IOT BASED SMART ENERGY METER FOR SMART GRID

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Abstract:-

A clear vision of the power system of the future is first necessary before we can start modernising the grid as it exists today. With the right alignment, we can inspire enthusiasm, investment, and advancement toward the Smart Grid of the twenty-first century. Future prosperity in society will be made possible by the Smart Grid. One of the most difficult problems facing the world in the twenty-first century is energy supply. Everywhere in the nation, the demand for energy has increased due to expanding populations, an increase in homes and businesses, and a plethora of new appliances. Utilities from all over the world are attempting to modernise their networks for the 21st century and the digital era. The creation of a "smart grid" refers to this effort to give the power grid more intelligence. The industry believes that switching to a smart grid will improve both delivery and consumption techniques. This paper introduces the "State of the Art" of the Smart Grid as well as its vision, applications, and controls. Additionally, the paper identifies the benefit, growth, and issue of the smart grid. The paper also includes a case study of the implementation of smart grid technologies, which is discussed in accordance with current sources and technical reports published by academic, government, and research institutions.

Keywords:- Smartgrid, IoT, Smart Systems and Communication Networks

1. INTRODUCTION

The rapid infrastructure replacement of the electrical wiring system in the US is referred to as the "smart grid." The term "smart" refers to features of communication across grids that will be possible once the advanced system is fully implemented. An advanced electrical distribution system with the ability to balance electrical loads from various, frequently intermittent alternative energy generation sources is known as a "smart grid." The ability to store electrical energy, which enables the "smart grid" to meet consumer demand, is a crucial element. The Smart Grid is flexible and relies less on operators, especially when it comes to reacting quickly to changing circumstances, Predictive in the sense of using operational data to inform equipment maintenance procedures and even foreseeing prospective outages, In terms of real-time communications and control capabilities, integration interaction between markets and consumers Reliability, availability, efficiency, and economic performance are all optimised Safe against assault and unforeseen disturbances [1]-[5].

The transmission and distribution networks used today are generally one-way and accommodate huge generating facilities that supply distant customers. The grid of the future, however, will unavoidably be a two-way system, with electricity produced by a variety of small, dispersed sources in addition to huge plants flowing through a grid based on a network rather than a hierarchical structure. The diagram in Fig.1 below depicts this architecture. The first depicts the hierarchical power structure in use today, which resembles an organisational chart with the main generator at the top and consumers below. In the second figure, a network topology like that of a fully functional smart grid is shown. Information and control are just as important to smart grids' fundamental concept as is electricity management. Broadband over Power Lines (BPL), which superimposes information on top of electrical power, is used to send a lot of data across power lines [6]-[10]. Using this knowledge, power may be diverted away from trouble regions until the issue is resolved and power levels can be changed to accommodate demand. Smart grids may accommodate electricity producers and customers alike. The grid may benefit from the addition of wind and solar energy, and users may be charged higher rates during periods of peak consumption and reduced prices during periods of low demand. In addition to the higher demands from air conditioners on hot days, smart grids can also adapt for lower production from solar cells on cloudy days and from wind turbines on still days.

