A Review on Demand Side Management Schemes for Optimized Energy Utilization in Smart Grids

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ABSTRACT

Smart grids are considered as the basic and fundamental technology through which environmental pollution and the user's energy cost is reduced. The management of smart grids is done by various demands Side management (DSM) techniques to ensure that there is an efficient flow of power. But it is a complex task in real time as energy demands of consumers rise continuously in an unpredicted manner. A literature survey is conducted to get an overview about the role of heuristic techniques in demand side management. The review states that such algorithms are able to schedule the power cuts in an effective way which in turn minimizes the load on the power grids. But as there are number of heuristic algorithms available it will be a challenge to select the efficient approach. Moreover, the important factors such as load, cost etc. are also drawn out from the survey to help the future research to give an efficient DSM system.

Keywords

Demand side management, electrical systems, energy management, energy efficiency, etc.

1. INTRODUCTION

With the increasing demand and use of the traditional fossil fuels like diesel and petrol and their high prices, it becomes extremely essential to use alternative ways in order to meet the future energy demands that are energy efficient and provide green and sustainable environment. The electricity grid is being transformed into a dependable and intelligent cyber physical system (CPS) in which information and communications technology (ICT) is integrated with the traditional grid to enhance their performance [1]. In addition to this various renewable energy resources such as wind, solar etc. are utilized along with the effective and novel DSM methods to meet the increasing demands [2]. DSM is a power supply strategy to enable customers to follow procedures and activities which are favourable to all parties. By doing so, all the abnormal activities that change the load demand can be analysed and amended [3]. However, the introduction of DSM raises the complexity in current power systems as DSM needs power system loads and generators, to be controlled. Consequently, there will be extra costs utilized in installing sensors, supplying encouragement to DSM and conducting general DSM tasks. In the smart grid, energy providers can transfer and deliver the power generated to customers with low running costs by using DSM techniques [4]. When demand for electricity is greater than output, the traditional approach raises the power generating unit and generates user electricity to satisfy their energy needs. However, this approach is not suitable due to the greenhouse effect.

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The issue of energy demand can be addressed by a proper DSM operation in which without adding an extra generator, the DSM handles and monitors the necessary energy for end users. It manages demand by introducing planning algorithms. The response to demand
reduces energy consumption and prevents power grid overuse [5]. In addition, by enforcing proper scheduling practices, this would offer the cost advantage for customers and last for decades.
Various DSM techniques are shown in Figure 1. Energy conservation, demand response and strategic load growth are the core components of DSM. The demand response is categorized into two categories i.e. Market-based program and reliability-based program.

