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Energy Efficient Load Optimization Techniques for Smart Grid with Futuristic Ideas

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Abstract*: The electrical network that is integrated with Internet of Things and synchronize the data in full duplex mode. The electrical grid is consists the generation, transmission, and distribution unit. A distribution unit is supply the energy to domestic and commercial areas. Our appliances need a rated voltage along with specified frequency. But the present scenario we have facing various type of challenges. Sometime our appliances received voltage from source is less than or greater than by its required rating. To overcome such type complications world requirement a next generation grid which fulfill our requirement as per specified at time of modeling and design of equipment/ machines. The smart grid consists the existing grid along with smart sensors, smart equipment, and real time monitoring & centralized controlling capabilities systems. We have performed a review of several research papers and occurred research gaps are discussed in this paper. This research paper is revealing the existing research gap and propose a solution to overcome occurred limitation.

Keywords: Demand Response, Energy Efficient techniques, Issues with Smart Grid, Smart Grid.

I. INTRODUCTION

The electrical or electric grid is a network of interconnected generation, transmission and distribution units. It supplies the electricity from generation unit to distribution unit. The electric power which is generated in generation unit is stepped up with the help of transformer and transmitted to the distribution unit. The distribution unit again stepped down incoming electric power and supplies the electricity in the usable or suitable format to the consumers.

The electric grid is being upgraded with time and technology since its origins in early 1880s [1].The grid is not following any specific topology. A sole objective for introduce or invention of electric grid is providing the light in night. After invention of electric grid in late 18th century, no doubt the lamps have been replaced with electric lamp. But initially that electric lamp is consuming high voltage and cost is also high. Implementation in field areas is not easy and the biggest issue for implementation in field areas or commercial and domestic areas that is transmission is not possible more than the 2 km. Today is the electrical energy is serving as the major source of power. Source of energy is Solar, Oil, Coal, Gas, Hydrothermal, Geothermal etc. The use of electric power is pollution free but generating electrical energy from Gas, Oil, and Coal is making numerous type of pollution. The solar energy is pollution free and it is renewable but today world need continuous and stable power supply.

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II. TYPES OF POWER BLACKOUTS

Power Blackout: The power blackout is loss of power for a short time period or long time period to a particular area and it is difficult to recover quickly. Blackout is result from power station tripping a circuit. The power blackout is also called the power failure or power cut or power out or power outage [2]. A largest power blackout occurred in 30th July 2012 and 31th July 2012 which affected a population of around 30 Crores and 62 Crores of northern and eastern India respectively [3]. In India on January 2001 also occurred this type power blackout. These two-power blackouts have been the largest power outage in history of India. We need power is uninterrupted and stable for a better life of human as well as devices. The power blackout is major problem in existing electric grid system. If the sudden power loss occurs it will a cause of failure our devices/ smart devices and loss of data.

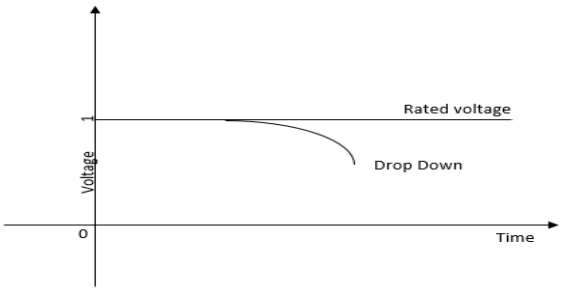

Fig 1: Power Brownout

Power Brownout: The power brownout is not completely loss of power but it is drop the voltage from the rated voltage. It will also affect our devices and instruments[2]. For example, if a person operate switch ON, electric fan on low voltage from its required voltage goes out of order and will not responsible for its assigned duties.

SMART GRID

The Smart Grid is important part of an IoT framework, which can be used to remotely monitor and manage everything from lighting, traffic signs, traffic congestion, parking spaces, road warnings, and early detection of things like power influxes. The Smart Grid complete this using network of transmission lines, Distribution line, smart meters, distribution automation, substations, transformers, sensors, software and more that are distributed to businesses and

homes in the city. A smart grid is an electricity network based on digital technology that is used to supply electricity to consumers via two-way digital communication [6]. The smart grid is actually extended version of existing grid. This system is able to monitor, control and analyze the daily data, communication within supply network which are help to improve the efficiency of the grid.