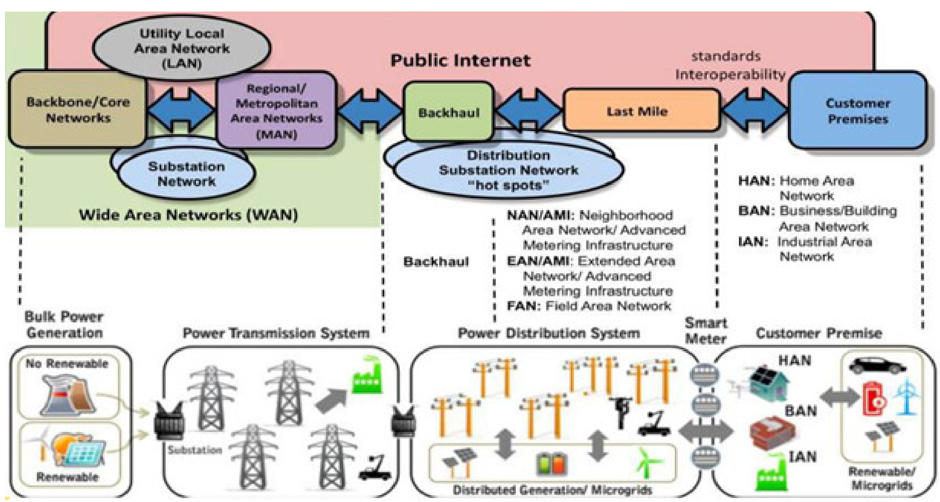


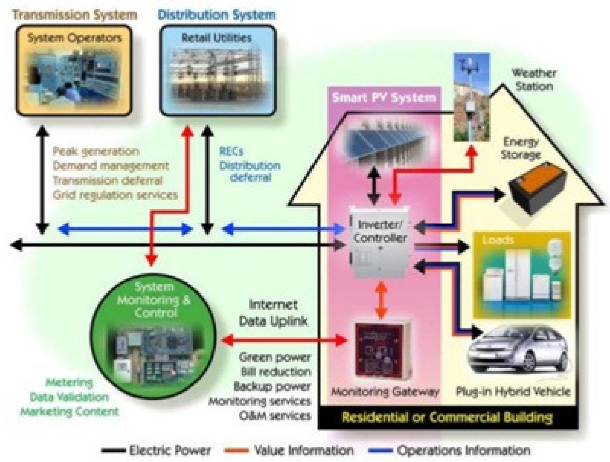
Figure.1. Smartgrid Technologies

By rerouting traffic around issues or shutting down the network altogether, smart grids may also swiftly react to terrorist attacks, natural disasters, and "Disaster Avoidance" scenarios. Additionally, they control rolling blackouts to save power when demand outpaces supply. The advantages of realising the smart grid go much beyond the electrical system itself since it is more than just one technology. The change from the current grid to the grid of the future will be just as significant as all of the improvements in power systems over the last century, but it will happen far more quickly [11]-[15]. It will need a new degree of collaboration between stakeholders in the sector, advocacy organisations, the general public, and particularly the regulatory authorities that have such immediate control over the course the process will take. However, a properly functional smart grid will ultimately be advantageous to all parties. Due in part to the availability of subsidies, the idea of smart integration of grid-connected photovoltaic (PV) systems has thus far gone unexplored. PV has had the quickest growth in recent years as a result of the subsidies provided under various government incentive programmes. Smarter grid interfaces will be a crucial component of future PV system designs as direct financial incentives and other forms of subsidies for PV systems are increasingly phased away [16]-[20].

2. SMARTGRID TECHNOLOGIES

While there are numerous effective instances of smart grid networks, Telegestore, which was established in 2005 in Italy, is the one utilised in this analysis. The 27 million consumers connected by the Telegestore initiative are the first grid to deploy smart metres. Additionally, it is said to be the first smart grid in the world that serves the domestic scale. This intelligent power system allows for significant energy savings. Three crucial components—communication, information technology, and electricity—are integrated to create a smart power grid. These components function in a certain way to provide utility and customer feedback exchange. Energy is transmitted electrically both from the power supplier to the user and the other way around . Customers that own PV systems that produce more electrical energy than they use may sell the excess energy to the utility provider for a profit. Access to inexpensive energy resources is vital for sustainable development in order to meet basic necessities and support productive activities without jeopardising the possibilities of future generations. The global economy is powered by traditional energy sources, yet 56.6% of greenhouse gases are released during the burning of fossil fuels. Thus, attempts to incorporate renewable energy sources (wind and PV) into electricity systems are pushed by worries about greenhouse gas emissions that contribute to climate change.

However, since it relies on wind or sunlight, the energy produced is unpredictable. As a result of the significant swings in their outputs, such systems are intermittent. It is also non-dispatchable since no external command may be modified to change its output. The unpredictability of conventional grids, in contrast, poses a challenge to the operation of the power system, particularly when the penetration of renewable sources is substantial. To fulfil the standards, it is also necessary to employ a cost-effective method of manufacturing solutions to improve the customary. In order to successfully upgrade an outdated system to a new smart arrangement, technical standards and rules to integrate the power system and IT-based systems are required. International organisations have varied definitions of the smart power grid, although they all agree on its general structure. The National Institute of Standards and Technologies (NIST) views the smart grid as a network of distinct power systems that uses two-way communications and information technology, including computation, intelligence, and cybersecurity. Figure 2 illustrates how any smart grid is built and how it must be resilient by disruption predictive maintenance and self-healing responding to disturbances occur due to the high penetration of renewable generators in order to improve power quality and reliability, optimise facilities to avoid peak load challenges, and ensure power plants efficiency and capacity of power networks.



