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Internet of Things in Smart Power Grids

Introduction

The rapid development of Technology has led to vast change in energy field, giving us the concept of smart power grids. The evolution of traditional power grids into smart power grids has vastly changed the way electricity is produced, distributed, and consumed. This is mainly due to IoT based devices enabling Real time monitoring, fast processing, Efficiency improvement, Integration with control systems, Enhanced decision-making and many more. This way smart grids have a clear advantage over traditional grids. Nowadays, IOT has played a critical role in bringing in a new era of efficient, sustainable energy management. This brought huge benefits to both consumers and utility companies.

Disadvantages Of Traditional Power Grids

Traditional power grids designed decades ago cannot handle the complexities of modern energy demands. The complexity of today's energy demands is too much for conventional power networks that were built decades ago. So, what was the solution due to rapid rise of technology experts integrated IoT into power grids for energy demand of this modern time. Moreover, the seamless integration of renewable energy sources into power networks is made possible by IoT technology. In review of the work, it can be seen that expert and practitioners very much appreciate power utilization of smart power grids. Furthermore, integration of IoT technology allows smooth operation of renewable power sources into power grids. This was not possible in Traditional power grids. As, Solar panels, wind turbines and other power sources are used more it poses a challenge to stability of traditional power grids, but smart power grids can adjust and balance the distribution of energy from different sources, giving us a reliable

Impact Of Internet of Things in Smart Grids

IoT has a huge impact on smart grids as it enhances the efficiency, sustainability, and reliability of electricity power systems. Some ways how IoT has influenced smart grids are Real Time Monitoring in which various component of power grids such as transformers are constantly monitored to identify and address issue promptly, another way is Grid Optimization which works when sensors on transformer can detect changes in temperature or load, allowing technicians for maintenance, next way is Demand Response where programs prompts for the users to change their energy consumption during peak period alleviating pressure on grids, next one is Fault Detection and Self-Healing in which smart grids can detect faults or disruption in system through IoT sensors, another one is Cybersecurity as the connection between power grids become more interconnected there may be compromise in system security by unauthorized access . Cybersecurity prevents this from happening, last but not least is Customer Engagement by providing customers their real time information about energy consumption. This increased awareness can help in saving power source and lead to sustainable development.

Component of Smart Power Grids

Smart power grids requires 3 kind of component to work. They are Measurement and Control devices, Networking and Computation Devices, and IoT applications. They use Measurement and Control Devices which is various kind of sensors for measuring electrical supply and usage. They provide this information to Computation Devices which computes the most efficient way to deliver power to the customer. These are adjusted by control devices as needed for optimum use. Finally, the information is provided to IoT application that are used by grid workers and customers through the network devices. This process can be changed as per needed depending on the requirement of population that depend on electrical grids for their energy supply.

Smart Grid Architecture

There are three kinds of smart grid architectures. They are

- ❑ Conceptual model
- ❑ Electrical network
- ❑ Communication network

Conceptual Model of Smart Power Grids

Smart grids are new era cutting edge technology which can intellectually integrate the action of all costumers connected to it in order to effectively deliver sustainable, economic and secure electric supply. In my research smart grids are large system of systems. According to Smart Grid Interoperability Standards Roadmap proposed by NIST the American National Institute of Standards and Technology, the conceptual architecture for smart grid is composed of seven big domains. They are Bulk Generation, Transmission, Distribution, Customers, Operations, Markets and Service Providers. All of these domains have inter and intra domain communication. The consumer domain is the user of electricity domain such as domestic, industrial, commercial or utilities. Market domain refers to power market operators. Operation domain deal with power supply management. Service provider points to service utilities companies providing customers with electrical power. Bulk Generation, Transmission and Distribution refers to generation, storage, transmission, and distribution of power to customers. One of the key elements for success of smart grids is the interconnection of Seven domains.

Electrical Network of Smart Power Grids

According to the research on Electrical Network it is divided into three big domains. They are Production Domain, Transmission Domain, and Distribution Domain. Production Domain is a domain where electricity is produced from various sources such as nuclear, solar, coal, wind, or hydro power plant. Power plants convert different kind of energy into electrical energy to meet the demand of customers. In this area, the energy mix composition is determined by a number of factors such as geographical location, resource availability, environmental considerations, and energy policies. The transmission domain is a domain where produced electricity is delivered to the customers for their day-to-day life. It is transported over long distance where it is needed. It consists of a network of power lines, substations and network operating systems that control the flow of electricity. This infrastructure operates at high voltage to minimize the loss of energy during long distance transmission. Distribution Domain is the final domain before electricity reaches to residentials areas of the customers, rural farms, metropolitan area, and industrial zones. Here, transformers, distribution lines and substation ensure electricity is reached safely to every consumer. It is made to handle different loads and work in different kinds of environments.

