Review of internet of things: distributed power in smart grid

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Abstract— Emerging technologies in the field of power sector are Artificial Intelligence and Information Technology. Electrical network is very complex and Far-reaching, the data that coming from the generation, transmission or from the distribution is abundant and needs to be processed for better efficiency and reliability. To achieve higher efficiency power grids are incorporating newer technologies and are adapting. Internet of Thing (IOT) is a modernized technology that can be used to collect the data or to monitor the physical components under the radar of the grids. This paper deliberates the use of modern technology in the smart grids to improvise the reliability and working efficiency. The concept of Distributed generation and the utilization of IOT in such scenario is discussed in this paper.

Keywords— Internet of Things (IOT), Distributed Generation (DG), Information Technology (IT)

1. Introduction

Existing power grids has to be upgraded so that it can adapt to the changes during increasing power demands, power outages, new requirements and self-healing. In order to upgrade the existing power grids, the grid architecture has to be restructured. This is done by IOT vision \cite{1}.

We are living in 21\textsuperscript{st} century and our power grids are 5 decade older. It is very much essential to upgrade the existing grids to new changes. This change we can call as smart grids which can adapt to change and self-sustained ones. These smart grids address so many shortcomings in the traditional grids. There are so many technologies available around the grid upgradation, SCADA is well proven one among them. Scada is limited to substations and above. The distribution side is controlled by DCS. IOT enabled smart grids provides better and reliable power and it proves to be more efficient than the traditional ones. It can be implemented along with SCADA and DCS which enables faster response from the distribution side also \cite{2}.

As the concept of smart grid come in to picture, many power companies are trying to introduce the concept of IOT as an enabling technology. So that each device in the grid can be considered as a connected object. Every smart grid incorporates various devices and sensors so that they can communicate autonomously with the grid infrastructure easily. Power disturbances, outages due to equipment failure, power constraints and other problems can be avoided by the help of IOT technologies. There are so many technologies available for communication in the smart grids so far. Major communication channels are classified as wired and wireless communication technology. When it comes to wired communication technology, fiber optical, DCS (Digital Scriber Line) and power line communication (PLC) are the best wired technology. Wireless technology such as WLAN, WiMAX is used now a day \cite{3}.

The rest of the paper is organized as: Section II overviews of the Smart grid technology and initiation of Smart grid in India along with the features of Smart grid. Section III gives overview of IOT and
definitions. Section IV deals with the role of IOT in Smart grid. Section V gives brief about Challenges for IOT based Smart grid.

2. Smart grid

Smart grids are nothing but more reliable, high efficiency, high quality, quick responsive and self-sustainable [4]. Smart grids play an important role in the development of the modern cities which we call as smart cities. Not just being efficient in transmitting the power but also reduces the carbon emission from energy saver. Which intern supports the economic development [5].

Energy and power industries are transforming in this 21st century. This transformation is because of the growing demand, reliability, sustainability and efficiency in power transfer capabilities. This is because of the growing population, digitalization and the lifestyle. Integration of the traditional grids with the advanced information technology to data handling and data analysis, to make it more responsive is nothing but smart grid. This advancement in the tradition grids comes with lots of benefits to the energy market including both consumers and the companies.

Smart grid is exposed to a greater number of problems, because of their cyber-physical nature. These attacks/problems occur at the physical entry points, Network places and communication points, causing serious problems on the operation of the grids. Integration of the smart grid with the information technology and the communication channels improves the reliability and efficiency of the power generation, transmission and distribution. Smart grid combines the network information with the renewable energy resources, to reduce the losses and minimize the power consumption from the suppliers [6].

Smart grid initiation in India was started in 2012 by Ministry of Power. Initially 12 pilot projects were sanctioned under smart grid initiation, later four full smart grid projects were sanctioned in 2016 [7]. Chamundeshwari Electrical Power supply Company, Mysore is one among these pilot Project and is completed under Smart Grid mission. It was awarded on march 2014 with a sanctioned cost of 5.05 million US$. Enzen is the agency that took this project for implementation. This grid is having a consumer base of about 2184.

2.1 Smart grid benefits

Utilization of the resources effectively to increase the efficiency of the grid and manages the distributed generation effectively to optimize the energy consumption and provides two-way communication between the grid and the consumer. Figure 1 gives the overview of smart grid in full pledged system [8].

![Figure 1: Smart Grid Overview](image-url)
2.2 Smart grids initiation in several countries.

Clean energy ministerial (CEM) came up with international smart grid action network (ISGAN). The main aim is to create a platform to support smoother, cleaner and flexible energy around the world. Few countries have taken initiatives towards smart grid. India, US, Sweden, Italy are the leading CEM Members. CEM member participate are: Australia, china, Canada, Denmark, European commission, Finland, French, Germany, Japan, Mexico, Netherland, Norway, Russia, south Africa, Spain, Korea, United Kingdom. Austria, Belgium, Island, Singapore and Switzerland are the Non-CEM members. Brazil and morocco are considered as observes to the initiative [9].

