Demand side management in micro grid: A Review

Kapil Sharma

U.I.E.T. Kurukshetra University
Kurukshetra (Haryana), India
kapil4333@gamil.com

Vijay Kumar Garg

U.I.E.T. Kurukshetra University
Kurukshetra (Haryana), India
vkgarg.ee@gmail.com

Abstract: Energy can be produced from the renewable and non-renewable sources. Due to the increase of generating resources, the power system is divided into three parts (generation, transmission and distribution). Now a days, with the help of using micro grid and smart grid the power system has become digital. In this paper, we will discuss the concept of micro grid and its types. Here we will also read about the distributed generation concept. Due to the increasing power demand day by day, energy management is compulsory. Demand Side Management (DSM) is the main part of the micro grid. The DSM help the consumers to do the more effective use of power system. In this review paper, we will discuss about that what is DSM and various types of DSM techniques and methods to implement it. Here we will also discuss about the various benefits and challenges of DSM. The DSM enables a secure and stable power system.

Keywords: *Micro grids, Distributed Generation, Demand side management.*

1 INTRODUCTION

PRESENT SCENARIO OF RENEWABLE SECTOR: Global energy demand has been increasing steadily at an average annual rate of since 2011. The growth of demand is mainly occurring in developing countries. Most of it is being met by fossil fuels. Several international efforts have been undertaken to tackle climate change. Paris climate agreement that aims at reducing greenhouse gas emissions entered into effect in November, 2016. At the United Nations Climate Change Conference, leaders of nations pledged to work against attaininginexhaustible energy. In 2015, inexhaustible energy assumed to be around the global final energy consumption. Cost devaluations of efficient sustainable technologies like solar PV and wind power and reliable forecasting; enable promoting countries to enhance their renewable scope. The global renewable power capacity increased by gigawatts (GW) in 2016; which is an increase compared to 2015.In India, An aggregate of around 73.35 GW of sustainable power source limit has been introduced in the nation as on October, 2018 from all sustainable power sources which incorporates about 34.98 GW utilizing Wind, 24.33 GW utilizing sun based, 4.5 GW utilizing Small Hydro Power and 9.54 GW utilizing Bio-power. Tasks of 30 GW sun powered and 10 GW wind power age will be finished in the year 2018-19 and 2019-20. Government has reported that the force age of 60 GW utilizing solar based and 20 GW utilizing wind vitality will be done till 31-3-2020. [1]

In India, solar and wind power capacities have expandedconsiderably over the years as per Ministry of New & Renewable Energy (MNRE) reports. Growth trend is shown in figure 1.1.[2]

Renewable mini-grids use innovation to saddle vitality from sunlight based, hydro, biogas, biomass, wind and additionally cross breed sources (with the last ready to include capacity or diesel plants, for instance). Their abilities extend from under 1 kilowatt (kW) to up to 10 megawatts (MW). sunlight based photograph voltaic (PV) has as of late experienced quick development, from 11 MW of limit in 2008 to 308 MW in 2017. The quantity of individuals associated with PV scaled down networks arrived at 2.1 million of every 2016 (IRENA, 2018a). Little hydro, being a fairly adult innovation, experienced consistent development to 509 MW in 2017 from 418 MW in 2008, interfacing more than 6 million individuals during the period. It is accepted that somewhere in the range of 2016 and 2030, 60% of recently introduced force plant will give power created sustainable power sources, of which around 40% will be through small lattices (IEA, 2017).[3]

