International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 648-652

A State of Art of Smart Grid and their Smart Solutions

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Abstract
More efforts are being made on a global scale to spread the word about clean energy for environmental protection and to plan the utilization of energy in order to keep up with the rising demand for it. In order to support renewable energy, regulate energy consumption patterns, and secure the system, it is necessary to conduct grid checks and upgrades. These requirements will be met by the smart grid. The smart grid concept is driven by developments in information and communication technology. The transition from the current grid to the smart grid is guided in part by sensor and control technology. The rollout of the smart grid is fraught with difficulties. In this paper, we discuss the problems and solutions associated with the smart grid concept.

Keywords: *National Institute of Standards and Technology (NIST), advanced metering infrastructure (AMI), flexible AC transmission system (FACTS)*

Date of Submission: 13-05-2023 Date of acceptance: 25-05-2023

I. INTRODUCTION

A smart grid is a system that connects consumers and power companies with two-way communication and electricity delivery. Integration into the country's power grid is crucial to the long-term success of this emerging technology. Since 2019, India's power demand has climbed by about 7%, albeit at a slightly lower rate than usual because to the COVID-19 lockdown in the first half of the year. Because so many businesses were shut down at the time, peak demand was lower than usual. A complete decentralization of the existing power infrastructure is necessary, however, because India is a developing country and its power need will only increase in the future.[1]-[3]

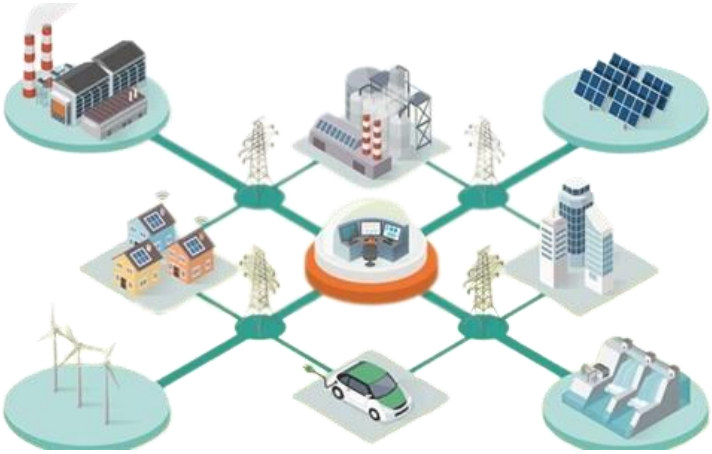

Figure1: Smart Grid with Smart Solution

The rollout and implementation of smart grid will rely heavily on contributions from both developed and developing nations. An uninterruptible power supply for all homes is just one of the many benefits of smart grid. Other advantages include a more secure electrical grid, greater energy storage capacity, the ability to interact with the electricity market on the part of consumers, market-based electricity pricing, and demand-side management. [4] Figure1 shows schematic of Smart Grid with Smart Solution.