3. Internet of Things (IOT)

Internet of things (IOT) is the latest trend in computer system and electronic engineering. Whereas enhancing the reliability of the grid being the greatest challenge of power engineering. To make the existing grids more reliable and quick responsive we can incorporate the existing grids with the IOT. Today we are having power line communication system where we can transmit data over the AC electric power transmission. Which results in data logging and communication between the devices connected in the power system. The devices connected which communicate to exchange data for cooperating the smooth operation concept known as internet of thing. It is the interconnection of physical things which are self sustained through internet [10]. Physical devices are connected over internet which includes passive sensors as well as actuators that collect, analyze and exchange data over the internet, referred as internet of things (IOT) [11].

The word (IOT) internet of things was first proposed by Kevin ashton in 1999, even before that also there were smart appliances which were using sensors and communication lines to internet. Information science and communication engineering being the back bone for modern power grid where data logging and controlling is done through these technologies. IOT based power distribution is shown in figure 2 [13]. IOT plays an important role in building smart grids. IOT is not just hardware components connected to perform a task nor just software that contain some coding in it. It is a combination of both hardware and software technologies which integrate information science and communication engineering [5].

![IOT based Power distribution](image)

IOT has ability to increase the reliability of the system also it has potential to raise the standards of the system by making it more accountable and efficient [14]. IOT provides a platform to interconnect device which enables person to machine (P to M) or machine to machine (M to M) interaction [15].
4. Role of IOT in Smart Grids

We can’t always rely on the centralized data, which takes a lot of time to gather and analyze. If the data is logged locally, then the accuracy of the data is more, and the same can be communicated with the existing SCADA systems. IOT provides such a platform to gather the data locally and to process it wirelessly. To do so, communication channels need to be good, and information technology and data analysis are major concerns in this regard. Most of the modern grids are connected to distributed generation, this data has to be logged and processed so that the stability of the system is not affected [16].

![Flowchart of data collection using IOT](image)

Above Flowchart in figure 3, validates the consumer load data and verifies the data for variations and if there is no variation, it saves the data to the cloud. If there is an error in the data, the data is cross-verified and will be updated. These data are fetched over the internet using sensors at the consumer base. If there is any variation of load or power factor at the consumer end or there is any fault at the consumer base, it is made to inform the consumer about the same using SMS or mailing the consumer about the variation in the data. Flowchart for the same is shown in figure 4.
5. IOT in distributed power generation

Distributed generation is a concept where even a consumer can generate power. Excess power generated can be fed back to the grid. Basic parameters that are discussed in this content are load power ($P_D$), power loss ($P_L$), power generated ($P_G$), and distributed power generated ($P_{GD}$). Basic calculations regarding these are shown below.

Generated power is always equal to the load power and line losses and is given by

$$P_G = P_D + P_L$$  \hspace{1cm} (1)

If distributed generation is also taken into consideration then the equation becomes

$$P_G + P_{GD} = P_D + P_L$$  \hspace{1cm} (2)

If power generated by DG’s is sufficient to power the loads near to the DG’s then the equation becomes

$$P_{GD} = P_D + P_L$$  \hspace{1cm} (3)

In these cases we can’t stop the generation. In such cases we can say the generation is set to hot reserve. Sudden increase in load can be shared by $P_G$ and $P_{GD}$ whenever necessary. The flow chart for the same is shown below.
6. Challenges for IOT based smart grid

IOT is the booming technology in the context of Smart grid, which may lead to disasters. Smart grid being the critical infrastructure in the present days as our lifestyle is totally depends on energy market. Cyber-attacks can happen on smart grid, since it is monitored and controlled over internet, few depends on public communication infrastructure. The damage may lead to affect the financial aspects of the utility also cause equipment damage [17]. Change in power industry is guided by the penetration of distributed generation and renewable energy resources. Due to the increasing electricity demand, the production and electricity management has to be taken care. This results in local electric companies and entrepreneurs at distribution level. This creates lots of opportunities and also challenges to the system efficiency and reliability.

| Sl. No | Challenges                        | Solution to challenge                |
|-------|-----------------------------------|--------------------------------------|
| 1     | Energy supply for IOT devices     | Use of renewable energy              |
| 2     | Data management                   | Dynamic servers and storage devices  |
| 3     | Big data                          | Volume, Velocity, Acceleration and Diversity |
| 4     | Uniform standard                  | Communication standards 6LoWPAN       |
| 5     | Security                          | 4-level security architecture¹       |

¹ Z Davood-Beni, N Sheini-Shahvand, H Shahnazadeh, M Mouazam, M Shaneh and G B Gharehpetian, 2019 “Application of IOT in smart grid: challenges and solutions” 5th ICSPIS Shahrood Iran, pp. 1-8.

Concept of smart grid attracts lots of energy industries creating opportunities. This transformation is critical to carry out improvements in the existing grids like testing, information changing, consumer education to make more reliable and accessible [18].
7. Conclusion
Distributed power generation solving many power problems, but managing the power distribution is a major task in grid side. IOT can be used to overcome such problems. Incorporating the technologies like Internet of Things(IOT) to smart grids will increase the reliability of the system. Literature on the recent trends was reviewed in smart grid technology. Information plays a major role in present world and by using IOT as a platform we can gather lot of information from the consumer base and can utilize it for the betterment of the society. This paper briefs about the smart grid technology and what’s the role of IOT in smart grid technology for distributed power generation.

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