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Controlling of Residential loads Using Demand Side Management Techniques

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Abstract

Electricity is indispensable for our financial growth and since it cannot be saved in gross, it should be produced, circulated and utilized instantly. To match the rising electrical consumption we demand an increment in the installed capacity. In India, there is an immense canyon between the Power produced and the Power demand. It is not conceivable to understand this canyon by boosting the installed capacity, as the resources are inadequate and due to financial restrictions also. For such, the Energy being created should be processed to the most and it is achievable by using the DSM standards. Demand Side Management (DSM) is the process of controlling the consumption of energy, ordinarily to optimize available and proposed engendering resources. DSM plays a pivotal role in promoting energy efficiency, system dependability and security. DSM decreases costs for both customers and monopolies and relieves environmental catastrophe. Another resolution is the productive use of accessible capacity which is illustrated by DSM standards. Demand-side management (DSM) is being increasingly adopted by monopolies as a subprogram for enormous stakes and as a method of optimization and resource use. This paper primarily presents DSM, its varieties and offers an algorithm for Load downshifting from peak hours to off-peak hours thereby demoting the peak demand and giving a financial interest to consumers. This paper intends to obtain and study the articles of the works done by researchers on demand-side management and implementation working several techniques. Presented paper is based on subsidiary data assembled from numerous online and published sources and is descriptive in nature. The study provides a sight of various demand side management projects based on power utilities. This would positively lead to marginalizing the canyon between demand and supply.

Keywords: *Demand side management, Power Utilities, Load Scheduling*

1 INTRODUCTION

1.1 Demand Side Management

The term DSM was started in 1973 after an energy crash which took place in the USA. Whose Main purpose is to decrease the peak demand of the Power Plant. DSM gives an advantage to both utilities and users. For utilities, it helps them to bypass the need for constructing new power stations by shifting the load to off-peak

hours. For the consumer, it presents many ideas to decrease their electricity bills by following the incentive plan as proposed by their utilities [1].

In India, the power efficient programs and DSM activities were initiated in the 1980 due to which several running organizations were created by the Indian state to push the public energy efficiency works in 1983 and as a result, several productions had introduced energy-efficient motors, variable speed drives, and dynamic lighting [2]. In India a major step towards DSM and energy conservation was taken in 2001 by drafting an Energy Conservation Act. Under this, (BEE)the Bureau of Energy Efficiency was created whose aim was to regulate and promote energy efficient projects [3]. In 2001, the administration chose to originate DSM in several states monopolies by offering a TOD tariff structure. And state's monopolies have executed TOD tariff for manufacturing and business consumers only. But for the domestic area, concise consideration has been given to originate TOD tariff formation [4]. As for single domestic users in India, it is a bit tough. But, it is desirable to use it for a collection of household user e.g. housing societies, large educational institutes where a huge quantity of devices are ready for control. DSM includes anything which is performed on the market side of the power system, ranging from replacing traditional light bulbs to compact fluorescent lights (CFLs), now also LED bulbs and up to creating an advanced progressive load management system. DSM is now being seen +more as user made exercise

1.2 Evolution and need of demand side management

The energy sector of India has increased its generation range from 30 GW in 1981 to above 350 GW in 2018. Despite of this increase, our power system is continuously striving to defeat power deficits and poor power quality which continue to deteriorate the sector. In 2014-15, the North India actual peak demand shortage was 1.4% and supposed to be the same in the coming tomorrow [4].

Introducing fresh power plant is not a reasonable explication to eliminate the distance between supply and demand. To cope with this obstacle demand-side management (DSM) is a feasible answer. DSM makes load management with regard to time and quantity of use so that there is an overall reduction in the system peak. Precise execution of DSM exercises gives large aid in achieving the equilibrium among demand and supply. Load shifting, energy efficiency and Time of day (TOD) tariff are one of the applications under DSM that helps large commercial and industrial users to manage electricity efficiently [1].