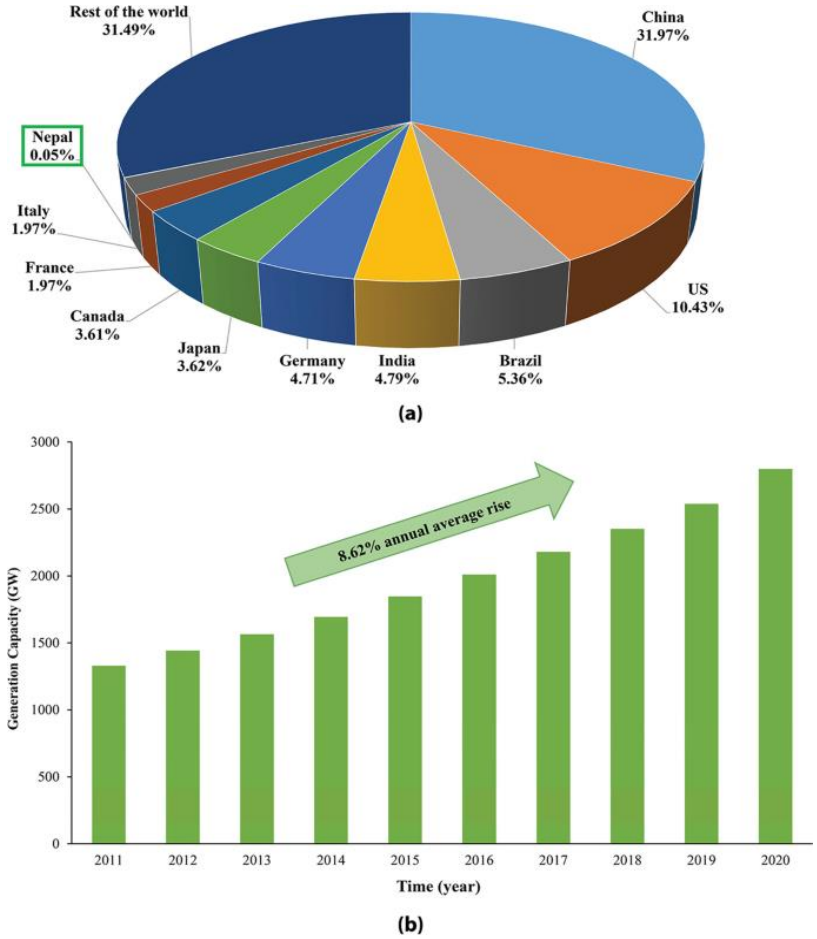

Figure 2: Development of Smart Grid Technology (GSGFR 2022[1])

Implementation of pilot projects, smart grid interoperability standards, promotion of distributed renewable energy generation, and studies on the cost effectiveness of smart grid technologies have all contributed to the field of smart grid's overall success. The 2022 report from the Global Smart Grid Federation shows how countries including Italy, France, Brazil, Ireland, Japan, Germany, the United States, and Canada have progressed in this area as shown in figure 2.

II. LITERATURE SURVEY

The smart grid is an intelligent grid that utilizes information and communication technology via smart meters and a control system to regulate the anticipated load and dispersed resources. It's an idea for the future of power generation that involves a two-port grid with real-time market involvement. [5]- [7] Smart grid also helps with things like ensuring a steady and affordable supply of electricity, maximizing the use of existing infrastructure, and generating power from a wider variety of renewable sources. The generation, transmission, distribution, customer service, market, and original equipment manufacturer links in the corporate value chain will all feel the effects of smart grid. The promise of smart grid is a power grid that is more reliable, safe, and environmentally benign. [8] To receive power in accordance with consumer preference and to engage with utilities to control load and obtain data, "smart premises" are simply modern buildings with two-port connections to both the power grid and communication networks. A hybrid power system (HPS) is utilized to generate electricity for the facility's needs and to supply the grid, while a massive amount of energy is stored in a battery for usage during peak hours. [9] A smart controller connects the building's renewable energy sources (RES), energy storage system, load, and electricity grid in a smart building. Two-port smart meters that can track energy use in three different directions (grid, RES, and RES back to grid) are also placed in smart buildings. Smart buildings can receive power from, and supply power to, the smart grid. Interoperability standards must be supported by the smart grid. The smart grid's data and communications infrastructure has been hardened against hacking. Each country's electrical infrastructure and growth rate of energy consumption must be factored into the strategy and framework for implementing smart grid. To build the smart grid as a global grid, internationally recognized standards for communication and network security must also be developed. [11]- [14]

III. CHALLENGES AND ISSUES

Developed nations have stable power grids and low population growth rates. This frees them up to work on things like smart meter implementation technologies and ensuring the interoperability of distributed renewable energy generation that is connected to the grid. However, developing countries like India, which have a poor grid but expanding energy needs, would need to strengthen and enhance the electric network in addition to implementing information and communication technologies and an automated system to make the grid smarter. They should also focus on minimizing transmission and distribution (T&D) losses and ensuring that all residents have reliable access to power at all times. Some of the difficulties and issues that would arise throughout the rollout of smart grid in both developed and developing nations are explored.