MICROGRID

Energy can be produced from the renewable and non-renewable sources.Day by day, there is an increase in Power demand and the fossil fuel in this world are in the limited quantity, these fuels are conventional. Generally, central grids use the fossil fuel but the central grids have the disadvantages like reliability, power quality, transmission and distribution losses. Therefore, small scale grids or micro grids come into play which has less investment in transmission lines. The micro grids are the best solution for the remote areas where transmission is not easy. There is the bidirectional flow of power between the utility grid and the micro grid if operated in the grid connected mode. By the definition of MNRE, the micro grids operating in islanding mode are under 10 kw but mini grids are greater than 10 kw . Micro grid has many operating modes like grid connected, islanded mode, transition between grid, islanded connected, PQ mode, V/F mode, droop mode. (Kalkal and Kumar Garg 2017). An electrical grid is an interconnection of power providers and consumers through transmission and distribution lines and operated by one or more control centers. Micro grid technology also gives the detail about the features of on-site generation. A micro grid is a small scale grid that connects the generated power, load, equipments like battery for energy storage and other controlling equipments constructing in a specific unit and controlled power system. Micro grid is the best solution to overcome the problem of environmental pollution and other issues. The feeder failure, rise in the loyalty of local power supply,energy efficiency can be boosted by using micro grid. Micro grid has the characteristics like uniqueness, independence, interactivity, controllability. (Zhou, Guo, and Ma 2015).

Distributed Energy Resources

As the installation landscape is obtaining restructured and market deregulated, new players square measure coming into the energy sector and investment in renewable technologies has been on an increase. There is a growing enthusiasm for little scale power generation over the last decade and a replacement approach towards electricity production referred to distributed generation is developing, there's no correct definition of distributed generation as per a survey of literature. It will be loosely delineated as AN installation of multiple tiny or small generation units directly coupled to the distribution network within the shut neighborhood of shoppers for the purpose of meeting real power demand.(Zaffar, Kumar, and Sharma 2018) .On-site generation is the technology of Generating power, including non-conventional energy resources and fossil fuels. Distributed generation gives less devaluation, greater energy productivity, soft installation region, less transmission losses and cost when distinguished to the consolidated power generation.(Zhou et al. 2015).The distributed generation is used for micro grid which includes the combined Heat and Power (CHP), fuel cells, wind turbines, photo voltaic (PV), micro turbines. Due to the demand of clean and reliable generation of electricity and because of aging of the centralized infrastructure of power generation requires the innovative and Economical solution. Thus, the distributed and renewable energy generation use increasing rapidly.Distribution energy resources (DER) is the combination of the distribution generation and the storage devices. Mostly, DER system use the inverter to convert the generated energy into AC power. Micro grid operation is supported by the inverter using the voltage and frequency control.(Henry and Janzén 2006)
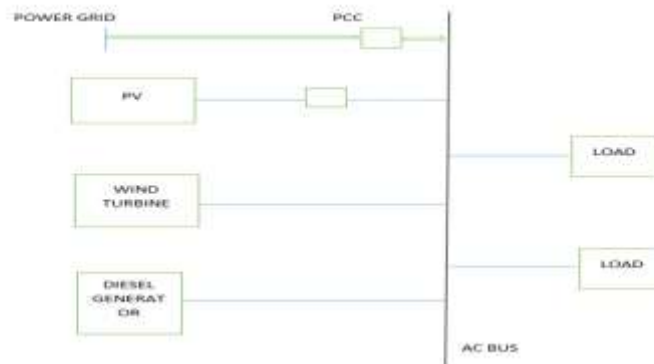

2 Demand Side Management Electrical power can't be stocked at an extent level. So, a equity between requirement and supply has to be maintained. To assure subsistence of supply, the total scope of generation have to be greater than the peak requirement. It is an operation to reduce the energy consumption to the optimum level and to create the new resources for power generation. DSM's main asset is that it is less pricey to logically control a load as compared to construct a new power station or fixing some electric storage equipment. DSM can be in any form like changing of old incandescent light bulbs with the compact fluorescent lights (CFLs) (Palensky and Dietrich 2011). Energy management may be described as the actions taken by the consumers to optimize the energy consumption. It can also be says that how efficiently they use the energy. DSM can be of type like manual,semi-automated,automated(Zaidi, Zia, and Kupzog 2010). DSM can also be explained as the planning, implementation, and monitoring of those utility activities which effect the load shape. The programs used by the utility to implement DSM includes the load management, customer generation,purchasing of highly energy efficient appliances and the other adjustments in market share (Clark W. Gellings 1985).DSM can be explained as the steps taken by the consumers to change the way of consuming electricity.To inspire consumer participation in DSM initiatives,a balance between the utility driven and consumer driven have to make (Srinivasan et al. 2016)

