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Electricity Demand Side Management: Various Concept and Prospects

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Abstract: ***Since electrical energy is the form of energy that cannot be effectively stored in bulk, it must be generated, distributed and consumed immediately. But load on the power plant is variable in nature. The power plants are designed to meet the maximum demand. However, there is large difference between peak demand and average demand which results in high generation cost per unit. Since peak demand is increasing sharply that demand large installed capacity. It is not possible for developing countries to meet the targeted capacity by installing new power plants. Since electricity is an essential input in all the sectors of any country, hence we need to focus on alternating means by which electricity can be saved and effectively utilized. The effective solution to above said problem is DSM strategies that lower the peak demand and bring immediate benefit to utilities and customers. This paper deals with the basic concept of Demand Side Management (DSM), objective, problems, types of DSM measures and theoretical and practical approach by which electricity demand could be reduced at consumer end through effectively control and manage loads from utility side, and to use unsustainable energy practices into more efficient.***

Index Terms*: *Demand Side Management, Energy Conservation, Energy Efficient, Load Curve, Load Scheduling.

I. INTRODUCTION

A. Basic Concept Of DSM

The term DSM was coined after the energy crisis in 1973 USA. DSM is also known as Energy Side Management [3] or Energy Demand Management whose ultimate aim is to reduce the peak demand of power plant. DSM has different means for different categories of peoples. For utility company, DSM means avoiding or delaying the need to construct new generating capacity by reduction or shift of consumer's energy use period [6]. For domestic consumer, DSM means an opportunity to save money by reducing their electricity bill taking the advantage of financial incentive provided by utility. For industrial customers, DSM would translate to lower production cost and more competitive product. In other words, DSM refers to steps taken by utility and consumer on meter side to change the amount or timing of energy consumption.

B. Why Need DSM

The Indian power sector has more than tripled its installed capacity, from 30,000 MW in 1981 to over 100, 000 MW in 2001. Despite this growth in supply, its power system is struggling to overcome chronic power shortages and poor power quality. With the demand exceeding supply, severe peak (around 18%) and energy (around 10%) shortage continue to plague the sector. In 1991, IPP proposal exceeds 150,000 MW, while in 2001, just 3,500 MW of IPP power was actually operational. Even if captive market capacity addition of 1500-2000 MW per year is included, a total capacity addition of not more than 6,000 MW a year over the next 4-5 years is only expected. This translated into US$6 billion of investment and several million tons of additional pollutants but would still not close enough to meet the targeted capacity increases [1]. Ever increasing demand for electrical energy has become a notable feature of modern civilization for quite some time now, we find them in situation, where the gap between the demand and supply of electrical energy is continuously widening. We are not able to meet the energy demand. The gap between demand & supply of electric energy is widening at the rate of 3% day by day. Bridging this gap by setup of new power plant is very difficult & expensive proposition. This situation is not likely to improve in immediate future. As we know that electricity is an important input in all the sectors of any country's economy, hence need to find alternate methods to reduce peak demand and to save electricity.

Electricity shortages are exacerbated by inefficiencies mainly in end-use system. The inefficiencies in the end use system is due to irrational tariffs, technology obsolescence of industrial processes and equipment, lack of awareness, nascent energy services industry and inadequate policy drivers. The only value way in handling these crises is to overcome these inefficiencies in end uses that is possible with Demand Side Management Strategy [2]. Numerous studies in China and other countries have found that cost effective DSM programs can reduces the electricity use and peak demand by approximately 20-40% [3]. In India, great opportunities for reducing energy demand using DSM are available in all the sectors, many are low cost, or even individual can adopt them that help to reduce the electricity demand [4] and per unit generation cost, improving reliability and environment and social improvement.

