ORIGINAL RESEARCH PAPER

Engineering

INTEGRATION OF ENERGY MANAGEMENT SYSTEMS WITH SMART GRID

KEY WORDS: energy management system, power grid, renewable energy, smart grid

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ABSTRACT

The purpose of smart grid is to ensure reliability, efficiency, and security of the electrical power grid system. The smart grid engages technologies in advancing digital communication, advanced metering infrastructure, automation and control, and integration of distributed energy resources. When some recent innovations in the renewable energy sector with solar and wind applications for meeting energy demands for residential and commercial market is considered, it becomes evident that smart grid promises a solution to the integration of these distributed energy resources. Although smart grid and energy management systems go hand in hand, there is a need to assess a proper fit to the smart grid applications when customers continue to add renewable energy generation of varying sizes. Energy management system offers controlling the power usage at user end based on communicated data from grid on intensity of loading. During a less burdened condition the tariff may be cheaper and vice versa. This paper documents the functionality of the power grid with respect to smart grid and thus integrates the energy management applications to the same to ensure smoother penetration in the market.

INTRODUCTION:

Smart grid applications are growing in the market ever information technology applications become promising in ensuring reliability, efficiency, and security [1] [2] [3]. Traditional power grids are known to have no communication of the user demand intelligently by means of communication via fiber optic or wireless. Some applications of communication over power line have been known for telecommunication between the substations at transmission and distribution at high and medium voltage. With varying low to high voltage systems the interference of power lines with communication lines vary but by ensuring system designed to reduce the radio frequency interferences the communication lines can operate with minimal to nil impacts and thus offer great solutions in monitoring and controlling the grid power operations. Smart grids offer reduced green house gas emissions [4]. The generation is supposedly produces about 40% of the entire carbon emissions in the United States [4] thereby smart grids have excellent applications in curbing the green house gas emissions.

The generating stations normally monitor voltage, and the frequency drops to sense the loading of the grid and accordingly alter the power generation. When in heavily loaded conditions with frequency drops below the normal frequency, the generators inject power and keep the frequency within 5% variation [5] [6] [7]. The advanced digital technology with available high speed communication protocols the speed and reliability of the communication extends into the smart grid. As the term smart grid means information technology integrated with traditional power grid, there is a huge scope around integration of energy management systems with smart grids. Some authors have presented applications of home energy management systems in reducing the residential energy demand and how it can assist with demand response. However, available literature has a gap when speaking about the smart grid and energy management integration. When users starts to have an active communication with the grid to not only for monitoring purposes but also to select the source of power generation, the motivation to this integration goes beyond to best practices in resourcing renewable energy for the customers. For example, a customer will feel delighted to control the power delivered to them via renewable energy resources at a given point rather than from a conventional thermal power plant. This lets them track their path in cleaner and greener environments.

Figure 1 shows how a smart meter (right) differs from analog meter (left). Smart meters are equipped with digital display and report the energy consumption to utility remotely [8]. Analog meters are robust design but lack the remote monitoring of the energy consumption by utility companies. Energy Management System integrates the smart meters with users by using a software interface (apps) as discussed in the Methods and Practical Application sections. The users are often notified of their energy consumption via energy bills that indicates the whether they have a smart meter and advanced metering infrastructure. This allows a transparency to the customers on how their data on energy usage is utilized. Some consumers may want privacy for the way they consume electricity. So, the data collected for energy usage by each customer requires security. The smart grid application offers security of the data.

Table 1 shows a count of installed smart meters in major five economies in the world. There is a huge scope of smart meters addition in India. Although government initiatives have approved to install more than 250M smart meters for customer, the scope of smart grid infrastructure picks steady pace with meter installations. Major reasons for the lower penetration of smart metering in India were identified as lack of funding, standards, and awareness. The advantages of smart grid applications ensure integration of renewable energy generation resources, improve customer experience by deployment of monitoring and control, and reduction of transmission and distribution losses. As the goals orient towards a sustainable future the total losses from transmission and distribution is resultant of the copper losses from the lines. Super conducting materials for the transmission and distribution are promising solution but have faced many practical challenges for wide spread usage. A direct current superconducting cables have least amount of energy dissipation from copper losses.

Figure 1: Comparison of Smart and Analog Meter
Sources: https://whatissmartenergy.org/

Table – 1 Smart Meters

Location	Smart Meters
United States of America	130.6M
China	242M
Japan	80M
Germany	1.6M
India	11.6M

Source: Web resources [9]

Smart Grid

The United States have three major power grids the Eastern, Western, and Texas interconnection. They operate in an integrated manner to ensure minimal to nil outages. The penetration of advanced metering infrastructure (AMI) is significant nationwide. However, in India smart grid is a becoming popular amongst the utility companies and around 50 million smart meters have been reported in 2022. The smart grid necessarily means to eliminate any major losses from stalled generators by smartly allocating the generation sizes and planning the future requirements. As the electric vehicle industry grows [10] the smart grids with their regular monitoring of the loads will ensure planned infrastructure for power generation for the large-scale charging infrastructure.

Energy Management System

The energy management system is a applicable for systems that can operate either with the grid or without it. They are primarily focused on promoting micro-grid applications. For example, intelligent monitoring of the loads connected to the system and monitoring the availability of power from grid and distributed energy resources in the system such as wind and solar is possible. Efficiency of the appliances and equipment used by customers is questionable from the manufacturers standpoint as they have to take measures in producing equipment with low energy consumption [10]. Additionally, equipment specifiers must use energy efficient equipment at both residential and industrial applications such as LED lighting and EV chargers [11] [12].