Role of DSM in India: The historic problems of the Indian power sector were been often found to three main issue i.e. high T&D loss due to old electrical equipments, large commercial loss due to poor billing collection or energy theft and low end-use efficiency of energy use specifically in agriculture. The explanations an influence utility in India might undertake DSM include: (a) demand outstripping the potential provide to produce supply, particularly peak supply, (b) improve the income revenues of the utility, (c) improve the standard and reliability of power supply and (d) mitigate the impact of rising tariffs to the sponsored customers.(Sinha et al. 2011)

History of DSM: DSM may be a field that came into being within the late 1970s.Thatwas not until the 1970s when critics argued that it might be more cost effective to scale back the demand for electricity instead of to extend supply by expanding the generation capacity. Following the oil embargo in 1973 and therefore, the subsequent rise within the electricity delivery service, DSM programs started slowly to seem within the strategic plans of electrical utilities The IEEE PES Load Management working party (WG), which was originally formed as a task force in 1978, disseminated technical knowledge and coordinated activities associated with load management. Later, IEEE activities associated with customer-side programs and policies were attributed to the Customer Services WG which was organized under the facility System Planning & Implementation (PSPI) Committee. Currently, the committee operates through six WGs, one among which is the Integrated Intelligent Customer System Planning (IICSP) WG that considers DSM applications and technologies. Protection fuses were developed within the late 1950s and were installed at the customers' premises to scale back the effect of overloading of electrical equipment Other technologies allow remote of customer loads by the utility through a communication system. Communication technologies for direct load control are: communication via power lines, including ripple systems, power-line carrier, and waveform modification; via the public switched telephone network; radio systems; and via the web. In 1967, the Detroit Edison company pioneered the installation of a unidirectional radio system to remotely control water heaters. Clock based
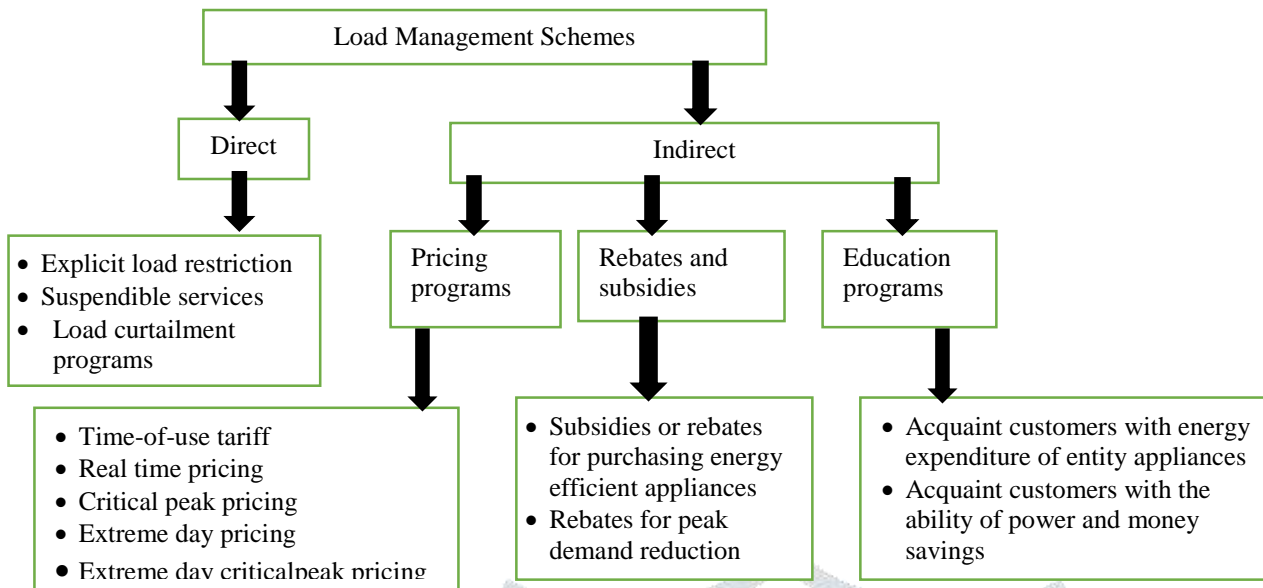
controllers are applied over end-use equipment within the 1970s within the 1980s, electric utilities followed a special approach by minimizing direct control on end-use equipment, and by inducing end-users to regulate own resources through incentives and penalties. Price-based control involves indirect load control within the sort of differentiated tariff structures like Time of Use (ToU), Critical Peak Pricing (CPP) and Real Time Pricing (RTP). Within the 1970s, Automatic load shedding and restoration supported frequency relays was used as an emergency measure, to guard assets from overloading or to command rolling blackouts. One option of applying DSM by controlling grid assets is through voltage regulation. Normal tolerances for voltage regulation through tap changer in transformers are between 0.95 – 1.05 (p.u.) (Lampropoulos, Kling, and Ribeiro 2013). Energy issues first raised within the 1970s put a crimp in this familiar process. Predictable demand and low-cost supply, the prerequisites of traditional electric utility planning, became harder and harder to realize. A key challenge of the 1980s is to integrate traditional supply planning and operation with the emerging concept of actively influencing the demand for electricity i.e. demand-side management. About 300 utilities nationwide already run some 1000 separate projects aimed toward shaping future demand (Clark W. Gellings 1985).Firstly, the term DSM was invented by C.W. Gelling in 1981. DSM includes actions like changing incandescent bulbs with compact fluorescent lights up to installing sophisticated algorithms. Seeing the potential of DSM, researchers have proposed many algorithms and implementation methods. The algorithms in literature are often classified into two broad categories, they are: (i) direct load control (DLC), and (ii) smart pricing (SP) like critical peak pricing, time-of-use pricing, and real-time pricing. To motivate consumer participation in DSM initiatives, there's a requirement to realize a balance between these "utility driven" and "consumer driven" algorithms that implement peak-saving to scale back aggregate load during peak-periods to extend reliability and reduce the energy costs (Srinivasan et al. 2016).