Figute.2. Smartgrid Technologies in IOT

The distribution system and energy flow are no longer unidirectional thanks to the smart energy grid, an unique electric power system that represents a significant advancement of the conventional electric grid. Additionally, the consumer side may play a very limited role in grid stabilisation. The resilience of the system depends on both the supply and demand sides working together. In order to shed light on this popular issue in the halls of electrical research institutions, this review study presents the benefits, components, historical, and future advancements of the smart grid. Many benefits of smart grids have been explored, including their self-healing, intelligence, adaptability, environmental friendliness, quality, and stability attributes. The requirements have been examined from a wide range of aspacts, including: architecture, components, and locations. Control and monitoring, integration with information and communication technologies, integration with distributed renewable generators, and distribution management are the topics addressed. Customers can help restore stability and manage their energy use thanks to the smart grid. With the quick development of new renewable energy sources, storage systems, information and communication technologies, and methods of integrating dispersed energy sources, a new paradigm has emerged in the power industry. The implementation and management of the electrical network have altered as a result of this, sometimes known as the "smart grid." Consequently, this new idea has altered the electrical network in a manner that permits the use of both a two-way stream of electrical energy and data using digital communications technology. All of this has enabled us to respond and take action in response to use fluctuations and a variety of challenges. As a consequence, smart grids have the ability to repair themselves and let power users take an active role in the process. To manage the present and future changes, all of these factors are essential. When considered in a larger global perspective, such as the case of smart cities, the duties of smart grids are even more crucial.

In order to minimise uncertainty in local flexibility calculations, the study offered a technique as a power management system (PMS) modification that computes a short-term reliable flexibility potential out of in-time operating circumstances and end-user inputs. A use-case scenario on working days in the spring with a condensed set of end-user inputs that were simple to create and include into the PMS interface demonstrated the applicability of the suggested technique. The method's ability to provide thorough insights on the energy system's capacity for short-term flexibility that is linked to a flexibility operator was confirmed. study on the issue of renewable energy's unpredictability highlighted the need to include energy citizens as fresh sources of flexibility into the energy systems. This article concentrated on identifying the regulatory, standard, and network-code gaps and hurdles that prevent individuals from participating sustainably in the energy transition. It also outlined the obstacles to public participation in the energy transit and took into account the enablers that make citizen participation possible, such as demand response (DR), renewable energy resources (RESs), and contemporary designs for local energy markets (LEMs).

The issues with electric vehicle (EV) chargers were also discussed in relation to their integration into distribution networks. Thus, for 50 EVs with 30 different models, the impacts on the grid for various session times were given in the study. The authors' suggested SOC-based dynamic charge coordination approach, which is based on actual charging patterns, was used to assess the data. The strategy also decreases the peak load of the grid by 0.8 kW per EV in the grid with PV and BES systems, according to the authors, by balancing the peak load by 0.36 kW per EV.. The optimal power quality improvement (OPQE) of grid-connected hybrid power systems with solar PV, wind turbines, and battery storage is therefore suggested by an intelligent control method that was provided in reference. In the proposed HRES system, a unified power quality conditioner with active and reactive power (UPQC-PQ) was created using a fractional-order proportional integral derivative (FOPID) controller based on atom search optimization (ASO).

