A Review: Framework-Approaches Of Trending Demand Side Load Management

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***Abstract*—Demand side management is a concept which enables user to monitor or manage the use of daily household equipments to control use of electricity. The main key factors for management are to load shifting, peak clipping, which are applied to achieve significant economic and environmental benefits from *load management*. The major focus of this paper is to define the demand side management (DSM) along with its approaches, also different load shifting and peak clipping methods etc. Along with this the theoretical framework for DSM is also represented in this work. The major focus of the study is to analyze the demand side management for residential users. A review to the traditional work that has been done in this domain by various authors is also shown in this study.**

Keywords*—Energy Consumption, demand side management, residential users, load balancing, electrical load management.

I. INTRODUCTION

In year 1973, DSM comes into existence after the crisis of energy that occurs in USA [1-2]. Also, it is referred as Energy Demand Management which has the major purpose of reducing the power plant's peak requirement. The advantages are offered to utilities and clients by the DSM. It is beneficial for the utilities in a way that it prevents the requirement of building new power stations as the load is transferred by it to the off-peak hours. It offers various ways for domestic and industrial users so that they can diminish their bills of electricity by complying with the inducement plan that is presented by their utilities. In 1980s, the programs of energy effectiveness and activities of DSM were initiated in India as a result of which Indian government created several working groups to propel the efforts of national energy effectiveness in 1983[3] and due to this, efficient motors, efficient lightening and variable speed drives were installed by various industries. In 2001, the act of Energy Conservation [4] was framed in India that was the main step towards the conservation of energy and DSM. The Bureau of Energy Efficiency (BEE) was created under the Energy Conservation act and the major purpose of BEE was to control and promote the activities of energy efficiency. Government had made a decision in 2001 to initiate the DSM in several states for their effectiveness, by presenting a structure of TOD tariff and inducements for programs of energy efficiency. The TOD tariff was deployed by several states utilities only for the commercial and industrial users. Although in residential sector's case, launching the structure of TOD tariff is not much considerable. Actually, implementing the structure of TOD for each domestic user in India is somewhat difficult. However, it can be utilized for group of domestic users such as, big education institutes, housing societies in which numerous devices are present for managing. Whatever thing that is done on the power system's demand side in comprised by DSM, varying from bartering the old luminescent light bulbs to the compact fluorescent lights (CFLs), and even now to the LED bulbs and up to forming a sophisticated dynamic load management system. Previously, DSM was referred as a utility driven activity, but at present, it is more considered as the user driven activity.

II. APPROACH TO DSM

In two branches, the DSM can be categorized. "Energy efficiency" (EE) is the first part. The major focus of the energy efficiency method is to conserve the electricity. The energy efficient devices must be utilized, in order to save the electricity. Also, the conservation of energy can be regarded as an energy efficiency technique's part. "Demand response" (DR) is the second part. It can be categorized into: direct load control, time of use, and load shifting. Different time is assigned to the users to utilize the electricity, in the time of use approach. Different range of cost is offered by different schedules of time.

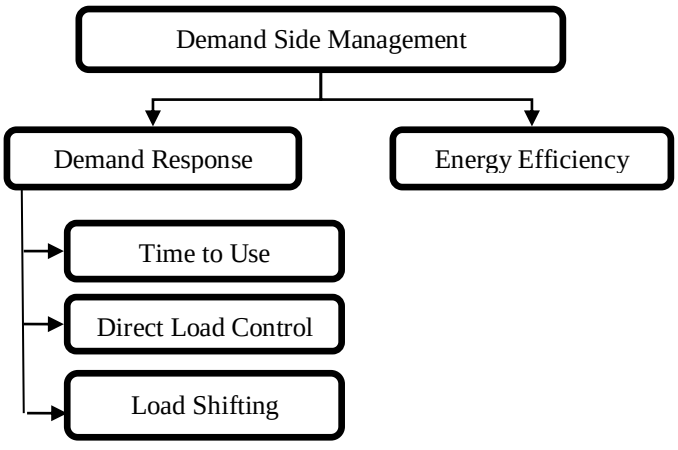

Figure 1 Approaches for DSM

Due to this the providers become able to control the supply and it motivates user to utilize energy in the sensible manner.