A**. Advances in Technology**

Over the past few decades, there has been remarkable development in information and communication technologies. However, if we want the grid to be as intelligent as we imagine it to be, we'll need to build a new, highly secure communication infrastructure, either in conjunction with or in addition to the current Internet. In order to execute phase measurement, consumer consumption data collection, automatic circuit breaker regulation for minimal interruption, and electrical appliance peak shaving in the smart premises and grid, cutting-edge sensor systems must be developed. There is a need for the development and implementation of state-of-the-art components such as smart appliances, smart meters, efficient energy storage devices, high voltage DC transmission devices, flexible AC transmission system (FACTS) devices, and so on. An additional crucial aspect of technical progress is the creation of cutting-edge software to manage and protect the consumer grid and home electronics.

With the help of cutting-edge control systems and decision-making aids, the smart grid will be able to function autonomously.

B. Providing Reliable Electricity to Every Home

Electricity usage per person is around a quarter of the global average in developing nations like India. In order to reliably provide electricity to all homes, the power grid will need to undergo massive expansion during the next few years. To realize the potential of the smart grid, it is also necessary to guarantee supply quality. To guarantee high-quality power to all residents, the current grid will undergo renovations and expansions. It is also important to encourage the use of decentralized renewable energy generation and the transfer of loads from peak to off-peak times in order to reduce the supply gap during peak demand and energy costs.

C. Lessening the Effects of Losses in Transmission and Distribution

T&D losses must be brought down to international norms. Technical losses because of a weak grid and monetary losses owing to theft and decreased collection efficiency are the primary contributors to T&D loss. Utilities should make considerable efforts to resolve these issues.

D. Incorporating Renewable Energy Sources

Since renewable energy sources like solar photovoltaic and wind mill are inherently unstable, it need sophisticated technology to integrate them with the current power grid. Power system issues are compounded by the harmonics generated by the complicated power electronics circuits utilized for integration. The need for extensive plots of land is another drawback of renewable energy. One of the biggest obstacles to using renewable energy is ensuring that the protection circuits can disconnect the system from the grid when necessary. Integration of renewable energy sources will also be hampered by a lack of technically competent labor and a poor choice of optimal location for deployment.

E. Cyber Security and Interoperability

Implementing several standards consistently is the only way to guarantee interoperability and cyber security. The interoperability standards developed by National Institute of Standards and Technology (NIST) in United States includes advanced metering infrastructure (AMI) and smart grid end-to-end security, revenue metering information model, building automation, inter-control center communications, substation automation and protection, application level energy management system interfaces, information security for power system control operations, phasor measurement unit (PMU) communications, physical and electrical interconnections between utility and distributed generation (DG), security for intelligent electronic devices (IEDs), NERC CIP 002-009 cyber security standards for the bulk power system, cyber security standards and guidelines for federal information systems and bulk power systems, price responsive and reliability DR event information, home area network (HAN) device communication, measurement, and control, HAN device communications and information model and smart grid Interoperability Panel (SGIP) catalogue of standards . In the beginning phases of smart grid deployment, each country must develop its own standards, taking into account its existing

standards and the ease of deployment. All countries implementing the smart grid will need to adopt the same set of standards and safety protocols that are recognized internationally.

F. Assistance to Customers

Lack of consumer awareness about the concerns in the power sector is a major barrier to smart grid deployment. Smart grid implementation to reduce peak load usage and boost distributed renewable energy generation requires consumers' buy-in. Power quality and dependability will both increase as a result of smart grid installation. It guarantees an accessible and transparent interface between utilities and their customers, more options for consumers (including green power) and the ability to save money by moving loads outside of peak hours. However, in order to reap the benefits of a smart grid on a national and personal level, customers must be knowledgeable about emerging technology and provide input to utilities.

