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Load Optimization Framework for Smart Grid: A Systematic Review

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ABSTRACT
A smart grid is an extended version of the existing electric grid. The smart grid technology consists of the smart equipment of Substation and Generation unit Smart grid will take us towards the smart India digital India. Smart Power Grid growth is slow in India but it is definitely going towards the digital power in India. Smart Grid have been minimizing the faults and operating time by using the advanced control and communication system. It is also a helping hand for improve the quality of power and efficiency of machines. It is also associated with advanced metering infrastructure (AMI) for phasor measurement. The smart grid's main objective is to deliver the power without occurs brownout, blackout with low cost and high efficiency. Smart Grid is also important pillar for smart cities in India. The Smart Grid is a necessary enabler for a prosperous society in the future. This paper is revealing the research gaps and proposes possible solutions.
Keywords — Smart grid, AMI, Demand Response, Demand side load Management, Optimization Framework, IoT based Grid.

I. INTRODUCTION

The grid refers to electrical grid which is consist of generation, transmission. The existing grid is unidirectional communication in nature but the smart grid is two way or bidirectional communication system integrated with sensors, actuator and other measuring unit. The smart grid is self-healing, efficient and reduce the aggregate technical loss When you plug-in and flip on your light switch or Switch on your computer it's all working as per defined manner and required supply is from our electric grid. Our electric grid was set up

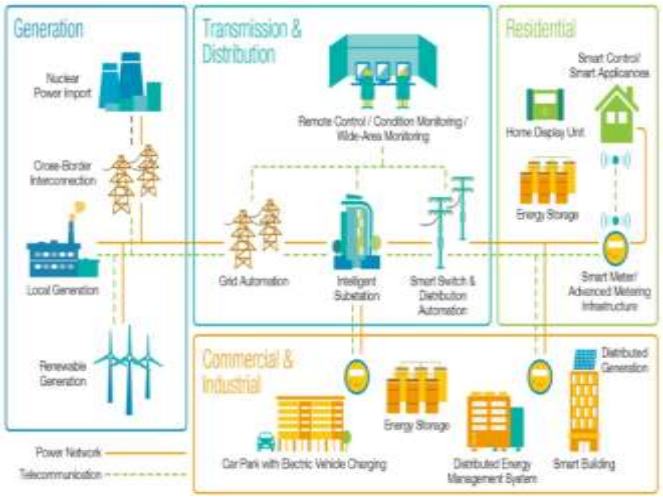

Fig 1: Smart Grid[20]

in1890s and upgrade technology with each decade [13].

A stable and rated power is improving the health of devices /equipment. The smart grid is integrated with internet of things and conventional and non-conventional energy sources.

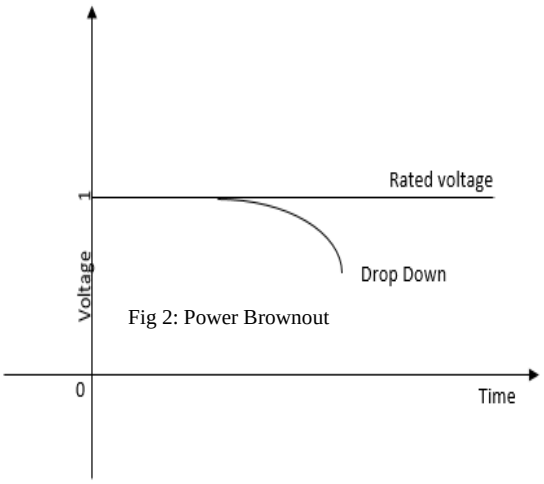

Fig 2: Power Brownout

A stable power supply is required for our devices/appliances. A power brownout is a threat for our devices which leads to damage or loss of data. The smart grid will be able to do two-way communication and easy to track the fault and able to protect the system, also connected with all the relay and a database of the employees. After occurring the signal from the fault section, a relay generates a signal for the trip to circuit and also send a message to mobile phone related to employee. To move next generation, we must be upgrade of our grid and an old technology that is built for only just handles with current system and static frequency. A smart grid will be automated and manage the increasing complexity and needs of electricity in the

21st Century.

II. SMART GRID TECHNOLOGY

An electrical network working with digital communication and able to do two-way communication is referred as smart grid.