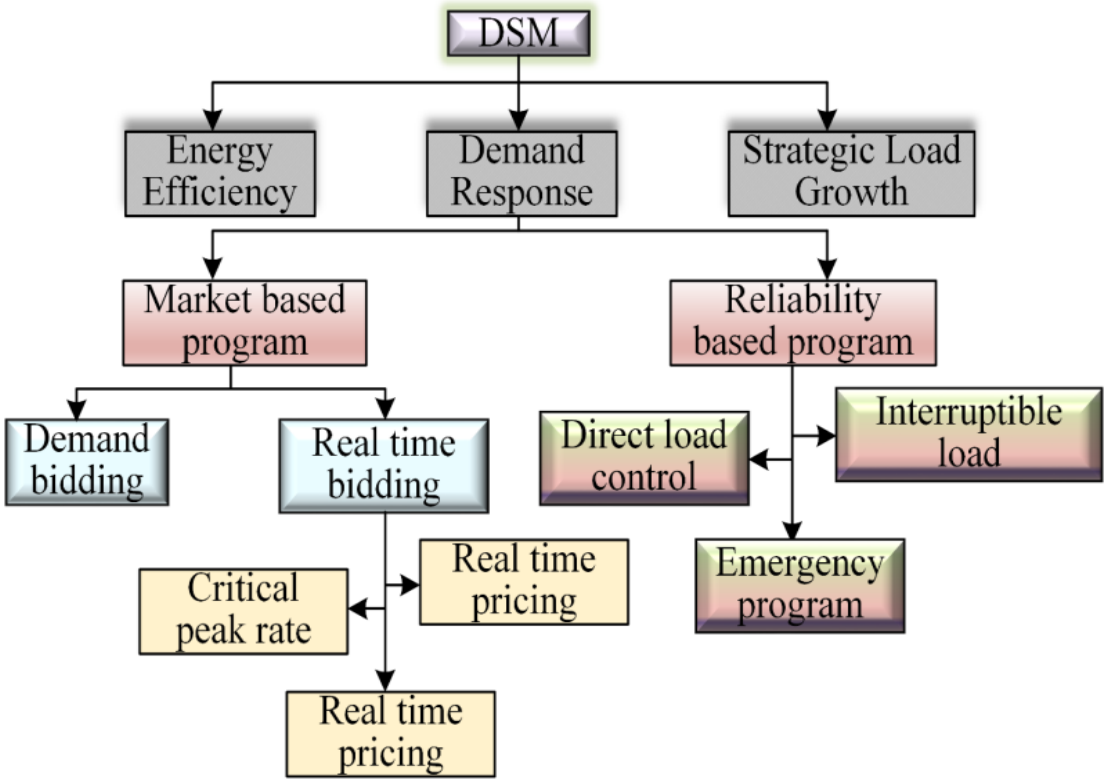

Figure 1: Tree diagram for different DSM techniques

1.1 Heuristic algorithms in DSM

Most of the techniques use both linear and non-linear programming method to solve the DSM problem. However, these programming techniques cannot handle a large number of controllable devices which have several computation patterns and heuristics. They may not find a feasible solution when the computational time is too high or when the problems belong to non-convex programming, Mixed Integer Nonlinear Programming or nondeterministic polynomial time (NP-hard) problems. These issues can be solved by using heuristic-based evolutionary algorithm that provides a fast and best optimal solution [6]. The heuristic based methods like genetic algorithm, Ant Colony Optimization and Particle Swarm Optimization (PSO) can search very large spaces of candidate solutions and find globally optimal solution in polynomial time. In addition to this, various other optimization algorithms were used which are discussed in section 2 and Table 1.

2. RELATED WORK

Significant studies have been proposed, and this section presents the works done in this field. Hussain et al. [7], implemented a home energy management system based on the genetic algorithm (GA) and the harmony search algorithm (HSA), to minimize energy costs and the peak to average ratio. Xu et al. [8], the uncertain optimization approach was turned into a convex optimization question by implementing the probability theory. Vatul et al. [9], carried out the DSM strategy on two systems first was on the RTS 24 bus system with wind energy sources spread at some system nodes and second on the institutional load of the built solar power plant to minimize the customer's utility bills. An immediate billing. Supriya P. [10], addressed a Game Theoretical Approach for Demand Side Management based on Nash Equilibrium (NE) utilizing consumer-based priority load control, by considering the power deficit. Nawaz et al. [11], described the use of Hybrid Bacterial Foraging and Particle Swarm Optimization (HBFPSO) method for determining the DSM strategy to meet all four fairly independent goals simultaneously, minimized cost, PAR, CO2 emission, and user discomfort, to return optimal consumer power use schedule. Jian et. al. [12], developed the generating firm, the grid organization and the society's avoidable expense model for various DSM investment programs. Hamrouni. [13], An advanced protocol with the combination of two algorithms Energy Scheduling and Distributed Storage (ESDS) and Microgrid Energy Management Distributed Optimization Algorithm was given that provides benefits to users. Philipo et al. [14], designed an algorithm to simulate the daily powers patterns of consumers or users of residential regions for load shifting and scheduled load reduction. Gupta et al. [15], proposed a combined Multi-Objective Dynamic Economic and Emission Dispatch model (MODEED) with DSM, to study on the generation side the benefits of DSM. Vatul, et al. [16], proposed the instantaneous pricing system to minimize the supply gap for consumers vulnerable to electricity prices. Lin. [17], presented an electrical energy management system (EMS) architecture based on cloud analytics that has edge analysis with push notifications for DSM. Hecht et al. [18], provided a significant assessment of DSM techniques to produces extremely realistic findings that would be utilized for evaluating the efficacy of several load shifting methods. Sarker et al. [19], reviewed the algorithms and approaches that were utilized in the DSM applications in SG, and for efficient implementations, the researchers of this paper also reviewed the issues faces by DSM techniques. Talwariya et al. [20], carried out residential load-scheduling by utilizing EMC (Energy Management Controller). Pilz et al. [21], proposed a DSM strategy based on the potential technology for consumer's residential neighbourhoods. Anand Vatul et al. [22], evaluated the DSM strategies on an institutional load with installed RES to reduce peak demand. Tai et al. [23] suggested method using real-time multi-agent deep reinforcement learning to lower the peak time value, the power cost, and the PAR value. Kaddour et al. [24], implemented isolation forest, one class SVM and k-means algorithms to identify abnormal usage of electricity by users. Other than this few more studies are available in domain of DSM [25], [26], [27], and [28].

