period [3,4] DSM point toward six main practices to amend the load curve, specifically, Peak Clipping, Valley filling, Load shifting, Load building, Strategic Load Growth and Flexible load shape. DSM techniques provide a variety of measures to minimize energy use throughout peak load period and the cost benefits to the consumer. This paper emphasizes on DSM techniques and different pricing models applied for future smart grid for maximizing load factor for contraction of the gap between load and supply.

All the DSM development is interconnected with one another and reason for this is to share information regarding consumption [2] of energy among them. They can be gathered under string of the DSM as appeared in Fig. 2.

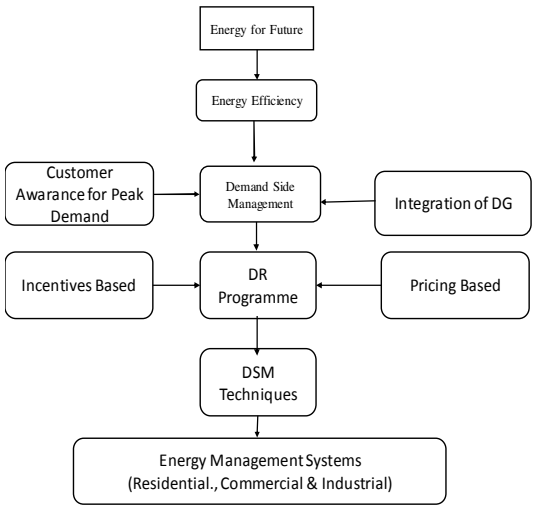

Fig. 2. Progression of the DSM.

The demand side management techniques are as follows:

A. Peak Clipping & Valley Filling

Peak clipping is load management technique initiated by the utility by directly controlling the energy consumption of consumer by shifting load from peak load period to off peak period. This load management technique will help utility to serve consumer with no addition of new generation sources during peak load demand [4]. For Valley filling utility will build the load demand during off peak load and encouraging consumer for consumption of energy with low cost.

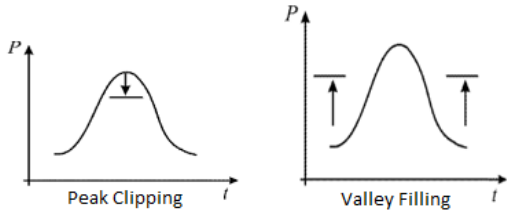

Fig. 3. Peak Clipping & Valley Filling.

Peak clipping and valley filling accentuation on deficit between the pinnacle demand and valley load levels to improve the expansion in peak demand, thus improves the security of smart network. Peak clipping is an immediate load control (DLC) system to make the lessening of the overload, and valley filling builds the off-crest request by applying direct load control [3], [6]. This program is fundamentally offered to residential consumer & commercial. Controllable Load Program has the obligation to diminish or interfere with an electric energy utilization under duties or contracts that give a rate rebate or bill credit for consenting to manage load if there should be an occurrence of system emergencies [21].

B. Load shifting

Load shifting is one of the most common techniques used by utilities for fulling peak load demand management [4]. It is based on shifting energy use of consumer during peak load hours to off-peak hours of the day by providing incentives to the consumer for the shifting of the load.

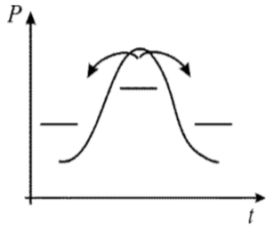

Fig. 4. Load Shifting.

The variable cost of energy during specific hours of the day, lead to encourage consumer to control energy consumption during peak hours and results in reduction of energy bill and the system load factor improves [6], [7]. This system best suits utilities and clients when the steady expense of power is not exactly the normal expense of power. A standout amongst the ablest strategies for valley filling is off-top modern generation, which exchanges loads served by petroleum products with power [6].

C. Strategic Load Growth

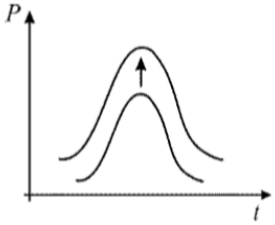

Fig. 5. Strategic Load Growth/ Load Building.