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II. OBJECTIVE OF DSM

The objective of DSM is to reduce the peak electricity demand and promoting the energy efficient devices. In fact to reduce the overall load on electrical network, total consumption and peak demand can be reduced by:

- Improving the load curve
- Energy Conservation

The DSM strategies have the objective of maximizing the end use efficiency to avoid/ postpone the requirement of new generating capacity. In DSM three concepts are clearly identified: Demand Response, Energy Efficiency and Energy Conservation [5].

III. TYPES OF DSM MEASURES AND PROGRAMS

Utility try to encourage energy users to alter their demand profile by shifting demand towards valley using various strategies. There are various opportunities and techniques available for reducing energy consumption and to reduce peak demand. Broadly DSM programs are:

- Financial Incentive/Plenty
- Load Scheduling
- Energy Conservation

A. *Financial Incentive/Plenty Programs*

In financial incentive DSM Program, Consumer's should charge at different tariff depending upon the energy use time [8]. Utility companies should provide the inspiring prices to consumer's i.e. high unit rate during peak load time, average rate per unit during base load time and discounted rate per unit if consuming energy during low demand period. In addition to that also provide discounted rates at week end, holidays etc. Implement requirements of this program are discussed below:

- Units consumed during peak load should be charged highest rate, average rate per unit during base load period and discounted rate per unit during low demand period; hence it is required to distinguish between peak load, base load and low demand periods.
- However, some consumers are ready to pay high unit rate during peak load time but still not allowed to use energy more than predefined KW say as per their sanctioned maximum demand.
- Duration of time for which consumers used energy.
- Sum up all units consumed during a fixed time say one month.
- As Consumer's are ultimately used energy, hence he should be able to easy understand the load period i.e. whether peak load, base or discounted load time.

IV. EFFECTIVENESS

Since consumers have opportunity to reduce their energy consumption bill without reducing the demand, so they voluntary participate to shift their load towards valley (disconnected time). During low valley periods consumer can also store the electricity by converting it into thermal power, chemical energy etc. Then utilize energy during peak demand period, while enjoying the discounted rates.

V. LOAD SCHEDULING PROGRAMS

Load on the power plant is variable in nature. There is large difference between peak demand and valley demand. However, the power plants are designed to meet the maximum demand, which results in high generation cost per unit and demand large installed capacity. It is not possible for developing countries to meet the targeted capacity by installing new power plants. Consider a power plant having load curve as shown in Figure. 1, having maximum demand of 2000 kW and average load of 1200 kW. Load factor which is the ratio of average demand to the maximum demand is 0.6.