1.3 Objective of DSM

A broad examination on the study sections which have been taken out in the area of demand-side management based power utilities. The DSM programs have the aim of maximizing the end-use efficiency to avert/postpone the requirement of new generating capacity. The DSM aspiration is to defeat the peak demand for electricity and develop energy productive assignments. To reduce the over-consumption in the electrical network and reduction in the peak demand can be achieved by

- Conservation of Energy
- Betterment of load curve

2.DSM PROGRAMS

Utilities try to encourage consumers to change their demand profile by shifting demand to the off peak by practicing several methods possible for lessening consumption and diminishing peaks in the outline. Major DSM programs are[11].

2.1 Energy Conservation

In India, we are not able to meet the power demand of various areas of our marketplace, in fact, we have to implement load molting and power reduction to meet our existing demand. This query is not expected to be resolved in the coming tomorrow. Load scheduling methods, however, encourages us to conquer the peak demand by changing the load towards the off valley without even a decrease in the total consumption. So certain programs are not the alone answer to the query. Introducing a different energy plant in India is not a solution due to the scarcity of supplies and stocks and further, it needs an extra period of time.

- Lighting:Lighting is a notable part of the power utilized in all areas especially during the peak demand. Illumination loads use around 50 percent of the entire consumption in residential sectors and about 10 percent in industrial regions. Electricity uses due to Un-optimized burning of energy which should be lessened by practicing small action whosesoever it is desirable. Various places where there is a way to save energy are:
- Colleges and Industries:A huge amount of electricity is wasted in educational institutes. So we need to ensure that the electrical appliances used in the institutes are organized and there is a decent connection of sensors and automated switching operation is mandate to save electricity.
- Street Lighting: Street lighting in India should be equipped with LDR circuits that automatically shut down the lights when Sun rises this is how we preserve the power as lights are not turned off at the particular time. Another solution is to use LEDs instead of using traditional incandescent lamps. As these traditional lamps transform the maximum of the energy into heat and only a few percent's (around 3-5%) is converted into light.
- Festive periods: On festive periods, weddings and functions a tremendous quantity of electricity is exhausted due to the inefficient lighting system. Hence there is a necessity to conscious the people regarding potential emergencies and encourage them to use efficient lights instead of unnecessary decorative light. Another solution is to prefer a daytime celebration rather than an evening.

Moreover, the subsequent steps can be practiced for saving of power:

• Use of CFL instead of incandescent lamps.

• Use of electronic ballast rather than choke.

• Print walls by flashing shades as they bounce extra illumination.

• Prefer Daylight instead of unnatural lighting.

2.2. Energy Load Scheduling

An increment in buying electrical appliances for a better standard of living creates a growing demand for energy in residential buildings. Improper use of these devices causes wastage of energy. One way of tackling this is to

give information to users regarding their habits of consumption and another way is the demand side management. In succession to achieve load scheduling, this must be put in a thought that the customer's comfort is not hindered. While appliances which are not of customers primary relief matter could be operated at any time of the day considering the wastage constraints. The first point which prepared in Energy load scheduling is load categorization. In this, home appliances are initially divided into three categories, i.e. Appliances with real-time power dissipation, Appliances including cyclic non-real-time power consumption patterns, and devices with non-periodic non-real-time energy consumption. The use of the first category of devices is directly related to customer behavior, which indicates that besides the user turns them ON, the appliance remain ON till they are switched OFF by the user itself. The power scheduling of certain kinds of things can't be made and they need to run immediately to meet customer requirements. Ceiling Fan, LEDs, personal computers, and TV are few cases. The power dissipation of the second class of appliances is regular and of varying nature. Fridge and AC are few cases

2.3. Financial Incentive Programs

In this catalog, consumers are charged at varying tariffs at various periods of a day for their energy use. Services should advise prices that prompts the user to utilize electricity when there is a base load time. Long unit rate through peak load time, the normal rate per unit during base load time and the lowered rate per unit if expending energy during a low demand period. This kind of project should be applied. Steps needed to execute this plan are explained below:

• Units of energy utilized during peak load should be credited high-priced rate, the normal rate per unit when the base load period and the reduced rate per unit during the low demand period; consequently there should be a perceptible differentiation between peak load, base load and low demand periods.

• Though, some consumers are enthusiastic to spend large unit rates during peak load time but yet, they should not be permitted to apply energy higher than predefined KW.