Need & Objectives of DSM: The power sector of India has tripled its production capacity, i.e. 100,000 MW in 2001from 30,000 MW in 1981. Regardless of this improvement, our power structure is continuously seeking to demolish power lacks and low power aspect which continue to deteriorate the sector. In 2014-15, the Northern India actual peak demand deficit was 8.3% and expected to be same in the near future. Installing new power plants are not the feasible solution to remove the gap between supply and demand. To cope with this problem demand side management (DSM) is the viable solution. DSM urges load management on consumer side with respect to time and amount of use so that there is overall reduction in the system peak. Proper execution of DSM activities provides great help in managing balance between demand and supply. Use of Time of day (TOD) tariff is one of the programs under DSM that helps large commercial and industrial consumers to use electricity efficiently.The DSM goal is to lower maximum requirement of electricity and promote energy efficient tasks. To reduce the overconsumption in the electrical network and rebate in the maximum demand can be obtained by using Conservation of Energy and Reduction of load curve. The DSM programs hold the aim of boosting the end use performance to avert/delay the need of new set up of power plant(Gaur 2016).DSM have four categories which are Energy Efficiency (EE), Time of Use (TOU), Demand Response (DR) and Spinning reserve (SR).(Palensky and Dietrich 2011)
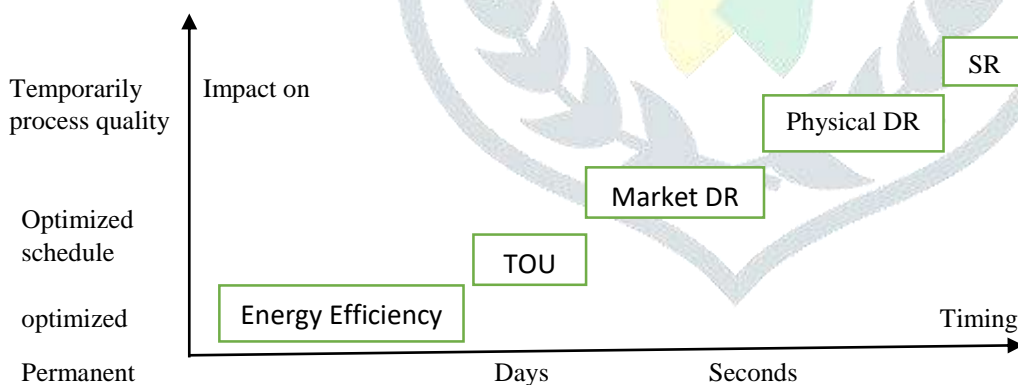