The daily excess demand of energy beyond valley filling is improved by strategic load growth technique of load management it is essentially load building approach [6,7]. It involves increased market share of loads through the development of new applications (electric cars, automation etc.). It controls an expansion in the seasonal utilization of electrical energy.

It controls an increase in the seasonal consumption of energy. For achieving the objective of strategic load growth, the utility will promote the intelligent energy systems, energy efficient devices and progressively focused on competitive sources of energy.

D. Energy Conservation

It is adopted by utilities as a part of DR programs to motivate the consumer for changes in electricity usage pattern. The objective behind this is to minimize demand not only at peak hours but also during off peak hours. [3,8]. Energy conservation conserves the energy. It reduces both demand and total energy consumption. It can be implemented by motivating customers to use more energy-efficient appliances, e.g. Photo sensitive switches for street light. It reduces KVAR of the load.

Passive energy efficiency is achieved by such measures as reducing heat loss and using equipment which requires less energy. Active energy efficiency is

achieved by putting in place an infrastructure for measuring, monitoring and controlling energy use with a view to making lasting changes.

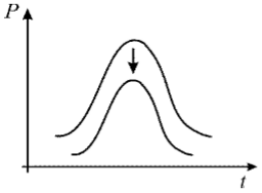

Fig. 6. Energy Conservation.

Active energy efficiency does not require highly energy efficient devices and equipment to be already installed, as the approach can be applied to all types of equipment. Energy management is the key to optimized use and eliminating waste. Energy savings lost through unplanned / unmanaged downtime affecting equipment and processes. A lack of automation / adjustment mechanisms, motors heating and a failure to ensure energy saving measures is adopted at all times [8,16].

E. Flexible load shape

Flexible load shape is mainly associated to reliability of smart electricity network. The utility is identifying the consumer on the basis of appliances used i.e. controllable or non-controllable, so as encourage consumer for shifting their load during peak hours. The consumer is benefited by the incentives received from utility against load shifting of controllable load to off-peak hours [3.6].

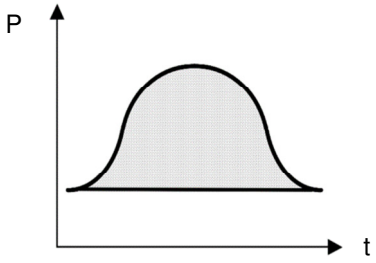

Fig. 7. Flexible load shape.

The utility allows adjusting the load shape to meet the reliability constraints. The consumers are given incentives for reduced level of service. This method involves interruptible load, incorporated power management and entity control devices.

III. DYNAMIC PRICING SCHEMES

DSM can be very much characterized from multiple points of view. DSM alludes to developments and advances to upgrade energy use and incorporates programs or strategies that support energy efficiency, effectiveness, preservation, and increases dynamic energy management of electric utilization. Demand side administration (DSM) and demand response (DR) are not correctly same practices, which are utilized conversely. DR is a specific form of the DSM concentrates on load shifting topographies and more over its intentions to put together customers' capable energy users in the extended tenure. The DSM is suggested following programs for a better indulgent of executions in this respect [4,7]:

- Price incentive for participation of customer in DR programs willingly.
- Direct load control and advanced load scheduling with reference to agreement with consumer.
- Initiation of use of smart appliances and better control over energy consumption using modern control technology.
- By educating consumers for better use of energy.

The type of tariff usually used for price of electrical energy cost is conventional tariff/ pricing scheme are [4,9]

1. Simple tariff
2. Flat tariff
3. Block rate tariff
4. Maximum demand tariff
5. Power factor tariff

With the expansion of modern trends in view of smart grids, conservative pricing scheme is not gratifying the impartial pricing for electricity. With the advancement of communication technology and intelligent electronics devices (IED) in smart grid, only smart pricing scheme encouraged by DR program can be formulated to fulfil the requirement of the modern electric network. These pricing schemes include [4,9]:

IV. CATEGORIZATION OF THE DEMAND RESPONSE (DR) PROGRAMS

A. Price-Based DR

Demand Response is characterized as a customer capacity to modify its power request by diminishing or moving utilization accordingly to trade costs or other economic situations [22,25]. Cost responsive demand could decrease energy demand unpredictability and diminish the peak demand, which thus lessens the need to introduce extra generation and transmission foundation to serve the peak load demand. The comprehensive analysis of the effects of different pricing schemes on DSM is discussed in successive section [17]. Price approachable demand response management is vital for the accomplishment of a smart grid. Electrical Energy Regulatory Commission shows that demand response holds huge potential to profit for consumers however cost responsive interest remains a subtle target [22].