IV. REMEDIES

Due to the extensive time and resources required for smart grid installation, the concept is still in its infancy. Then it needs to be implemented gradually. Taking into account their current infrastructure and projected growth rate, each nation should offer a policy for deploying smart grid. There are numerous utilities across a country, each with its own unique set of requirements, regulatory landscape, energy resources, and legacy systems. Therefore, it is highly doubtful that a universally applicable, low-cost, and beneficial solution will develop for the world's electric utilities and consumers. All utilities face the difficulties and concerns discussed in this paper, while their priorities may vary. In this article, we suggest a few ways to make room for them.

A. Advances in Technology

With the help of universities and other research organizations, governments around the world should help utilities and industry integrate cutting-edge ICT like sensor and control technologies. Through bilateral agreements, the government may also obtain the same from foreign countries. Utilities, businesses, and governments throughout a region need to collaborate on smart grid technology development and deployment. The government should make it easy for everyone to access the available technologies. The countries are also working together as a bloc to promote progress. Only then can the idea of a global grid become clear.

B. Reliable Electricity for All Homes

This might be guaranteed by the industrialized nations. However, developing nations must invest heavily in grid construction. The government, with the help of international organizations, should priorities resolving this problem.

C. Decrease Loss in Transmission and Distribution

In order to secure funding for infrastructure developments from global organizations and deliver reliable power to all homes, it is necessary to cut down on T&D losses. Theft and loss due to a weak grid are the two main causes of losses in the distribution business. Consumers can be educated about the advantages of preventing theft through the media and online communities. The installation of energy meters in all of the city's buses will enable the government keep tabs on the electricity grid and catch thieves. T&D loss must be minimized, and power industry workers will play a crucial role in that.

D**. Incorporating Renewable Energy Sources**

Integration of renewable energy sources relies heavily on the advancement of power electronics to manage high power through quick semiconductor switching using IGBTs. Power electronics circuits have the potential to introduce harmonics into the power grid. Static synchronous compensators (STATCOMs), static series compensators (SSSCs), and unified power flow controllers (UPFCs) are all examples of FACTs devices that will aid in making a grid with a high proportion of renewable energy more stable and reliable. These systems include filter circuits that reduce harmonics introduced into the grid by power electronics.

In order to maximize power extraction from renewable sources and minimize fluctuations in renewable energy generation, real-time computer controllers that can apply advanced and complex algorithms are essential. Overcharging is prevented, which is important for batteries and other storage devices. The battery will last longer if you do this. Using the intermittent power produced by renewable sources for irrigation is more cost-effective and grid-friendly. Distributed renewable energy generation from a wider geographical area in small power plant rather than large power plant concentrated in one area can also lessen the variability in renewable energy generation. Within five to ten minutes, local phenomena like cloud passage can cause a 70 percent swing in solar photovoltaic output. Distributed renewable energy generation reduces the need for extensive tracts of land and smoothest out the intermittent nature of renewable energy.

E. **Cyber Security and Interoperability**

Before a widespread rollout of smart grid technology, each utility must resolve interoperability standards. The measures for cyber security are to be integrated into the design from the start. Utilities must respond appropriately to cyber-attack notifications. If the smart grid is going to live up to its potential, the system needs to be able to fix itself and resist attacks. Utilities companies should staff the smart grid's intricate communication, control, and sensor technology with highly trained experts. When it comes to managing the recovery of complex networks, human members are both the most vulnerable to failure and the most flexible.

F. **Assistance to Clients**

Consumers should be afforded easy access to monitoring and control tools so they can take charge of their energy usage. Consumers will embrace autonomous energy management systems only if they experience tangible savings in both energy and money, according to smart home field tests conducted for a smart grid. Consumers need to see a return on their investment in energy efficiency and peak load control, and the market price plays a role in this.

V. CONCLUSION

In order to keep up with the ever-increasing demand for electricity, smart grid development is essential and can be deployed in an ongoing manner. In the process of upgrading to a smarter grid, implementing agencies will have to deal with a number of obstacles. Some of the problems and solutions associated with introducing a smart grid are presented in this study.

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