Smart metering in smart grid framework: A review

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Smart Metering in Smart Grid Framework: A Review

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Abstract—Purpose of the paper is to discuss and analyze Smart Grid, particularly explain its need and basic idea behind it. Further, different characteristic features are explained. Here we present different ways in which smart grid can overcome different problems in conventional electricity grid. It is also explained that how smart grid can overhaul the Home Energy Management System (HEMS). Additionally, status of smart grid in India and abroad is given. As a result, it is concluded that smart grid development will allow consumers to use energy effectively and thus help in securing energy needs of India and the world. It will be an important component of Smart City mission of Indian Government as well.

Keywords- Smart Grid; Smart Meter; Energy Management

I. INTRODUCTION

Electric power infrastructure has revolutionized our world. With the advent of electricity, way of living our life changed completely. It became our greatest achievement in 20th century. But as our energy needs are increasing faster than we realized and sources of energy depleting at a similar rate. Our grid is running against its limitation. Cases of blackout are increasing [1]. Due to increase in green house gas emission, our carbon footprint is increasing which is leading to climate change and numerous problems due to that. That is why, a solution is needed to tackle all this. A solution is required for using electricity in a sustainable manner. Fortunately, we have a way forward. We can use information technology to overhaul the electric grid.

II. IDEA OF SMART GRID

A Smart Grid will apply technologies, tools and techniques to existing power grid so as to revolutionize the grid system in a way internet has revolutionized our lives.[1] There are numerous characteristics of Smart Grid due to which it is capable of handling problems of conventional electric grid. These are explained in following sections.

Firstly, conventional grid consists of electromechanical components. however, smart grid comes into picture when ICT (Information and communication technology), electric and power system are used collectively. In existing grid, communication is one way; information goes from power generating units and utilities to consumer but never from consumer to utilities. Smart grid system allows two way communication of all stakeholders so that information can be shared by all. Utilities may understand the consumption pattern of consumers and decide price per unit electricity depending on peak load and time. [2]

Secondly, in existing grid, production is always centralized. Power generating units generate and transmit it to several distributing units ex. UHBVN (Uttar Haryana Bijli Vitran Nigam). From where, electricity is distributed to different consumers. But in Smart Grid (also known as Intelligent Grid), distributed generation of electricity is possible. Different consumers can produce and contribute to the electricity grid by different techniques available. Integration of rooftop solar plant is one such option provided by a number of governments (ex. Haryana govt). Here, consumer can produce electricity by installing solar plant at her rooftop and then share any extra electricity available with the utility using net metering option. In other words, Smart Grid framework support renewable energy integration as well.

Thirdly, existing grid is hierarchical in nature while smart grid will be networked. All the stakeholders (Power generator, Power distributor, Utility company, Government) are connected by two way communication. Further, in smart grid framework, pricing of electricity will be differential depending upon time and total load on network.

Fourthly, Conventional grid do not have much sensors on its network due to which network is considered blind as it is not able to monitor itself, leave about restoration. That is why, a number of times, utilities are not aware of failure or blackout until told. Testing and restoration work are also manual. On the other hand, in smart grid framework, a number of sensors are attached throughout network which enable it to self-monitor. Utilities will be able to test the network remotely and network will have the capability of self-healing as well. [2]

Thus, in existing grid, different stakeholders have limited control while smart grid framework allows pervasive control. Further, smart grid allows more customer choices than conventional grid because consumer will be able to plan her consumption in a way to reduce cost which is not possible in conventional grid. Smart Grid will also reduce T&D losses.

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III. Status of Smart Grid in India and Abroad

Keeping in view the potential of smart grid, Ministry of Power, Government of India constituted a forum named 'India Smart Grid Forum (ISGF)' and a task force named 'India Smart Grid Task Force (ISGTF)' for timely and effective implementation of Smart Grid in 2010. At that time only 6 other countries in world were working on such developments.[3]

In India, many components of smart grid are implemented in almost all urban areas. This is done under a program named 'Restructured Accelerated Power Development and Reforms Program (R-APDRP).

A new mission on Smart Grid named 'National Smart Grid Mission (NSGM)' was launched in 2015 for achieving smart grid vision. NSGM is working very efficiently. For Project Management, NSGM has a unit named 'National Project Management Unit (NPMU)'. This unit mainly oversees day-to-day operations. [3]

A number of other countries of world are also working hard on smart grid. To modernize electric grid, American DOE (Dept of Energy) is using PPP (Public Private Partnership) model. American government is working in collaboration with a number of leaders in field of smart grid so that it can smarten its grid timely. [4]

Germany is experimenting wind power generation and electric vehicles. Countries like UK, France and China are also doing extensive research to leverage smart grid framework. [5]

IV. Smart Metering

There are a number of building blocks of smart grid. Some of the examples are: Geographic Information System (GIS), Enterprise Application Integration (EAI), Outage Management System (OMS).
Meter Data Management Systems (MDMS) and Advanced Metering Infrastructure (AMI) are required to manage electricity in home environment that is, to reduce wastage and improve customer experience.[6]

AMI allows utilities to collect information about consumption pattern of users in real time and provide customers time based pricing and thus improves customer experience. AMI also allows to remotely detect and correct any problems in transmission.

V. Home Energy Management System

A Network in which a number of electricity consuming devices which are of usage in home environment are connected, such a network is called Home Energy Management System (HEMS). Central part of such a system is a controller at which all algorithms of energy management runs. [7] All devices are two way connected. Smart meter act as interface between HEMS and smart grid[8].

Following is the review of work of different researchers to manage energy consumption in home environment.

Seong Jun Noh et al proposed a method to efficiently manage energy consumed by HVAC system. In this system, temperature is adjusted in a way to minimize electricity cost while keeping temperature in a comfortable range. [9]

To increase efficiency and reduce cost, A. Arabali et al used stochastic models to generate renewable energy like solar energy, wind energy for matching it with the HVAC load. GA-based optimization approach is used. [10]

Anil Aswani et al built a platform to study temperature dynamics of room due to the furniture and other such occupants of the room. They then combined mathematical model with statistical methods to implement a learning based control which can learn and compensate for the heat as and when it changes. [11]

Yu-Wen Chen et al discusses that on a smart grid framework, how to allocate power to air conditioners in a way that is fair. In this, all residents are allowed to request temperature that they want to obtain. Depending on the total demand and supply, electricity is distributed to households in a fair manner. Iterative water filling algorithm is used to distribute power. [12]

Frauke Oldewurtel et al investigate significance of weather predictions and Model Predictive Control (MPC). Purpose is to automate room environment while keeping efficiency of energy in mind. Apart from energy efficiency, comfort of occupant is also to be taken care of. They concludes that MPC has large potential in terms of energy efficiency when compared with other techniques like deterministic MPC and stochastic MPC.[13]

Conclusion

Smart Grid is the buzzword of power sector today. It is set to change the manner in which electricity is produced, transmitted, distributed and even consumed. It will surely help us to reduce our carbon footprint while increasing experience of all stakeholders in the sector.

It is going to provide reliable, efficient and sustainable way to handle our ever increasing energy needs while keeping in view our duty towards mother nature.

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