3 DSM Programs and techniques:

1 Energy conservation: - It can be done by the replacement of CFL in place of incandescent lamp and use extra illumination by printing walls with flashing shades and using variable speed drives and by using electronic ballast in place of choke.(Gaur 2016)
2 Direct and Indirect method – Direct method includes the direct load control and activation and deactivation of loads and Indirect method includes various price based programs and subsidies on purchasing of appliances. (Cox and Brown 2016)

Load Management Schemes

Direct

Indirect

- Explicit load restriction
- Suspendible services
- Load curtailment programs

Pricing programs

Rebates and subsidies

Education programs

- Time-of-use tariff
- Real time pricing
- Critical peak pricing
- Extreme day pricing
- Extreme day criticalpeak pricing

- Subsidies or rebates for purchasing energy efficient appliances
- Rebates for peak demand reduction

- Acquaint customers with energy expenditure of entity appliances
- Acquaint customers with the ability of power and money savings

3 DSM in terms of Load Shape Objectives i.e. Peak clipping, Valley filling, Load shifting ,Strategic conservation ,Strategic load growth and Flexible load shape (Clark W. Gellings 1985)

peak clipping

Valley filling

Load shifting

Demand side management

Strategic conservation

Strategic load growth

Flexible load shape
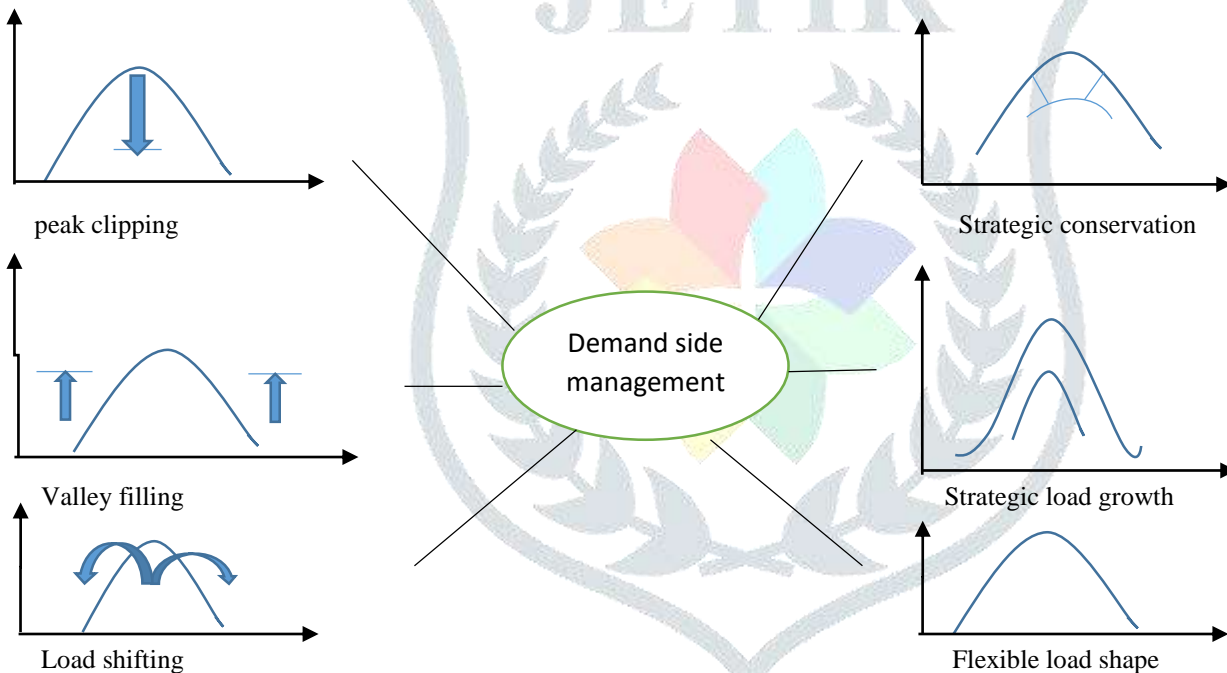
4 DSM by load recognition. In this unessential loads are disconnected from the micro grid. (Zaidi et al. 2010)