• The time span for which consumers utilize energy.

• Sum up all the units utilized in a set time say 1 month.

• As consumers are that sequentially manage energy, therefore he should be capable to efficiently follow the load period i.e. whether peak load, base or reduced load time.

3. TYPES OF DSM TECHNIQUS

DSM techniques were divided into two groups i.e. Demand response and Energy efficiency. Techniques like load shifting, direct load control and TOD tariff comes under the category ofDemand response and Energy efficiency is the separate techniques which only concern about saving of electricity by using energy efficient appliances

3.1 LOAD SHIFTING

Keeping the amount of energy consumed constant, the load is shifted in such a way that in off-peak hour's maximum utilization of energy takes place. It is a type of periodic management of smart home appliances which aims to reduce power in peak hours. This makes both supply and demand to the best reasonable low rate [13].

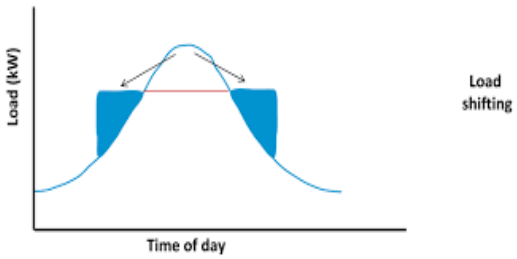

Fig.1 Load shifting curve [15]

From the above load shifting versus time of day curve, the peak period load has been transferred to the off-peak period load. As according to TOD Tariff structure rate at peak hours are usually maximum. Therefore users can save money by the implementation of load shifting technique and this is done by motivating the consumers to do so.

3.2 DIRECT LOAD CONTROL

Direct controlling of supply of the user by the supplier such that during peak hours if user consumes more than certain amount of power then the supplier can limit that consumption[12] 'Segregation of interruptible load from priority load' for 'direct load control (DLC)' benefits utility as well as customers by way of saving in 'peak hour high price power purchase, and high price power generation' and also by 'cheaper rates and assured supply' respectively. Customers' willingness to put their loads on 'direct load control scheme' is quite essential for load segregation. Incentive to customers for their cooperation increases the scope and success of the DSM scheme [16,17].

3.3 TOD TARIFF

For the use of electric energy more efficiently large industrial and commercial consumers should follow the time of day tariff system which is one comes under the category of DSM. In TOD tariff system instead of a flat rate, a periodic time-based tariff is been applied to the consumers. For example at the time of peak hours rate of tariff is more than that of off-peak. This technique is done to motivate the user to consume power at the time of off peak hours. TOD Tariff will benefits both i.e. monopolies to decrease their operational cost and consumers to reduce their electricity bill[1].

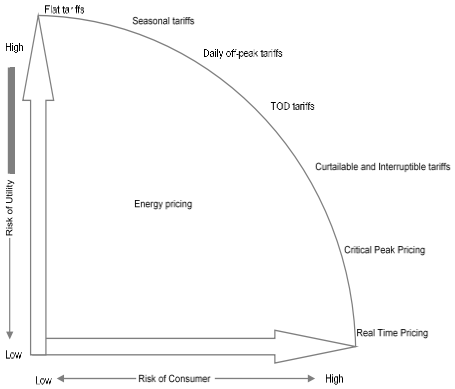

Fig.2 Types of Tariff Structure in India

Based on the Report of establishment and study of TOD tariff in India [31] it has been concluded that TOD tariff system is most favorable among all others for Residential loads. As shown in fig 2 structure like flat rate tariffs, seasonal tariffs and Daily off-peak tariffs, risk to the utilities are more and likewise in curtailable and interruptible tariffs, critical peak pricing and real time pricing, bills for the consumers may increases. But TOD structure is balanced between these which benefits both utilities and consumers.

3.4 ENERGY EFFICIENCY

Energy Efficiency targets in reducing power demand by utilizing better and productive load efficient appliances [18-20].Energy efficient technologies are the structured use of a variety of control techniques that permits an association to recognize and execute actions for lessening power dissipation and prices [21].Increase in use of 'efficiency of energy' leads to a decrease in national energy consumption, and an useful strategy in overcoming CO2 emissions. Also this save users money, encourage productive and rich market, and allow the investor to influence towards fossil-free energy tomorrow [22].