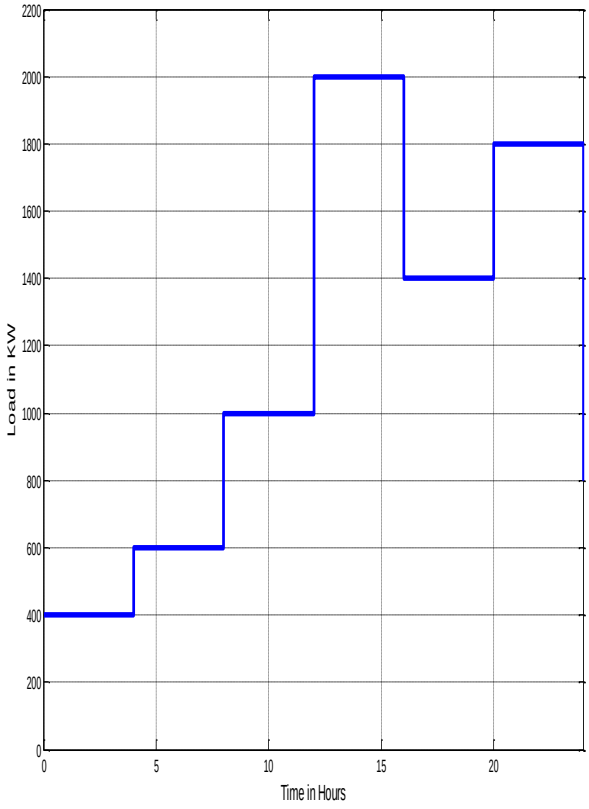

Figure. 1: Load curve of Power Plant

Load factor of a plant is less than unity. Lower the load factor higher the rate per generation as power plants are designed to meet the maximum demand. Higher the difference between peak demand and valley demand, resulting in the higher generating cost per unit [7] and demand. In order to reduce the peak demand, here we use the load scheduling strategy [8], in which 400 KW load is considered as base load and allowed to supply for 24 hours and remaining 19200 KW load is scheduled into three groups. Each group is allowed to operate for 8 hours. The designed model of load scheduling in MATLAB Simulink is shown in Figure. 2 in which load scheduling settling time is implemented and utility have the direct control over the load.

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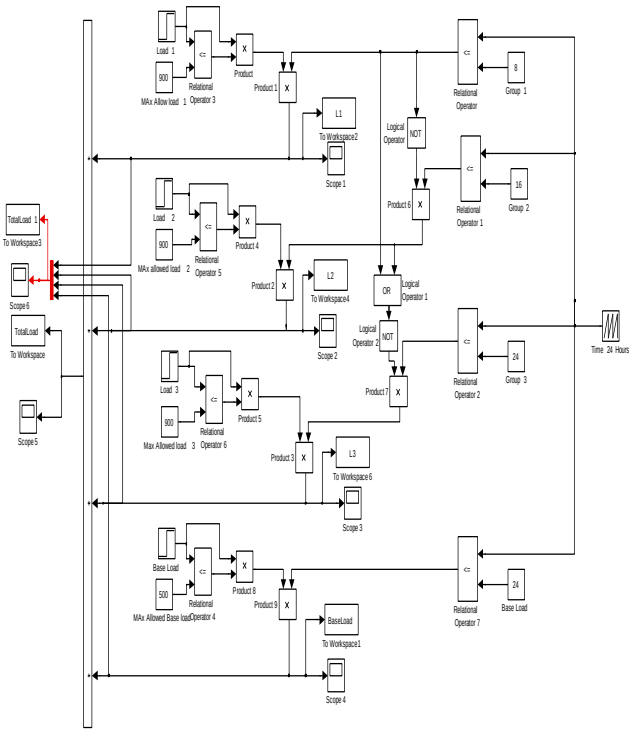

Figure. 2 Simplified model of Load Scheduling

Load curve of all the load groups after load scheduling is shown in Figure. 3 and total load curve of plant after scheduling is shown in Figure. 4.

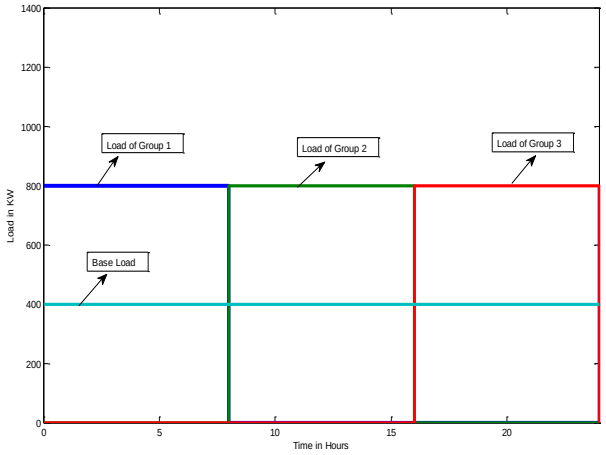

Figure. 3 Load curve of All the Groups

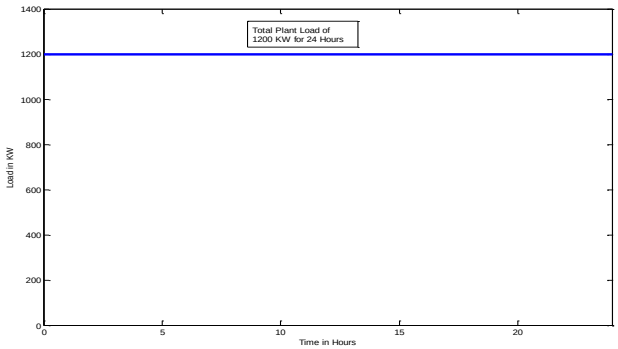

Figure. 4 Total Load curve of Plant after Scheduling

VI. EFFECTIVENESS

Power plant's maximum demand is reduced from 2000 KW to 1200 KW by load scheduling that can be used to meet future increasing demand requirement. Since now plant is operating at unity load factor, hence also low generation cost per unit.