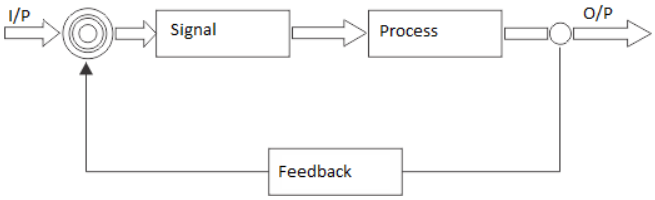

Fig 2: Feedback System of Smart Grid

It is minimizing the theft of electricity and reduce the wastage. It is intelligent two way delivery system from source to sink through the integration of non-conventional energy sources, smart transmission and smart distribution. The smart grid is enabling the real time monitoring and control of the power system as well as it will helps in reduce the aggregate technical and commercial losses.

III. REVIEW LITERATURE

Smart grid is a way towards the next generation grid and need to do more effective for researcher, industries, Public sector undertakings and policy makers etc. Review of literature has been done to keeping in mind the objective of the present study. In this context, some of review of literature discussed as follows:

Barbierato et al (2019) have proposed a distributed framework for real time management and demand side response. The proposed framework consists the three-layer architecture which is integration layer, middle layer and an application layer. This study discusses the EAP software which is providing the services of demand response and demand side management. Further, the study is pointed out the GrAI algorithm which can be embedded into EAP Virtual box and proposed framework [5].

Sajjad khan et al (2019) have introduced an energy efficient scheduling technique. This study has made an attempt on cost minimization and load optimization. In order to implement the proposed technique, MATLAB have used. Further, study perform comparison between the existing and proposed technique [6].

S.M. Shuja et al (2019) have proposed a model for scheduling smart home appliances. A candidate solution updation Algorithm is used to scheduling the load and reduce the cost. In order to implement the proposed model, the simulation is performed in MATLAB. The proposed model is used the metaheuristic technique for optimization. The study discusses various scheduling algorithm like JAYA, Bat algorithm etc. [7].

W.S.Huertas et al (2018) have reviewed the several algorithms for solving integration of microgrid and smart grid problems. Microgrid consists the elements Generation Unit, Distributed Storage Unit, power converter and a control system. This study suggested the Distribution Management system to control, optimize and plan to network's operation as well as design the supply chain. Further study discusses several optimization algorithms i.e. Ant Colony Optimization Algorithm (ACOA), Genetic Algorithm (GA), Particle Swarn Optimization Algorithm (PSOA), Bee Colony Algorithm (BCA), Taboo Search, Meta-Heuristic hybrid method**.** [8].

Abrar et al (2018) have proposed a real time load management using advanced infrastructure metering. The proposed system consists the Xbee, GSM and supported microcontroller. In order to implement the proposed design MATLAB Simulink have used. The proposed model consists the hybrid grid stations. Local control center is introduced for continuously monitor and make the reports at local point. Further, the study analyzes the security of smart grid like theft detection, inter-networking, collection of meter code and messages [9].

Hiwale et al. (2018) have introduced a system for monitor the real time energy. The system reduces the theft of energy. An application is developed for android OS and also developed a webpage which are helpful in absence of android mobile phone or an alternate option for desktop/laptop/tablet users. This system establishes two-way communication and provide an interface to consumer and utilities. Both are able to monitor and control their usage and also information about peak usage time and load. Based on demand of peak load and time, utility can manage the electricity purchase system and balance the nearer station either they deliver or receive the energy [10].

J. wang et al (2017) have discussed the routing algorithms of smart grid. This study playing a vital role for communication, healthy information about operation, control and production management. This study also suggested the smart grid communication needs the analysis for a safe and stable power system. Further they discuss several clustering algorithms and routing algorithms. In this study, overviewed the Leach, Teen, Pegasus, Node independent multipath, link independent multipath, correlated multipath routing algorithm. Further they also discussed the typical multipath routing algorithms like Split multipath routing (SMR), Ad-hoc On Demand Multipath Distance Vector Routing (AODV) algorithms [11].

C. Bharathi et al (2017) have proposed a solution for reduction of load during peak load hours. The proposed solution is for peak clipping, valley filling, load shifting, load reduction, load growth, flexible load shaping. In the proposed framework, Load shifting is done using the heuristic based evolutionary algorithm to minimize the cost. An artificial Neural Network has been trained for identify the load curve pattern-based power usage data from smart meters. This study has been emphasized on management of demand using Genetic Algorithm in Demand Side Management (GA-DSM). In order to implement the proposed solution, MATLAB has been used. Further the study discusses the performance of proposed solution and compared with heuristic based evolutionary algorithm [12].