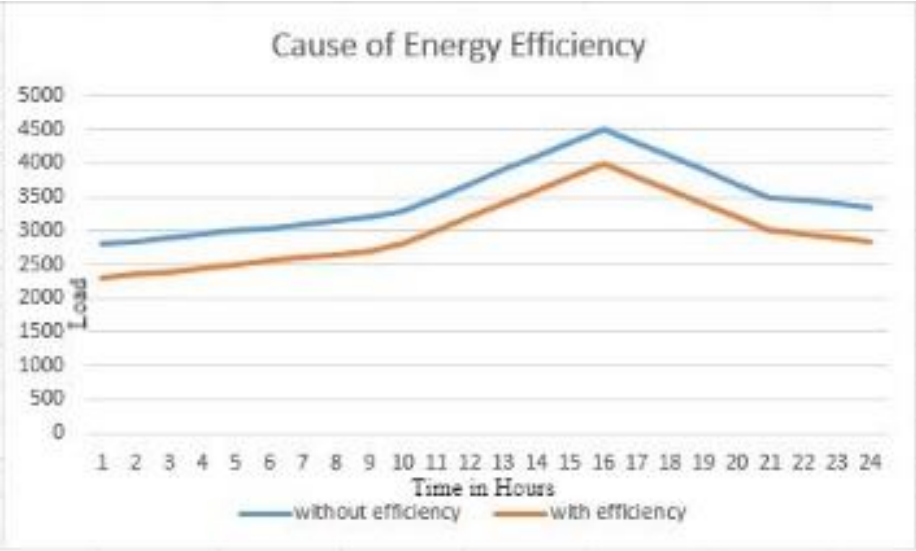

Fig.3 Effect of Energy Efficiency [32]

From the above figure 3 it seems that by using more energy efficient appliances there is a saving in total power consumption

4. CLASSIFICATION OF RESIDENCIAL LOADS

4.1: Behavioral and Physical [5]

Behavioral loads are associated to the existing practices of personalities residing in the homes, these are cooking food, dishwasher, washing and drying which are not dependent of outside factors like heat, sunlight and wind velocity.Physical loads extremely depend upon climate conditions. Like illumination, freezing appliances, and water geyser as these hold no connection with people's practices.

4.2: Consecutive and Concurrent

Concurrent dependent loads lead to processes which may be executed altogether. Consecutive dependent loads lead to actions that can't be executed altogether.

4.3: Deferrable and Non-deferrable [6]

An electrical load that requires to be provided for a fraction of the time and that can be compiled in the given time is known as a deferrable load. This needs a specific quantity of power in a given interval of time, in spite of this specific interval is not necessary. Loads may be listed as deferrable when compared with loads such as water pumping. Loads such as illumination, TV, PC, etc. can't be listed for a definite duration.

4.4: Flexible and Non-flexible loads

Flexible loads are necessary for any DR plans as they allow to re-scheduling of the load curve and load shifting [7]. Inflexible loads relate to household devices in which work can't be changed or obstructed for succeeding times. Two types of inflexible loads are there, those are "Always ON" and "Stand-by". Examples of always-on loads are Wi-Fi routers, sensors, and landline phones etc., likewise TV, light, and most of the Cooking devices are examples for "Stand-by" loads.

4.5: Controllable and Uncontrollable loads

Ability to operate the appliances remotely are controllable loads [8]. Loads such as geyser, submersible pumps, AC, etc. can manage remotely for reducing peak demand and increase performance and can be turned off for a short duration of extent without affecting overall satisfaction. Though, appliances such as lighting, TV, and PC are not controlled.

4.6: Shiftable and Non-shiftable [9]

shiftable loads are allocated based on the interruption. AC, geyser, washing machine, and dishwasher are the examples of shiftable loads, while induction cooktop, freezing, and lighting comes under the category of non-shiftable loads.