5 DSM through Smart meters. In this method ,smart meters are used which stores the actual energy consumption. The web server is also used to track the real time tariffs.(Hemapala and Kulasekera 2012)

6 DSM by Load Scheduling. In this, a device like printers , washing machine etc. is scheduled at a particular time.(Radziszewska and Nahorski 2013)

7 DSM by Switching ON/OFF of energy consuming devices.(Shipman, Gillott, and Naghiyev 2013)

8 DSM Programs like Price based demand response programs i.e. Time of use pricing, Critical peak pricing and Real time pricing and Incentive based demand response programs i.e. Explicit load restriction, Interruptible/ curtail able rates, Demand bidding, Emergency demand response.(Safdarian, Fotuhi-firuzabad, and Lehtonen 2019)

9 Ancillary services market program and Demand bidding/buyback programs(Saad 2016)

4 Optimization Techniques to Implement DSM

Dynamic Programming, Stimulated Annealing, Differential evolution, Abu Search, Langrange Multipliers.(Subramani and Vijayalakshmi 2016),Gradient Based method, Direct search method ,Population based method (Kumari 2016),Optimal power flow (OPF),Load shedding, Economic dispatch, Carbon dioxide emissions reduction, Mixed-integer linear programming (MILP),Non-classic optimization techniques, Niching evolutionary algorithm (NEA),Genetic algorithms (GA), Game theory and

multi-agents, Adaptive search algorithms, Mixed integer nonlinear programming (MINLP)(Vargas-mart, Minchala-avila, and Garza-casta 2015),Ant Colony optimization.(. 2018) and Genetic algorithm.(Jayadev and Swarup 2013)

Benefits & Challenges of DSM: The several benefits of DSM are that we can reduce the consumer's electricity bill by using time of using pricing scheme with load shifting, chances of blackouts are less due to load sharing of power plants, dependency on import of fuel, stress on power house due to distributed generation and reduced load, maintenance of power plant is less and also requirements of installation of new power plants. DSM improves the efficiency of power plant when load is shared.There are some challenges also using DSM which are Less awareness of energy importance and DSM programs, scarcity of the link and trust between utilities and shoppers, scarcity of energy audits and failure in collection of accurate data analysis and experimental work. (Gaur 2016).Also the scarcity of ICT infrastructure and Inappropriate market structure and scarcity of incentives and scarcity of understanding of the benefits of DSM solutions(Strbac 2008)

5 Conclusion: - This literature survey and the studies have given an overall acquaintance of various DSM methods and micro grid and optimization techniques. Various factors related to DSM are also considered. It can be stated that currently DSM has got its deep roots. It is very important part of the power system. The further research on DSM will be helpful in the conservation of energy.

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