Suppliers can control the load, in the direct load method. In order to conserve energy, some of the loads are turned off for a specific time period. Load shifting is the third one. Load shifting is a method of transferring the load to the off-peak hours from the peak-hours. It can be categorized into two types: automatic load shifting and indirect load shifting. Classification of DSM is represented in Figure 1 [5].

III. DSM TECHNIQUES

DSM's main objective is to even up the regular morning and evening demand peaks and construct valleys to utilize the available resources effectively and to reschedule or remove, like the situation can be, the requirement to obtain extra peaked plants in order to fulfill the peak demand of users.

The utilization of power saving technologies, financial inducements, electricity tariffs and government policies can be consisted by it in order to alleviate demand of peak load [6]. In [7], users load profiles' alteration was utilized for classifying techniques of Demand Side Management into peak clipping, load shifting, load building, load conservation, flexible load and valley filling [7, 8].

3.1 DSM methods Load shifting method

some electrical device's time-independency features are utilized by it and their utilization is transferred to the off-peak time from the peak-time by it. [8-13]. In current networks of distribution, it is a general method for managing the load effectively.

a) Peak clipping technique: in order to decrease the users' load profiles' peak demand at particular times through direct device's control or utilization of tariff, the peak clipping technique is utilized by utilities [11].
b) Load conservation method: in order to obtain load shape optimization via demand reduction technique's application at user grounds, the load conservation technique is utilized. This can have long lasting impact over network planning, utility grid and operation.
c) Load building technique: this technique endeavors to optimize the regular reply in situation of huge demand introduction further than valley filling method by contribution from storage systems, energy conservation or Distributed Energy Resources(DERs) [14,15].
d) Valley filling technique: Valley filling method comprises the valley demand depth's diminution through constructing the off-peak demand [8 16, 17].
e) Flexible load technique: Reliability is provided to smart grid by flexible load technique through providing customers, who want to be controlled while times of critical demand in turn for specific inducements, with the flexible loads.

Here, some motivations for Demand Side Management in the smart grid are presented in brief. Initially, demand of users at peak times will be scheduled more auspiciously for conserving electricity and cost, with the help of TOU and dynamic costing techniques that are famous among utilities all over the world. After that, the requirement to construct the extra energy network architecture for meeting the rising peak demand of users can be reduced with the help of PDR. At third, with the help of DSM methods' applications like load shifting, the energy utilization of the users can be optimized through paying less for same utilization of energy. At fourth, environment is safe because of diminution of just about 1 kg carbon dioxide release from the plants that generate peaker per kWh energy at peak time [18]. In last, proficient DSM methods will result in success of users, utility providers, and environment.

IV. TRADITIONAL MANAGEMENT FRAMEWORKS

Traditional DSM framework comprises the concepts which are explained below:

4.1 DSM strategies and modalities

Matching the supply of electricity with the demand is the major aim of the DSM. There are approaches to achieve this aim:

1) Consumption reduction
2) Efficiency improvement

Consequently, Demand Side Management is categorized into 2 modalities known as 'static DSM (SDSM)' and 'dynamic DSM (DDSM)'.

4.2 Methodology of DSM

In DSM structure, there are 2 common methods (SDSM and DDSM) that are elucidated as below:

4.2.1. Electrical load management (ELM)

4.2.1.1. History of ELM.

In the seventies, the ELM came into existence as the initial step in implementing of managerial actions. Also, the ELM is considered as DSM theory's initial notion [19, 20]. Initially, DSM was called as load management [21]. The DSM's notion was also firstly limited to the load management, such as in [22-25]. In [21], the ELM notion's categorization was done where, in place of 'load management' term the 'demand-side management' term was used described as the implementation, scheming and monitoring of utility appliances and activities to encourage the consumption of electricity that leads to enviable modifications in the customer's utilization pattern. In addition, ELM's three traditional forms were introduced, i.e. valley filling, peak clipping and load shifting, and ELM's three modern forms were introduced, i.e. strategic conservation, strategic load growth and strategic load growth, in [21].

Now, the definitions of ELM's notions and techniques mentioned in [21] are usually considered as standard frame. The peak load diminution's notion is addressed along with the two strategies. Tariffing on peak-load hours for transferring the load is the first strategy in which some requirements of energy are shifted to off-peak hours that can be defined by the each indicator to inform the customers. Utilization of load control equipments is the second strategy. Communications systems are required by both of these strategies for the customers and utilities. In [22], the contrast of employing transmission lines as communication medium and applying radio network has been demonstrated.