VII. ENERGY CONSERVATION PROGRAMS

We are not able to meet the energy demand of many sector of our economy, even for existing consumer we have to perform power cut and load shedding. This situation is not likely to improve in immediate future. However Load scheduling methods help to reduce the peak demand by shifting the demand towards valley, without participating to reduce the total consumption. Therefore these methods are not only the solution to fight with this problem. Set up of new generating plant for developing country like India is not as easy because lack of funds, available resources and it also requires more time for proper installation.

A. Lighting

Lighting is a significant component of energy demand in all sectors particularly at the time of peak demand. Lighting load consumes 50% of total consumption in commercial buildings and 10% in industries. There are number of places where electricity is wasted in lighting, by taking little measure it is possible to reduce the wastage. The various places where opportunities are available to reduce the energy consumptions are:

Institutes/ Colleges and Offices

It is also observed that at institute level, a huge amount of energy is wasted. So need to ensure that the number of electrical appliances that are brought into campus should be there is a regulated and installed the automatic switching system and sensors in order to save electricity.

Festive Seasons

It is also observed that a huge amount of energy is wasted in lighting during festival seasons, marriages and parties, specially in these occasions peoples are using decorating light which are inefficient.

So there is need to aware the peoples regarding electricity crisis and motivate them to use efficient lamp and encourage them to avoid the use of unnecessary decorative light. One simple solution to this problem is promoting daytime marriages and parties rather than night.

Street Lights

Everyone knows the importance and wastage of energy in street light. Street lighting is required from evening to morning and actual timing depends on season, but it is seen that these lights are not switched off many time, hence energy wastes. In order to save energy install LDR circuits with these street lights that automatically switch off the lights when Sun rises. In addition to this, another problem with street lights is that it uses traditional incandescent bulbs. These bulbs waste a major proportion of energy to heat and only 3-6% of total energy is converted to light, so replace these bulbs with more efficient lamps.

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EFFECTIVENESS

Lighting plays an essential role in human activities in all the sectors. Above discussion does not mean, don't use lighting. Consequently it means to use good and efficient lamps. A great scope is available to save electricity by promoting following measures:

- Use CFL instead of lamps, since having high efficiency.
- Installed electronic blast instead of inductive Chock.
- Paint walls with bright colors as it reflect more light.
- Make habit to switch off unnecessary light points.
- Without utilization of proper Sun light effective saving from lighting cannot be committed.

B. Agriculture & Industrial Sector

Agriculture sector which consists of pumping loads mainly consume around 23% of total power generated. Generally speaking Industries consume about 50% of power generated in the country, out of which electric motor consumes about 65% of power, which comes to about 33% of total power generated in India. Combination of these two loads is about half of total power generated. Therefore main emphasis should be given to these areas. Energy consumptions can be reduced in these sectors by considering following measures:

Energy Efficient Induction Motor

In 90% industrial applications, Induction motor are used that operates at full load efficiency of 85%. Replace these standard efficient IM motors with energy efficient motors having efficiency 90-92%. Since these motors have cost 3-4 times higher than standard Induction motor. As these motors consume less power, therefore we can justify their cost in 1-2 years on payback basis.

Variable Speed Drives

In addition to improvement in induction motors, there is need to use variable speed drives. Uses of variable speed drives can reduce the energy consumption, since these drives follow the affinity laws.