Despite the fact that several research and expenditures have already been made, there are still numerous difficulties to be overcome. The dependability of these systems, communications systems, security, the Internet of Things (IoT), and demandside management systems are some of the factors that connect to these difficulties. The integration of electric cars into these grids, however, is one of the significant issues that requires a lot of study, development, and funding. Currently, the switch from combustion to electric cars is happening quite quickly. What has been seen, however, is that the infrastructure is seldom prepared and that its strengthening cannot be done in a straightforward manner. As a result, that integration has to be carried out deftly and within the framework of the smart grid. The presence of energy routers linked to intelligent automation systems to control various grid components, such as generators, storage systems, and loads, is another crucial factor. Consumer power use is a crucial factor in determining demand in the Smart Grid. In the conventional grid, metres had to be manually read, recorded, and then calculated to determine the actual consumption during a certain time. The implementation of the Smart Grid ensures that AMI will be used to monitor power use in almost real-time. AMI establishes a dual-channel network between utility companies' corporate systems and smart metres. This makes it possible to gather and provide useful information to consumers, energy companies, and rival retail sellers. Residential demand responses may be implemented using this information. AMI comes in a variety of architectures, but it always includes communications software and hardware as well as system and data management software. A new technology known as smart grids was developed in response to the need to update the electrical infrastructure. Since SG are more autonomous now and increase efficacy and efficiency, utilities are leveraging existing infrastructure and avoiding the need to construct new generating units. Due to the exponential rise in electricity consumption, there is a greater requirement for renewable energy resources. This has given power production a new dimension and incorporates clean energy sources like wind and PV cells in significant quantities. Renewable energy sources may now participate in the energy system thanks to deregulation, financial incentives, environmental awareness, and new energy regulations. In 2019, the total amount of energy produced by PV solar power plants was roughly 25% of the total demand, compared to the 12% produced by wind farms. The operation of the electricity grid has now become very difficult since all of these modern renewable technologies are reliant on nature. Since we have entered the digital era, the modern power system must be more dependable, efficient, and effective . These SG allow for the secure connection of any electricity produced by modern renewable technologies straight to the grid.

3. CONCLUSION

The primary determinant of a power system's efficiency is the amount of energy wasted. With the aid of SG technologies, these significant wastes can be reduced by reducing ineffective power distribution, communication, and monitoring. And the introduction of SG may settle all of these problems. Modern information and communication technologies may improve the power system's dependability, security, stability, and scalability. Because new communication technologies are readily available and allow for the exchange of real-time data, the balance between supply and demand can always be maintained. With the development of smart metres, real-time monitoring of distant electric loads has given consumers the best option for efficiently consuming energy, lowering consumption costs and suggesting a way to schedule electricity use that is directly proportional to grid frequency. The benefit is that it promotes energy production at the user level and enables end users to take part in energy management. With the use of SG, customers may modify their consumption in response to dynamic peaks when they are subject to higher tariffs. The utility operator learns how much electricity is being utilised and may adjust the power schedule appropriately. A thorough overview of the different communication technologies utilised in smart grids is provided in this study. The WSN for SG has increased throughput while reducing size and operating and maintenance costs. The SCADA programme handles data collection, and cross cryptographic graphic encryption ensures data security. Power system resilience enhanced as a consequence of SCADA to SG. With the effective real-time transmission of metre readings and sensor control signals with guaranteed security, cloud computing has proven ideal for Singapore. Block chain to SG doesn't need any significant architectural modifications, which has increased the power system's capacity to scale. With the block chain technology providing guaranteed quicker real-time data transport, we plan to continue this effort by using an artificial intelligence approach for scheduling the DG sets together with the rooftop PV production.

REFERENCES

[1] N. I. Landy, S. Sajuyigbe, J. J. Mock, D. R. Smith, and W. J. Padilla, “Perfect metamaterial absorber,” *Physical Review Letters*, vol. 100, no. 20, Article ID 207402, 2008.

[2] O. Luukkonen, F. Costa, C. R. Simovski, A. Monorchio, and S. A. Tretyakov, “A thin electromagnetic absorber for wide incidence anglesand both polarizations,” *IEEE Transactions on Antennas and Propagation*, vol. 57, no. 10, pp. 3119–3125, 2009.

[3] Q. Ye, Y. Liu, H. Lin, M. Li, and H. Yang, "Multi-band metamaterialabsorber made of multi-gap SRRs structure," *Applied Physics*, vol. 107, no. 1, pp. 155–160, 2012.

[4] J. Lee and S. Lim, "Bandwidth-enhanced and polarisationinsensitive metamaterial absorber using double resonance," *Electronics Letters*, vol. 47, no. 1, pp. 8-9, 2011.