4.2.1.2. Working Model and Variants of ELM

'Load Management Working Group of the System Planning Subcommittee of the Power Engineering Committee' proposed the ELM's initial scientific definition in [23]: The load management is the deliberate manipulating of customers so that the time of utilization for electricity can be shifted. In [23], ELM's three alternatives have been addressed that are, 'direct load control (by technological actions applied by utilities)', 'indirect load control (by electricity pricing's different forms)', and 'energy storage'. Also in [26], three of these alternatives are defined as demand-side load management that has been constrained to utilities through the peak periods' increasing cost of production and great intricacy of expansion of capacity. Electric load curve synthesis (ELCS) has been explained in Ref. [27] that can be utilized to forecast the modifications in load shape because of load management changes and non-load management changes. ELM was classified in Ref. [28] into five common groups consisting interruptible loads, energy storage, conservation (controlled), dispersed generation and customer load control. Options of ELM were also described in it and few methods of forecasting are defined that can be implemented to Electric Load Management. In [29], load management's usual evaluation methodology has been demonstrated which comprises every element of incorporated strategic planning system. In addition, an analytical framework has been described in [30] that consist of client's important considerations, rates of electricity, marketing, forecasting and operations. In [31], ELM-related terms' glossary was published.

4.2.1.3. Modalities and mechanisms of ELM.

In this paper the theoretical framework of DSM has been proposed in which the ELM's forms discussed regarded as techniques that accomplishes the ELM's goals. Like the modalities of DSM that was described, the ELM also has two modalities that are described below:

4.2.1.3.1. Static electrical load management (SELM).

SELM has been regarded as the activities and measures whose objective is to minimize the utilization of electricity when needed. 'Strategic conservation' has been comprised by the SELM that aims to consumption pattern's enhancement and 'flexible load shape' related with scope of reliability in power system operation. The Static Electrical Load Management is scrutinized by the below strategies related with load profile [21, 32, 33] which considers the SDSM approach:

1) Strategic Conservation: load's utility-stimulated reduction in order to change the shape of load.
2) Flexible Load Shape: modification of load based on reliability. SELM consists 'reliability-based SELM' and 'strategic SELM'. Utility-stimulated reduction of load is comprised by the strategic SELM in order to overcome the entire shortage of the energy. Therefore, 'strategic conservation' is the strategic SELM's mechanism. The goal of the reliability-based SELM is to fulfill the user's energy requirements when the available power's amount is reduced by the unexpected events. Flexible load shape is the reliability-based SELM's mechanism that is generally applied by each customer load control device.

4.2.1.3.2. Dynamic electrical load management (DELM).

DELM intends to enhance the power consumption's effectiveness. The activities and actions are consisted by the DELM by which the enviable modifications can be made in the load curve. In order to explain power consumptions' effectiveness, Load Factor (LF) is the major key. The Load Factor can be described as the proportion of the specific time period's average load to the same time period's highest load. The huge disparity among power utilizations allied to peak and off-peak times will lead to huge losses of investments and generation of noneconomic in the power system. The goals of DELM are 'load factor correction (LFC)' with valley filling, peak clipping and load shifting mechanisms (constructed for maximizing LF), and also 'load profile correction (LPC)' including mechanism of strategic load growth (designed for enhancing the power system operation's efficiency). With the help of following mechanisms related to load profiles [21,30], the DELM is scrutinized in order to achieve the DDSM's goals:

1. Peak-clipping: diminution of peak load of system (at peak load times)
2. Valley filling: constructing off-peak loads
3. Load Shifting: transferring the load to off-peak time periods from the on-peak time periods.
4. Strategic Load Growth: load's Utility-stimulated augmentation.

V. RESIDENTIAL DEMAND SIDE MANAGEMENT

5.1 Residential Energy Efficiency

The industrialization or building sector plays a major role in energy consumption. It is analyzed that more than one third of global resource consumption, comprising 12% usage of fresh water and 40% solid waste [31]. Whereas, the energy consumption at domestic level has been increased from 15.9% to 44.1% within the duration of 20 years. The population growth has been considered as the major reason behind this increment [32]. Except domestic level, the residential nd transportation sector has also been considered as the major energy consumption domains. For example, a statistics show that the percentage of metropolitan citizens in Portugal has been reached to the 68% from 19% within the tenure of 1950 to 2000 [35]. It is also observed that the 60% of the national electricity is consumed by building, 29% is consumed by domestic building and 31% is consumed by service buildings [33].