As per law:

$$\text{Torque} \propto (\text{Motor Speed})^2$$

$$\text{Power} \propto \text{Speed} * \text{Torque}$$

It implies that

$$\text{Power} \propto (\text{Motor Speed})^3$$

If a pump is running at half speed, output get reduced to square to the speed but power consumption is reduced much more.

Power Factor

In Industries mostly equipments are operating on low lagging power factor. Lower the power factor highest the power consumption. In order to reduce the power consumption, install the power factor correcting equipment with the load that is responsible for low power factor.

Power Boss

Generally all the equipments are operating below the full load capacity for most of the time. Since equipments are drawing power regardless of its connected load, thereby resulting loss of electricity. In order to reduce this type of wastage, it is recommended to install the automatic load controller power boss with motors that control the current consumption of motor related to the connected load and hence results in saving of wasted electricity.

EFFECTIVENESS

By adopting energy efficient motor, total consumption can be reduced by over 7%. But greatest gain can be achieved if these motors combine with power electronics converter to achieve variable speed drive. Combination of these two results in 15-30% energy saving. However energy efficient motor, variable speed drives and power boss result in saving of energy, but still people are not interest to buy these equipments because of their initial cost which is 3-4 times greater than normal motor.

VIII. ADVANTAGES OF DSM

DSM results in low peak demand on power plant and saving of electrical energy, ultimate advantage to consumer, utility and societies are:

- Postpone the construction of new power plant.
- Deferring high investment to setup transmission and distribution networks.
- Mitigating electrical system emergencies.
- Reduces the number of blackouts.
- Less stress on power plant that reduces local air pollution.
- Less stress on plant results in reduction of harmful green gas emissions.
- Low cost of generation per unit.
- Network reliability is improved.
- Power plant demand less maintenance.
- Reduction in consumer's electricity bill.
- Enhances the national energy security by reducing the dependency on expensive import of fuel.
- Creation of long term jobs due to new innovation and technology.

IX. OBSTACLE TO IMPLEMENT DSM PROGRAMMES

However, DSM has numerous advantages but still implementation of DSM strategy is facing following obstacles:

- Since electricity price level and its structure are mainly established by government especially electrical price structure. Hence regional political situation play a major role to decide the policies.
- Government as driving force is responsible for implementation of DSM programmes, but their supporting policies and regulation lag behind the practical situation.
- With the deregulation of energy sector, new problem arises which is come who is responsible to invest and sharing the benefit of DSM.
- Low awareness of energy efficiency and DSM programmes.
- Most of customers are less literate, therefore, not able to understand the future problems.

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- Since energy efficient appliances and control drives are costly than standard appliances, hence consumers are not showing interest to buy them.
- Lack of the communication and faith between utilities and consumers.
- Lack of energy audits hence companies fails to collect reliable information on their current operations.
- Lack of available funds for research and experimental work.

X. PROMOTION TO IMPLEMENT DSM PROGRAMMES

However implementation of DSM programmes has a number of practical obstacles but can be easily implemented by considering following points:

- As government is main driving force, hence promotion of DSM depends on the effective policies and decision taken by it.
- Awareness and motivate the market is another main key to promote the DSM.
- Government should provide direct subsidies on energy efficient appliances.
- Utility companies provide direct and indirect to consumer utilizing non-conventional energy sources.
- Arrange the funds for research and experimental work.

XI. CONCLUSION

DSM has reformed the traditional mode of thinking to construct a new power plant in order to meet the demand. DSM optimize the consumption manners and improving the terminal power consumption efficiency, it can not only fulfill the same power consumption function but also decrease the energy demand. DSM is a strategy to save energy, reduce consumption and environment improvement. DSM is an important tool for enabling a more efficient use of available energy resources. DSM applied to electricity systems can mitigate electrical system emergencies, minimize blackouts and increase system reliability, reduce dependency on expensive imports, reduce energy prices, provide relief to the power grid and generation plants, reduce investments in generation, transmission and distribution networks and contribute to lower environmental emissions.

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