Both energy management system and smart grid applications allow demand prediction capabilities for the future loading and hence are excellent tools for both policy makers and utility companies in preparing plans for adding new generation stations to meet the rising demands.

METHODS

Smart grid without energy management system integration is shown in Figure 2. The smart grid interacts with the renewables and conventional power generation by use of communication networks either separate or via power line communication. There is a large integration of the users such as residential and industrial to the smart grid. Utilities control the generation based on the demand response from the users [13]. Some newer types of loads require deployment of renewables and integration with grid by energy management systems [14] [15]. But additional measures in smart controls of the usage at the residential and industrial use becomes key when deploying an integrated operation of smart grid with energy management system. Figure 3. shows the integration of the smart grid with the energy management system. The intent is to ensure there is a smooth communication from users to the grid so that there is no lack of interest in attaining net zero carbon emissions from both user and power grid. For example, a user app with live updates communicated by the energy management system ensures users to select some criteria for power delivery live. Such as selecting the type of power generation resource, selecting the usage based on the time of the day tariff, select when to switch from grid to onsite distributed energy resources.

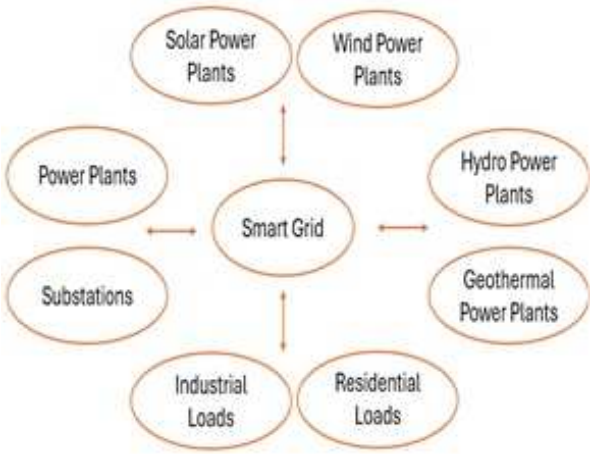

Figure 2: Smart Grid

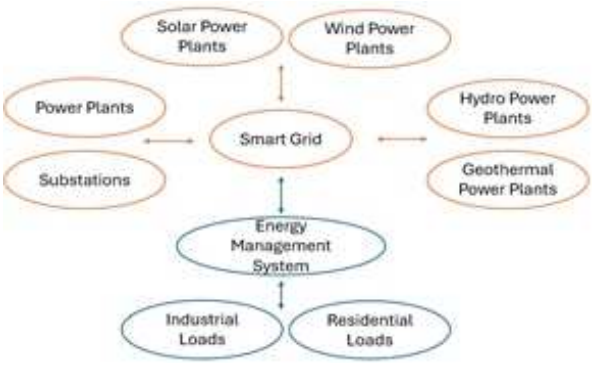

Figure 3: Energy Management System Integration

Practical Application And Results:

The total number of power grid and the infrastructure available in India and United States was documented for available room for new smart meters. The focus was around to utilize a large incorporation of smart meters in to the Indian grids to ensure smart grid transitioning faster. However, the concept of energy management integration to smart grid is known but they are being studied separately. An application integration is practically feasible solution to allow customer to track their power usage and other preferences. Concept for communication was developed in Fig. 3 that show cases how an integrated manner of communication can happen from either wireless or fiber optic network.

For practical application is shown in Figure 4 wherein a software apps are developed to ensure there is a provision for users to select the type of generation and select the appliances they would like to use, and live monitoring of

energy bills. Some users that are cautious about their carbon credits earnings from their switching to energy efficient options using the apps will find the Figure 4 app integration as a great tool.

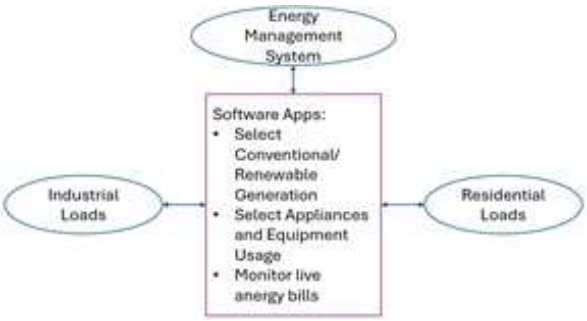

Figure 4: App integration for Energy Management System

CONCLUSIONS

A substantial user satisfaction is possible for both price sensitive and environmental impact sensitive people when an integrated operation of smart grid with energy management system is concerned. Smart grid by definition improve the communication application in the grid to improve the reliability, efficiency, and security but energy management integration to it is less prominent when smart grid definition is read by most readers in the industry. So it is recommended to use energy management system with smart grid applications to tie them together into one umbrella of innovations in the power industry. Utility companies even with limitations must start with incorporating smart meters. An app development as shown in Figure 4 is recommended when sustainability is considered.

About Author:

Pravin Sankhwar is a Global Recognition Award and Titan Award Winner because of his significant contributions to the electrical engineering industry. His research and practical experience are directly applied to improving the engineering standards and users of his designed works. He is a licensed professional engineer and has passion and commitment towards a sustainable future.

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