According to [34] from 2007 to 2009, the electricity consumption by the residential area is increased by 2.11%. Various factors such as growth in usage of electricity tools for dwelling (AC, Computers etc) are the reason behind this increment. The energy consumption by the residential domain is decreased by 7.12%. For the first time, it was noticed in 1990, that the annual energy consumption level of a year is decreased to such an extent from a year to another following year. This results due to the impact of residential energy efficiency policies. This decrement is the in the current trends, this means that the preventive measures could be done to reserve the energy. In fact, the climatic variations may also

effect the energy consumption in the respective areas. According to [35], It is assessed that the usage of electricity resources will reduce in Central and North Europe. The reduction in warming could leads to the decrement of the energy consumption in Central and North Europe whereas in Southern Europe, the requirement of cooling will overtake the less requirement of warming.

As per [36], the final energy is known as the energy that is obtained after transformation process of primary energy i.e. oil, wind, sun etc. There are losses of performance related to this transformation because of ineffectiveness of processes. Then, this final energy is transferred to consumption points (such as, service buildings, households or industry) via electricity grid and, in these processes again there are performance losses. At last, energy which emerges from plug at house is the electricity by which the equipments can operate. This is how the energy is supplied to the end-user (*example.*, in dishwashing and washing machines the water heating and pumping, the light from a lamp, and also the rotation of tambour in washing machine and in refrigerator the heating and refrigeration liquid compression)

Lastly, there is a productive energy related to end-utilize energy that corresponds to accurate manner in which the previous energy is used. For instance, utilize room lightening while nobody is there, choosing a program in washing machine or dishwashing machine which is very concentrated for the clothes' or dishes' griminess correspondingly, or placing food which is still warm in the refrigerator rather than previously waiting it to be get cool at room temperature, comprises bad practices that results in wastage of productive energy.

5.2 Consumption Behavior- Factors

The habits of utilization have implemented in an augmented propensity. Actually, in the national final energy consumption the residential sector's share raised from 13% [37] in 2001, to the 31% in 2009[38].

The habits of inefficient utilization in the house are reported which are quite common like discussed in [38]:

- During taking the shower, keeps the water flowing even while soaping.
- Using hot water to wash hands.
- Not turning off light when nobody is present in the room.
- Keeping the warm food in the fridge;
- Keep the devices on standby utilization;
- Utilize programs to hot (higher than needed by griminess) in the washing machines and dishwashing machines;
- Not covering the pan while cooking;
- Don't recycle;
- In short-range paths, recourse the car

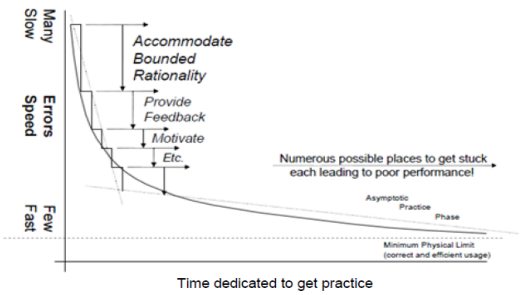

Figure 2 "How the user thinks:" an approach how practice is linked to efficiency usage [39]

The strategies should not be focused to engineering only, but also to social sciences for achieving the efficiency enhancement in habits of household utilization. On the basis of the later approach, the response of demand side to new behavior proposals differs. On the basis of [39], the change in behavior can be described like it is represented in Figure 2.

5.3 Management of Appliances (Dishwashing machine, refrigerator, and washing machine)

Refrigerator, dishwashing and washing machines are the appliances where the utilization can be transferred to periods having less energy load, that are concerned.

On the basis of [38], the freezer and refrigerator utilities show, 10 and 22% utilization of the household electricity respectively. The shares of the washing machine and dishwashing in the utilization of electricity are 5 and 2% respectively. Shares of freezer, refrigerator, dishwashing, washing machine and others are represented in figure 3.