Park et al (2017) have introduced two energy scheduling algorithms that is semi-automated scheduling and fully automated scheduling algorithm. If the appliances preference is possible then the semi-automated scheduling and if the appliances preference is not possible then the fully automated scheduling algorithm has been used. In order to implement the proposed algorithm, C language and MOSEK 7.1.0.54 has used. The proposed framework is trying to reduce the electricity cost [13].

Swastika et al. (2017) have proposed a design of architecture of IoT based smart home. This study discussed about various factor of IoT and smart grid. Study is try to examine the threat, weakness and vulnerability of IoT based smart grid. Introduce the new features in Supervisory Control and Data Acquisition (SCADA) and integrate with latest technology that helps in improve the existing system. Present study also discusses some key points of network protocol and topology of devices [14].

Chin et al (2017) have presented a survey to highlight the challenges related to IoT based smart grid. This study discusses about the threats, security and energy big data. Security of Big data is very serious issue because it has storage of customer as well as utility data. It has the energy management data such as internal and external grid data. This system able to demonstrate a stealthy blind energy big data attack using a replay mechanism without any information about topology of transmission lines. The data analytics include classification, aggregation, clustering and data mining. Their study proposed an attack system that can detect the bad data and bypass them. The energy big data are helpful for analysis and decision-making technologies [15].

J. klaimi et al (2016) have reviewed several energy management algorithms for smart grid. Their study discusses about energy management requirements Like Demand Response Program, Energy Storage, Depth of Discharge and State of Health. Further they discuss service tools for energy management and multi-agent system. They focused on how a agent is work with sensors and help the system to take an intelligent decision. This study has been also reviewed the Controlling Algorithms and Multi-Agent system with SCADA system in real time. Further study has been comparing the discussed algorithms with the parameters i.e. Use of Multi-Agent System, Use Storage Device, Centralization, Use Prediction Data, Use Negotiation [16].

Abrar (2016) has observed the power cut off and power blackout in India. This study discusses that power blackout, brownout, cut off, power outage is the major threats of power in India. Abrar study also discussed the challenges faced by the Indian power sector. Further the study describes the power failure reason and recent failure analysis. This study has been pointed out various issue which occurs after power failure in India. Further study have been made an attempt to touch all the corners of India in context of power outage and their possible solution. The rest of study suggested the preventative to overcome power cut off and high cost. He also described the smart grid's need, advantage, and how smart grid has been stable themselves in emergencies situation [17].

Atasoy et al. (2015) focused the salient pole of smart cities i.e. smart grid. Without the smart grid the smart city does not exist. This study has discussed about the smart lighting concept, energy storage and integration of electric grid. The further describes the major group of technical implications i.e. load flows, voltage control, fault level, network security. Smart grid is very important pillar for smart city. Storage level are also discussed which is generation level, grid level, customer level [18].

Lee and Bahn (2014) have proposed a Genetic Algorithm Based Power Consumption Framework. The smart building would be installed the non-conventional energy sources Like Solar, Wind Power Generator. The proposed framework integrated with the smart meters and real time pricing of electricity. The proposed algorithm is trying to reduce the cost of electricity. This is the Multi-Core system that can perform Multi-Task on different cores. They compared the proposed framework with Greedy scheduler and original ongoing system. The Greedy scheduler is slightly more than original scheduling system but genetic algorithm based proposed framework is best among them [19].

Satheyamoorthy (2013) has proposed a digital energy meter for collecting the data of energy usages and send to the utility and customer respectively. This system not only reduce the human effort to collect reading via door to door but also reduce the error committed by human. GSM service is used to send information to requesting devices and also same is used to receive request from various nodes. A circuit is designed for continuously monitor the meter reading and send the message to User and utility. This study also presented a mechanism which are monitor and control the power of any home appliance or any grid equipment [20].

Amin and Wollenberg (2005) have narrated about the smart grid and also how the term "Self-Healing" has been come to existence in power grid. This study also discusses about the modern power system programs & problem. The self-healing technology is adopted from the intelligent flight control system. The intelligent flight control system is the conceptual foundation of a self-healing power system. This study has found that a grid operator is similar to a pilot flying the aircraft. Further study has clarified the smart grid is not remove the faulted component. Remove of faulted component has been still job of protection system but smart grid protects the system in time of emergencies in a much faster way and made stable system. Further they suggested that make the power system components act as Plug and Play interconnects. This study has defined that self-healing network using computer agents are much faster than the modern power system [21].