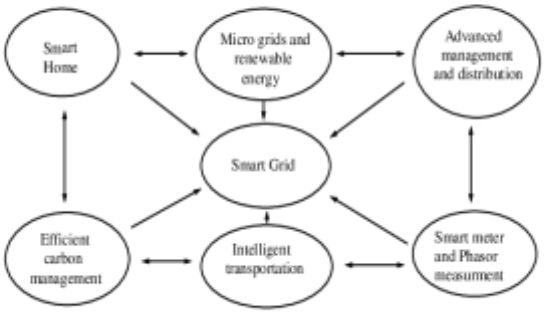

Fig 3: Working principle Smart Grid Technology [13]

A smart grid has capable integrated various distributed sources such as wind turbines, solar system etc.

Smart Grid Components

Components of smart grid is given below in the form of table.

Table 1: components of smart grid

Sr. No.	Components
1	Intelligent Appliances
2	Smart Power Meters
3	Smart Substations
4	Super Conducting Cables
5	Integrated communications

Integration of all component produce a smart grid and make the power continuous and stable.

Need of Smart Grid

After the analysis of given table is shows that the need of smart grid.

Table 2: Need of smart grid

Sr. No	Factors	Performance	
		Smart Grid	Existing Grid
1.	Transmission	Efficient	Less Efficient
2.	Restoration	Fast	Slow and manual
3.	Costs for utilities	Reduced	High
4.	Peak Demand	Reduced	--
5.	Integration of large-scale	High	Low
6.	Integration of customer-owner power generation systems	Batter	Poor
7.	Security	High	Poor

Hardware Requirements

Programmable Micro-controller, Smart Energy Meter, Active components and passive components

Energy Meter Reading via internet

Internet of things based smart energy meter is display the consumed units and cost for consumption, via internet it is able to make chart and as well suitable and readable format. We had taken a digital energy meter interfaced to a microcontroller of 8051 families. The sensor gives a signal to the microcontroller, at each pulse meter shows a flash or refresh the data.

Through an LDR. Per 1 unit, The blinking LED flashes 3200 times [15]. The sensor gives an interrupt to the programmed microcontroller, at each time of the meter LED flashes.

The microcontroller takes this reading and displays it on an LCD duly interfaced to the microcontroller.

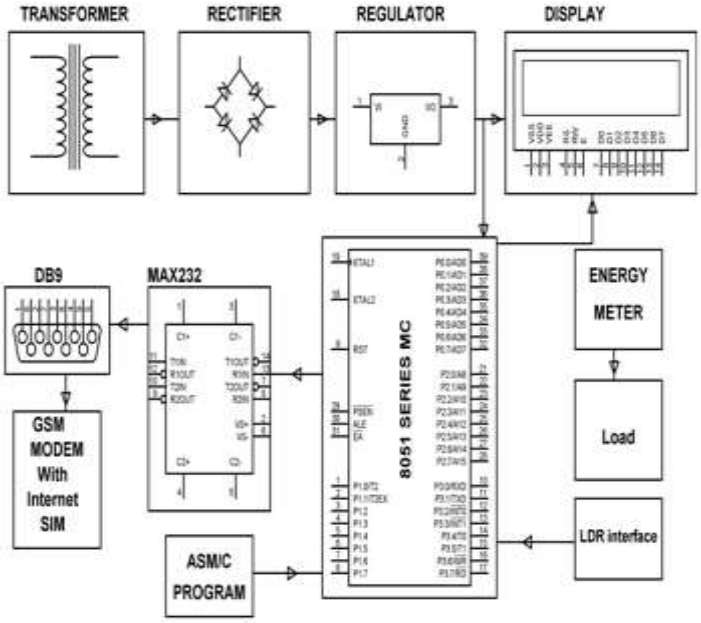

Fig 4: Smart Energy Meter [18]

This reading of the energy meter is also sent to a GSM modem being fed by the microcontroller via level shifter IC and internet [16]. A SIM used in the modem being internet enabled transmits the data directly to a website for collect and display or to the customer mobile phone, anywhere in the world in multi-level graphical format.

III. TESTING THE SMART GRID

The Smart Grid will consist of millions of pieces and parts—controls, computers, power lines, and new technologies and equipment. It will take some time for all the technologies to be perfected, installed equipment, and systems are tested before use it. And it won't happen all at once—the Smart Grid is evolving, piece by piece, over the next decade or so. Once mature, the Smart Grid will likely bring the same kind of transformation that the Internet has already brought to the way we live, work, play, and learn.