TABLE. ASSESMENT OF HOME APPLIANCES

1	Refrigerator	Refrigerator is a that type of appliance that cannot be ignore and this appliance remain at a running position throughout the day
2	Washing machine	Washing machine works for about 3-4 hours in a day so working of this appliance can be shifted from day hours to night hours
3	Television	Television or now a day's trend of led TV's are in common. This appliance run according to the mood of user. According to the Indian perspective people of India daily watch television 3hrs 44 minutes every day[14].so television cannot be shifted as it is a user oriented
4	Oven/Microwave	Microwave or oven is based on the kitchen use or depends on number of family member. Therefore usually the working time of microwave/oven is between 6pm to 8 pm
5	PC/laptop	Usage of laptop/PC cannot be actually predicted because every family and every person have their own need of using laptop/pc
6	Air conditioner	According to the Indian scenario usage of air conditioner vary from place to

		place, season to season and time to time. Like if talk about north India the peak month of using air conditioner is month of April to august
7	Vacuum cleaner	Vacuum cleaner works according to area of house and the family members therefore approximately running hours of vacuum cleaner is about 1 to 2 hours
8	Water filter	As water filter in almost every home remain in ON state. And during the summer season its requirement increases. But it can be switched OFF at night hours
9	Dish Washer	Dish Washer is another appliance of modern India which included in the kitchen. And its time can be shifted accordingly.
10	Iron	A small appliance which is used daily in every house for about 1-2 hours and its time of usage can be shifted.
11	Ceiling fan	Ceiling fan mainly works at higher temperature regions. Running hours of fan can be vary from 12 hours to up to 24 hours
12	Geyser	For winter seasons maximum use of water geyser comes into trend and in this season geyser works for almost 24 hours therefore there is a need of shifting the work of this appliance
13	Tube light	Tube light or now a day replaced by led lights works at nights hours i.e. mainly from 7pm to 11pm approximately
14	Bulb	Likewise Tube light,bulb also works mainly between the time interval of 7pm to 11pm but these bulb should be replaced by LEDs or CFL to save the energy
15	Mobile charger	As now a days every mobile comes with the automatic power cut off facility so mobile can be charged at off peak hours rather than to peak hours
16	Modem/Wi-Fi router	Modem or Wi-Fi router remains at ON state in 24 hours so when there is no use of internet it can be switched off according to the need of user
17	Water submersible motor	About 20 to 30 minute in whole day an averageIndian house use submersible motor or depends upon the rating of motor
18	Electric chimney	Electric chimney which replaces exhaust fan works at the time of cooking and usage is about 3-4 hours daily
19	Food processor	Appliances like mixer,grinder,juicer comes under the category of food processing and they work according to the need of user
20	Induction Cooktop	Induction cooktop mostly not used or used in case of emergency because this appliance need a very high power which is much costly then LPG

5. BENEFITS OF DSM

DSM lowers the peak demand and greatens the saving of electrical energy. The final advantage to user, utility, and communities are:

- Defer the need for installation of a new power plant [23].

- Shelve a large amount of investment to set up transmission and circulation networks.
- Overcome electrical system difficulties [24].
- Blackouts number are lowered [25].
- Limited stress on a power plant which in turn degrades air contamination in the neighborhood area [26].
- Fewer burden on plant effects in the expulsion of deleterious greenhouse gas emissions.
- Fewer costs of generation per unit [27].
- Reliability on the network is enhanced.
- Inadequate preservation of power plants is challenged.
- Decreasing in the electricity bill [28].
- Improves nationwide energy protection by demoting the authenticity of the fuel import [29].
- Long term jobs are produced by the dint of the latest innovative technology[30].

6. CONCLUSION

This literature review and the studies have given an overall acquaintance of the demand side management and the various factors related to it. In nutshell, it can be asserted that currently, the DSM has got its wide roots and certainly can be seen in the power utility system. Further research will certainly be necessary to unleash the different methods to analyze and implement DSM. DSM has displaced the thinking of construction a new power plant to meet the requirement. DSM optimization is now being used to control electricity bills of various residential, industrial and commercial users. DSM not only improves power consumption efficiency but also reduce the energy demand. It is an important method of using available energy resources in a more efficient way.

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