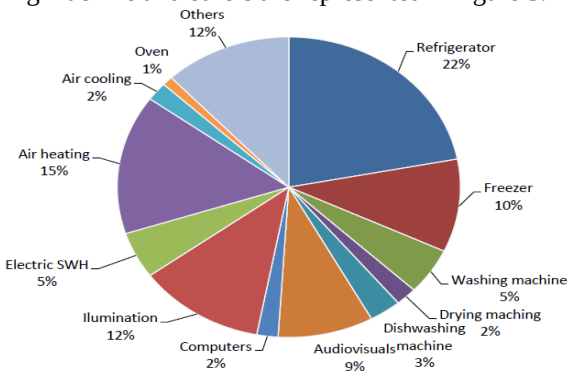

Figure 3 Repartition of electricity consumption according to the various uses in 2002.

VI. RELATED WORK

Various advanced technical optimization strategies which contend with residential DR for smart homes in smart grid was developed in the literature, in which (1) heuristic-based load control techniques to divert peak power utilization [40] and shedding domestic appliances [41] and (2) load-scheduling strategies to schedule power utilization on domestic appliances [42, 43] had been proposed. The residential DR had been addressed by the authors. However, Real-Time Pricing (RTP) along with Inclining Block Rates (IBR) was not considered by many strategies. RTP was recognized as dynamic pricing's popular variant for implementation of DR in a future grid like

discussed in [43], as compared to Time-Of-Use (TOU) model in which the dynamic pricing's variant created a structure of variable electricity prices for off-peak shoulder, and peak hours. Demands of peak energy can be reduced by IBR. Moreover, prior to acquiring the benefits of Real Time Pricing in DR, the users first requires to find the domestic appliances' physical features on the basis of their past style of manually utilizing the electricity. Automated residential DR was not concerned by them; interference of customer to the strategies is needed. Moreover, renewable energy which is generated locally like wind power generation and/or photovoltaic power generation while residential DR was not considered by every of the approach in literature since, renewable energy provides the benefit that energy is clean and present in abundance in the nature. In [**40**], the study majorly concentrates on presenting a house energy management system, Home Energy Management as a Service, comprising learning of reinforcement along with four peak diminution thresholds and to interfere with the smart environment. The heuristic-based load-scheduling technique which optimizes the cost of electricity was comprehended in [44]. Though, in research, when the considered price of electricity is less, then peak power utilization resulting to relatively high Peak-to-Average Ratio (PAR) can come out. Therefore, for implementation of residential DR, the Inclining Block Rates must be comprised and considered. Both the PAR and cost of electricity can be minimized at same time, in [45].

Though, as represented in [42], the assumptions considered in the study not appears practical. Reference [42] presents a Genetic Algorithm (GA)-based load-scheduling technique, which optimizes domestic appliances on the basis of RTP along with IBR, in order to reduce the defects in [44]. RTP is anticipated and recognized as dynamic pricing's famous variant for implementation of DR in smart grids, as compared to TOU which establishes an electricity price-varying model for off-peak, shoulder and peak hours. As proposed in [8], users who utilizes and conducts load-scheduling strategy for optimizing their cost of electricity requires to describe in advance the physical features of all the domestic appliances manually. The cost of energy utilization was considered by authors as the DSM's key goal function, in [45. 46, 47]. Moreover, the IBR which reduces peak power utilization is not considered in the research. In [48], on four load control scenarios the recursive process was developed by authors in order to diminish the peak power utilization.

In [48], the Real-Time Pricing is considered while the recursive process. In [49.], in order to resolve the DSM issue, the ant colony optimization's variant is employed. In [50.], the research against most updated studies in non-intrusive load monitoring [51, 52] as a element of DSM considers the RTP along with IBR for implementation of DR. Though, in the research the PAR that is reported can be enhanced. Considering an enhanced building energy management system for facilities of air-conditioning in commercial buildings, in [53] the researches study a simulated annealing optimization which reduced an assessment function including power cost and terms of comfort degradation.

VII. CONCLUSION

As surveyed above, it is observed that the energy efficiency and management has become the central issue in residential and industrial buildings. In all over the world, the energy is consumed in various forms such as electricity, water etc. The demand side management is a concept that was developed in 1973 in order to manage the energy consumption rate at various levels such as industries, building and residential. This study is organized to have a review to the basic concept of DSM along with its various approaches and theoretical framework. The residential demand side management is the major focus of this study. An analysis to traditional DSM approaches is also done in this work. On the basis of the related work, it is concluded that a large number of research has been conducted to manage the energy consumption in residential domain. Few of the authors have applied heuristic approaches for this purpose and few of them have also applied the scheduling to manage the peak to average ratio.

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