Testing is important for software as well as hardware. Is it follow the instruction or not. The software testing is an investigation about the product performance and quality.

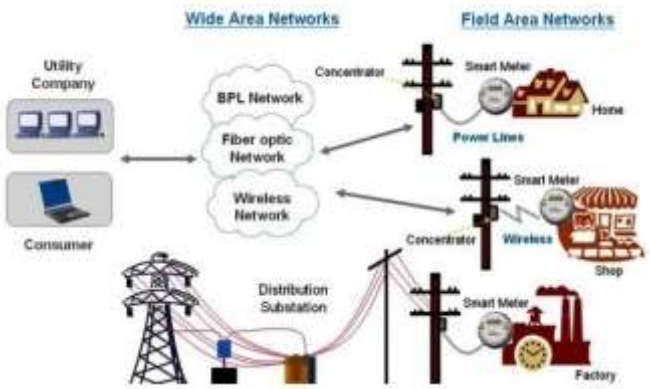

Fig 5: Testing Smart Grid [19]

It is initiated at early stage of software development cycle. The software testing i.e. Unit testing, system testing, interface, regression, alpha, beta etc.

IV. RELATED WORK

This section describes the existing ongoing IoT application and their requirement. This section also reveals the ongoing research of smart grid and their performance. We had studied many of research papers and some of them are enlists below:

Hudedmani et al. (2019) [3] have proposed IoT based smart energy meter for smart grid. It is a management system for power consumption. The proposed system eliminates the limitations of existing energy meter. It is also providing the information about the tempering of meter and theft of energy. The energy management is essential in smart building and smart home. The proposed system is cost effective because new features are added in existing system. It is implemented using Arduino Uno microcontroller include current and voltage sensors. The proposed system is able to control the appliances via internet from anywhere.

Pujari (2018) [6] has proposed an IoT based monitoring and controlling system. This study is focused on calculate consumed units bill and maintain the previous data. In order to implement proposed system Arduino Nano microcontroller ATMEGA328 has used. Which are able to maintain 8-bit data size and operating range will be 3.3 v to 5 v. A wi-fi and buzzer is used for wireless communication and alarm purpose respectively. The proposed system provides an interface to disconnect the connection remotely if bill is not get paid within stipulated time.

Sahani et al. (2017) [9] have proposed IoT based energy meter. This system is reduced manpower and energy wastage. In order implement the proposed system Arduino Uno microcontroller, GSM and wi-fi has used. A signal conditioner circuit used for maintain microcontroller required voltage level. The meter synchronizes all information i.e. reading, usage etc. on the webpage. A threshold value is required for usage notification. For increasing or decreasing in threshold value two button forward and reverse are provided. The proposed system sends the information to the user as well as supplier.

Sidid, D. & Gaur, S. (2017) [10] have introduced an automatic system integrated with IoT. Which is able to monitor temperature, pressure etc. In this study basically focused on home automation applications and synchronizing process with smart grid server. Monitoring and controlling of

home appliances using this system is a simple easy task. The Proposed system defined the three levels of user interface which is Registered, unregistered and administration user. They found that the comparative analysis between SCADA system and proposed system shows that the proposed system is better than SCADA system. SCADA system are also automatic control and monitoring system which is used in power system for last many decades.

Visalatchi, S. & Kamal, S.K. (2017) [11] have proposed a smart energy meter and control module for the theft of energy using Arduino and GSM technology. This study focused on energy meter which are able to display the information about the usage of energy and also able to determine steps of theft of energy or tempering the meter. It is also send the complete log file to remote device. This smart meter designed on various parameters i.e. power factor, active / reactive and consumed power. The proposed system is able to communicate with wireless data protocol. It is a vital step of prevention the theft of energy.

Raut et al. (2016) [8] have presented an integrated approach of Internet of Things and smart grid. The smart grid is basically automatic system for monitoring and control of power. It is communicating between utility and consumers. The present study has also suggested the way of prevention of theft of energy. The grid is energy delivery system and this study also try to design a system which integrate old grid and IoT for improve the efficiency and power quality of existing grid. Present study has pointed out the basic features, advantages of smart grid.