IV. ANALYSIS OF EXISTING WORK

In this section, Discussion is about the existing work and their limitation. An appropriate solution is proposed for next phase which is Implementation. Implementation would be done using various simulation hardware/software. Some of related work are given below:

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Table- I: Limitation and their Proposed Solutions

Publication Year	Title of Paper	Author(s)	Techniques / Tool Used	Research Gaps/ Limitations	Proposed Solution
2019	Energy Efficient Scheduling of Smart Home	S. Khan et al [22].	• Metaheuristic • MATLAB	Cost Reduction is possible.	Integration of energy sources reduce the cost.
2019	A Distributed IoT Infrastructure to Test and Deploy Real-Time Demand Response in Smart Grids	L. Barbierato et al [5].	• Greedy Algorithm	Load is not shift and switch off the appliances.	Shift of load is possible to another available source(s).
2019	Towards Efficient Scheduling of Smart Appliances for Energy Management by Candidate Solution Updation Algorithm in Smart Grid	S. M. Shuja et al [7].	• Metaheuristic • MATLAB	Efficiency of grid is ignored.	Efficiency can be increase with improvement in power factor.
2018	JAYA Optimization Based Energy Management Controller for Smart Grid	O. Samuel et al [6].	• JAYA Algorithm	Cost Reduction is possible.	In future, with the help of integration of energy sources cost can be reduce.
2018	Optimization Algorithms for Solving Microgrid and Smart Grid Integration Problems	W. Sanchez et al [8].	• Genetic Algorithm • Ant Colony Optimization • Meta-heuristic hybrid	Voltage is not stable.	Pre-shifting load analysis is help to stable the voltage.
2018	IoT Based Smart Energy Monitoring	Prashant et al [10].	• Linear Hall Circuit (HLC)	Limit of energy is not defined.	Using limit of energy is able to prevent unwanted usage.
2018	Real Time Smart Grid Load Management By Integrated and Secured Communication	Muhammad Abrar et al [9].	• Metering Network. • MATLAB	No Application found for consumer.	It is possible to make an application for consumer.
2017	Genetic Algorithm Based Demand Side Management for Smart Grid	C. Bharathi et al [12].	• Genetic Algorithm, • MATLAB	Scheduling Mechanism not defined.	Energy sources Integrator with GA-DSM improve the load reduction.
2017	Automated Energy Scheduling Algorithms for Residential Demand Response Systems	L. Park et al [13].	• Energy scheduling algorithms. • MOSEK 7.1.0.54	Optimal value for variable is not consider.	Future research may be find the optimal value for variables.
2017	IoT-based Smart Grid System Design for Smart Home	A. Candra et al [14].	• Network protocols.	Energy consumption is high.	Further Implementation of IoT is reduce the energy consumption.
2016	Energy Management Algorithms in Smart Grids: State of The Art and Emerging Trends	J. Klaimi et al [16].	• Energy Management algorithms	Lack of integration of power production system.	Energy source integrator overcome such type problem.

2014	A Genetic Algorithm Based Power Consumption Scheduling in Smart Grid Buildings	Eunji Lee and Hyokyung [19]	• Genetic Algorithm, • Greedy Scheduling Algorithm.	Efficiency parameter is not considered.	Efficiency can be increase with improvement in power factor.

V. RESULT AND DISCUSSION

The above table is indicate that the research gaps and their proposed solution. A genetic algorithm is used to find the optimal or fitness function for the next iteration. At present, We have many energy sources and need to integrate them all . A solar energy is help in the day time for providing energy. Solar panel which is able to convert solar radiation to electrical energy associated with respective hardware or appliances. The proposed solution is realistic and a helping hand for future work. An implementation of proposed solution is leading towards the power factor of smart grid and efficiency of smart grid. The table -1 is shows that the last decade work and Used techniques and implementation tools/software. MATLAB most frequent used for implantation. A load optimization framework's optimization techniques and Implementation tools revealed from their study. The load optimization framework directly affect the grid efficiency and equipment health.

VI. CONCLUSION AND FUTURE WORK

A demand side management is very important. The user able to control and monitor their appliances real time. User might be able to decide and deals real time pricing and energy management system. The meta-heuristic technique is mostly used for the optimization framework. Greedy algorithm, Ant Colony Optimization, Meta-heuristic hybrid, network protocol, linear hall circuits used by them mostly. Integration of energy sources fulfill a healthy way to fulfill the demand of power. We have several paper analyzed and discussed their impacts and relative parameters along with latest technology. In Future, it is possible to include more research papers and implement the proposed solution.

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