Table 1
Summary of related work done by various researchers

Author Name & Publication year	Methodology used	Advantages	Disadvantages
Hussainet al., [7], 2020	Implemented a home energy management system based on the issue of energy reallocation and used GA and HAS.	Reduced the electricity cost of users.	Causes loads in winter season as appliances.
Xu et al., [8],	A random disturbance and quasi	Improves the utility of	Slow

2020	newton method is applied to minimize the electricity bills.	consumers as well as reduce the cost of energy consumption.	convergence rate.
Vatul et al., [9], 2020	Analyzed the proposed DSM strategy on two systems first was on the RTS 24 bus system with wind energy sources and on institutional load of the built solar power plant.	Ensures optimum load and minimized the electricity bills for customers.	-
Supriya., [10], 2019	Presented a Game theoretical Approach for DSM based on NE utilizing consumer-based priority load control, by considering the power deficit.	Performs well in smart grid systems for predicting loads.	NE is inefficient and mutually beneficial output.
Nawaz et al., [11], 2020	Implemented HBFPSO method for determining the DSM strategy to minimize cost, PAR, CO2 emission, and user discomfort.	Reduced the cost or electricity, peak average ratio.	PSO gets stucked in local minima while as, BFO has slow convergence rate.
Jian et al., [12], 2018	Introduced an extensive unit cost model for the power grid, which takes account of the allocation factor to represent the different value of load decreased in different time.	Reduced load and electricity bills.	Energy density is low and complicated.
Hamrouni., [13], 2020	Demonstrated that the energy consumption optimization, distributed storage and generation helps in combined form for demand side management approaches.	Minimizes the load, energy is optimized.	Complex and costly.
Philipo et al., [14], 2020	Designed an algorithm to simulate the daily powers patterns of consumers or users of residential regions.	Save up to 4.87% of energy and 19.23% reduction in electricity bills.	-
Gupta and Subramani., [15], 2018	Proposed a combined Multi-Objective Dynamic Economic and Emission Dispatch model with DSM.	Provides benefits to users and companies by shifting the loads effectively.	Highly dimensional, coupled nonlinear multi objective.
Vatul et al., [16], 2019	Proposed the instantaneous pricing system to minimize the supply gap for consumers vulnerable to electricity prices.	Additional power is generated by reducing the peak demand.	Difficult to implement and costly.
Lin., [17], 2019	Presented an electrical EMS architecture that is based on cloud analytics and has edge analysis with push notifications for DSM.	Minimize the electricity consumption cost and carbon dioxide emissions.	Not secure and can result in data loss

Hecht et al., [18], 2021	Provided a significant assessment of DSM techniques.	Decreases the consumption of energy in grids and thus enhanced the efficiency of load shifting method.	Insufficient planning and lack of information.
Sarker et al., [19], 2020	Reviewed the algorithms and approaches that were utilized in the DSM applications in SG.	Minimize the carbon emission, cost and peak to average ratio. Also, it improves the convergence rate.	SG face challenges like reliability, data delivery and interoperability.
Talwariya et al., [20], 2020	Proposed heuristic-based EMC to Carry out residential load-scheduling.	Regulates load and reduce the power consumption.	-
Pilz et al., [21], 2020	Proposed a DSM strategy based on the potential technology for consumer's residential neighborhood.	Robust and reliable .	-
AnandVatul et al., [22], 2019	Evaluated the DSM strategies on an institutional load with installed RES.	Reduces the gap between supply and demand power.	Costly and difficult to establish.
Tai et al., [23], 2019	Proposed a real-time multi-agent deep reinforcement learning to solve issues related to DSM in HAN.	Reduces electricity bills, peak to average ratio and PAR value as well.	Lead to overloading.
Kaddour et al. [24], 2021	Implemented isolation forest, one class SVM and k-means algorithms to identify abnormal usage of electricity by users.	Reduced load	-

3. CONCLUSION

This paper presents a brief overview for the available DSM methods in power systems. It is observed from the literature study that DSM problems may vary under different operating conditions. Number of optimization techniques such as Heuristic approach, Game energy theory, Home energy management (HEM) etc. were proposed by researchers to solve different DSM issues such as overloading of the power grids, costs, power scheduling, demand response etc. Most of the researches were done on the basis of the standard dataset to work on real-time scenarios. After analyzing the various papers based on DSM we find that there is still a scope of improvement in these techniques in order make smart grids more efficient. Moreover, if these improved DSM techniques will be used in future, a balance can be achieved between the supply and energy demand of customers.

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