Dimple Rani et al (2016) [7] have proposed an intelligent fault detection system which can sense the fault and send the email to registered e-mail ID. The proposed system divided into two unit that is Hitchhiker (vehicle Unit) and fault sensing unit. Hitchhiker unit working with the Raspberry pi but sensing unit is working with the Arduino Uno. The Proteus simulation software has been used for implement of proposed work. The proposed approach has trying to reduce the cost and eliminate the human effort to make the system more stable.

Zavoda et al. (2013) [12] have proposed a universal controller for smart grid which is able to control various type of services. Smart Distribution is introduced which is integration of geographic information system (GIS), Outage Management System (OMS) and Distribution Management System (DMS). This study discussed about a universal feeder level controller that allows the remote control, monitor and operate of feeder through application. The smart distribution applications like Fault Location (FL), Power Quality Monitoring (PQM), Underground Grid Monitoring and Control, Power Flow Control and Peak load management etc.

V. ANALYSIS OF EXISTING WORK

Sr. No	Title of Paper	Author(s)	Techniques / Tool Used	Limitations
1	IoT Based Smart Energy Meter for Smart Grid Applications	Hudedmani et al. (2019) [3]	Arduino controller associated with Wi-Fi, GSM etc.	Error in time of energy consumption occurs.
2	IoT Based Energy Meter	Jayaprakash. (2018) [4]	Atmega 328	No real time data. No remote connection. No encryption and decryption.
3	IoT Based Smart Energy Monitoring	Prashant et al. (2018) [5]	Linear Hall Circuit (HLC)	Limit of energy is not defined.
4	IoT based smart energy meter monitoring and controlling system	Pujari. (2018) [6]	Arduino nano ATMEGA328 associated with Wi-Fi, GSM and 3v to 5v.	Data is not collecting automatically by server. It need to synchronize manually or use by administrator.
5	Smart Energy Meter Using Arduino and GSM	Chaudhari et al. (2017) [2]	Arduino Uno with GSM module and Real Time Clock(RTC).	Long procedure to convert the analog data (Analog--Electromagnetic meter—Digital data) into Digital data.

Table 3: Analysis of existing work **Source:** Compiled by author.

Sr. No	Title of Paper	Author(s)	Techniques / Tool Used	Limitations
6	IoT Based Smart Energy	Sahani et al. (2017)	Arduino controller associated	Provided interface use only a

	Meter	[9]	with Wi-Fi, GSM etc.	single attribute for remote access it will be opportunity for hacker.
7	Smart Grid Building Automation Based on Internet of Things	Sidid & Gaur (2017) [10]	PIC microcontroller with smart plug and sensors	System congestion is possible due to heavy sensor and actuator data transmission.
8	Smart Energy Metering and Power Theft Control using Arduino & GSM	S Visalatchi & Kamal. (2017) [11]	Arduino Uno associated with GSM and other sensing element.	Power quality is not stable.
9	Measurement and Fault Detection in Intelligent Wireless System using Wireless Devices	Rani et al. (2016) [7]	Hitchhiker, Fault sensing, Proteus	Manpower is need to monitor the data and location of fault.
10	Internet of Things(IOT) Based Smart Grid	Raut et al. (2016) [8]	Atmega328 controller Tools: Pub Nub, FreeBoard.io	Meter Tempering possible. Less Efficiency
11	Universal Controller for Smart Grid	Zavoda et al. (2013) [12]	Programmable integrated controller	Operating frequency mismatch.

Table 3: Analysis of existing work **Source:** Compiled by author.

During literature survey we have found various research gap and limitations of existing proposed algorithms/techniques. The above table is indicating the research gaps of research paper and proposed solution column is indicating the solution of respective problem/paper.

VI. CONCLUSION

The existing technology is only one-way communication it is like open loop control system which are no responsible for end user got the right thing or not. It is similar to an open-loop control system but another hand, the smart grid is like the closed-loop system. The smart grid is responsible for the distribution of the rated voltage. It helps to stabilize the system. It is a next-generation system integrated with the smart environment. The above study has discussed the research gaps which are occurred during the literature survey. Moreover, the above study recommended a possible solution to win the occurred problem. In the future, it may be extended as more research papers and implement their proposed solution.

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