Communication Network of Smart Power Grids

Wired, wireless, and hybrid network technologies are only a few of the many communication methods used in smart grid systems. Four Different kind of Communication network are:

- Home Area Network (HAN)
- Neighborhood Area Network (NAN)
- Field Area Network (FAN)
- Wide Area Network (WAN)

Home Area Network

IT is Client-Domain Network. It covers appliances and smart gadgets for the house. IEDs use residential gateways or smart home meters to relay data readings over HAN to AMI applications. The home energy management system (HEMS), which enables users to view household power use in real time, is a crucial part of the HAN. When used in commercial or industrial settings, BAN, and IAN networks, respectively, refer to HAN parallel networks. It uses Wireless technology: 6LowPan, ZigBee.

Neighborhood Area Network

It is a Distribution domain network. It is Mesh of smart meters. NAN connects the AMI applications access point to smart meters in customer domain and various gateways in the distribution domain. Main purpose of this network is data collection from smart meter for monitoring and control. It uses Wireless-ZigBee, 6LowPan, WiMAX, LTE, 3G and 4G. Wired -PLC and Ethernet.

Field Area Network

It is a Distribution domain network. FAN includes power line monitors, breaker controllers, voltage regulators, capacitor bank controllers, recloser controllers, transformers, data collectors, etc. These are used to response automatically when detecting any abnormalities and failure. Enables mobile workers to access field devices using their laptops, tablets, or hand-held equipment. Wireless - WiMAX, LTE, 3G and 4G and wired - PLC and Ethernet could be used for FAN.

Wide Area Network

It is composed of two types of networks backhaul and core network. Core network offers connectivity between substations and utility systems. Backhaul network connects the NAN network to the core network. A variety of technologies such as WiMAX, 4G, and PLC could be used in WAN networks. Also, virtual technologies like MPLS could be used for the core network. It affords communications systems between smart grid & core utility system

ZigBee

ZigBee is the most popular and low cost , low power mesh networking standard available in market right now. It is most personally used for personal or home area

network or network that operate over very long distance. There are lot of benefits of ZigBee one of it is that nodes can stay in sleep mode most of the time, which extent a lot of battery life. Additional mechanism is required for communicating with other protocols, which means it cannot communicate normally.

6LoWPAN

6LoWPAN makes it possible for even the tiniest devices with constrained computing power to send data wirelessly over the internet. It is ZigBee's most recent rival. Engineers thought that the tiniest devices were being left out of the Internet of Things, which is why the concept was conceived. Using an IP network link such as Wi-Fi, 6LoWPAN may interact with 802.15.4 devices in addition to other kinds of devices.

Challenges Of Implementing Smart Power Grids

There are countless problems in implementing Smart Grids. As we implement millions of devices for smart grids each of these devices could be a target for hackers, being a major national level security threat. One great example is of Ukraine in 2015. Ukraine attack is a great example, this may be a shoert attack but next one might not be so short. The first-ever cyberattack on a power system occurred in Ukraine. Prykarpattya Oblenergo reported a total of 27 substation outages, resulting in total darkness in 103 cities and partial effects on another 186. Concurrently, a phone denial-of-service assault rendered contact centers inoperable, hindering the reporting of blackouts. The fact that control centers were hacked for more than two months, despite the speedy restoration of electricity, highlights how sophisticated and persistent the cyberattack on Ukraine's energy system was. Many sensors must be used to use IoT enabled Local grid, which provides a large amount of data. There are a lot of problems in maintaining this data and also storing it. It is also difficult to maintain operability between different networks properly and it's a critical concern for smart grid deployment. Solving these challenges is necessary for seamless operation and facilizing effective energy management.

Conclusion

The development of smart grids in inevitable and IoT is most important factor for its promotion. By utilizing IoT devices in power grids they will be sustainable energy usage. But we should overcome economic crisis, policy, and important technical hurdles for successful implementation of IoT in Traditional Power grids. Although the transition from traditional power to smart power grids is a very long process, it is inevitable that for progress of technology it will surely be implemented. Widespread deployment of smart meters facilate two-way communication, enabling control center interaction. Smart meters via Real time pricing facilates customers for less energy consumptions and

saving. This lowers carbon emissions and reduces the likelihood of blackouts, establishing the smart grid as a pioneer in environmentally friendly technologies. The transition to a more intelligent, environmentally friendly energy future is essential, despite obstacles. Smart grids' leadership position in green technology highlights their contribution to the development of a more ecologically friendly and sustainable energy future. This smart grid technology can really solve present and future related energy issues. Right now it is not fully developed but we should embrace this coming era and give importance to smart grids fro sustainable development. The growth of Internet of Things based smart power grids is inevitable as consumers are aware of changing energy environment.

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