[5] H. X. Xu, G. M. Wang, M. Q. Qi, J. G. Liang, J. Q. Gong, and Z. M. Xu, "Triple-band polarization-insensitive wide-angle ultra-miniature metamaterial transmission line absorber," *Physical Review B: Condensed Matter*, vol. 86, no. 20, Article ID 205104, 2012.

[6] S. Bhattacharyya, S. Ghosh, and K. Vaibhav Srivastava, "Triple band polar-ization-independent metamaterial absorber with bandwidth- enhance-ment at X-band," *Journal of Applied Physics*, vol. 114, no. 9, Article ID 094514, 2013.

[7] L. Huang, D. R. Chowdhury, S. Ramani et al., "Experimental demonstration of terahertz metamaterial absorbers with a broad and 2at high absorption band," *Optics Letters*, vol. 37, no. 2, pp. 154–156, 2012.

[8] N. Mishra, D. K. Choudhary, R. Chowdhury, K. Kumari, and R. K. Chaudhary, "An investigation on compact ultra thin triple band polarization independent meta-material absorber for microwave frequency applications," *IEEE Access*, vol. 5, pp. 4370–4376, 2017.

[9] H. F. Zhang, H. Zhang, Y. Yao, J. Yang, J. X. Liu, and J. X. Liu, "A band enhanced plasma meta-material absorber based on triangular ring-shaped resonators," *IEEE Photonics Journal*, vol. 10, no. 4, pp. 1–10, 2018.

[10] J. Zhang, J. Tian, and L. Li, "A dual-band tunable metamaterial near-unity absorber composed of periodic cross and disk graphene arrays," *IEEE Photonics Journal*, vol. 10, no. 2, pp. 1–12, April 2018.

[11] Maharjan, S.; Zhu, Q.; Zhang, Y.; Gjessing, S.; Basar, T. Dependable demand response management in the smart grid: A Stackelberg game approach. IEEE Trans. Smart Grid **2013**, 4, 120–132.

[12] Parvania, M.; Fotuhi-Firuzabad, M. Demand response scheduling by stochastic SCUC. IEEE Trans. Smart Grid **2010**, 1, 89–98.

[13] Deilami, S.; Masoum, A.S.; Moses, P.S.; Masoum, M.A. Real-time coordination of plug-in electric vehicle charging in smart grids to minimize power losses and improve voltage profile. IEEE Trans. Smart Grid **2011**, 2, 456–467.

[14] Carryl, C.; Ilyas, M.; Mahgoub, I.; Rathod, M. The PEV security challenges to the smart grid: Analysis of threats and mitigation strategies. In Proceedings of the 2013 International Conference on Connected Vehicles and Expo (ICCVE), Las Vegas, NV, USA,2–6 December 2013, pp. 300–305.

[15] Liu, J.; Xiao, Y.; Li, S.; Liang,W.; Chen, C.P. Cyber security and privacy issues in smart grids. IEEE Commun. Surv. Tutor. **2012**, 14, 981–997.

[16] Liu, N.; Chen, J.; Zhu, L.; Zhang, J.; He, Y. A key management scheme for secure communications of advanced metering infrastructure in smart grid. IEEE Trans. Ind. Electron. **2012**, 60, 4746–4756.

[17] Qi, J.; Hahn, A.; Lu, X.;Wang, J.; Liu, C.C. Cybersecurity for distributed energy resources and smart inverters. IET Cyber-Phys. Syst. Theory Appl. **2016**, 1, 28–39.

[18] Srikantha, P.; Kundur, D. A DER attack-mitigation differential game for smart grid security analysis. IEEE Trans. Smart Grid **2015**, 7, 1476–1485.

[19] Lu, R.; Liang, X.; Li, X.; Lin, X.; Shen, X. EPPA: An efficient and privacy-preserving aggregation scheme for secure smart grid communications. IEEE Trans. Parallel Distrib. Syst. **2012**, 23, 1621–1631.
[20] Radoglou–Grammatikis, P.I.; Sarigiannidis, P.G. Securing the smart grid: A comprehensive compilation of intrusion detection and prevention systems. IEEE Access **2019**, 7, 46595–46620.