(i). Real time pricing (RTP)
(ii). Time-of-use (TOU)
(iii). Critical peak pricing (CPP)

a. *(i). Real-Time Pricing (RTP).* A rate where power cost oscillates hourly relying upon the adjustments in energy wholesale market [9,17,24]. For the most part, these tariff are known ahead of time to consumer daily ahead or hourly premise.

b. *(ii). Time-of-Use (TOU).* The rates [4,11] can be structured in a variety of ways, depending on the utility costs and the type of customers. Commonly, TOU rates have on-peak and off-peak periods varying by time of day and time of week (weekday or weekend). Some utilities offer also TOU rates varying by season. TOU rates are predicted over a certain period (e.g. a year), that is the customers know the time and the corresponding prices of on-peak and off-peak periods a year ahead. When designing TOU rates, utilities have to determine their costs and convert their costing periods into rating periods. Nevertheless, rating periods may differ from costing periods, because [10,12]:

When implementing TOU rates, a utility may benefit from a decreased on-peak demand and an improved load-curve and as a consequence from lower generation costs [4,11]. Not only the utility but also the consumers can benefit mainly from a reduced electricity bill if they can shift electricity demand from on-peak to off-peak periods. TOU rates diverge with time of a day (e.g., peak, mid peak, and low peak). TOU duties are broadly utilized by industrial and residential consumers.

(iii). Critical Peak Pricing (CPP). It is arranged so that high cost is predefined over specific interims of time. CPP can be actuated because of high costs of energy or by high system certainty by utilities getting power from wholesale markets [4,17].

B. Incentive based

DSM program is appropriate in the comprehensive energy market in the form of agreement it comprises direct load control (DLC), interruptible service, demand bidding, emergency DR program and ancillary service market. The time-based DSM program will encourage the consumer to select the period of consumption of electricity with reference to the prices of electricity [5,19].

(i) Direct load control. Under this utility program will directly cut-off load of the consumer to fulfill the energy demand during peak hour. The consumer will be continuing to use partial load. The important feature of DLC [12] is any violation of agreed polices between consumer and utility during this period will be eligible for either penalty or incentives to the consumer. DLC is applicable for small industrial and residential consumers only.

(ii) Interruptible Service. This program is mainly intended by the utility under fault conditions. The consumer participated under this program is given incentives for the reduction in load all through fault conditions. This is applicable to large industrial consumers and commercial consumer [6].

(iii) Demand Bidding / Buyback. In demand bidding, end user of energy subtle the utilities of the costs at which they confirm to reduce their energy utilization and support the consumers for minimizing in load demand on the given utility cost [15].

(iv) Ancillary Services Market Programs. These projects are similar to demand bidding. A few consumers offer to constrain their individual load demand. In the event that their tenders are acknowledged, they are compensated with market cost since they are on hold. In the event that load Ceiling are required, they can be repaid at the energy cost of the spot market [15,18].

(v) Smart Metering (SM). Smart metering plays a vital role in demand side management and demand response program carried out by utility. With the advancement in modern distribution network communication and metering technology, smart metering provides a full independence to a consumer over his energy consumption pattern and monitoring of energy bills [13,20]. In addition, smart meter has numerous advantages to improve the energy distribution system with reference to the smart grid concept. The consumer can explore more benefits of advance metering technology is employed smart appliances in his use.

V. CONCLUSION

The DSM alongside DR has been recorded in this paper as a powerful instrument to diminish operational expenses in industry and trade and has about advantages for both, the customers and utility. The different load management techniques give better solution over an energy crisis during peak hours. Energy management is called DSM under smart grid concept. The different pricing models or dynamic pricing models help consumer to reduce electricity bill and equally utility is benefited for reduction of its operational and functional cost which helps to maintain reliability of the distribution system at the supply end.

However, these ingenuities and execution on demand side management and energy efficiency are peeling light on and inspiring us to follow in near future.

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