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Review on Smart Grid – A Future Energy Management System

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Abstract— **This paper is mainly focused on the study of smart grid which is a future energy management tool for all energy resources. The intelligent grids are integrated with innovative technology to provide long-term electrical supply and to deliver the energy productivity. The smart energy meters will play a major role in smart grid system and compared with the conventional energy meters. Beyond the energy management system on smart grid, the paper also brings forth the constraints and benefits of the smart grid which concludes a suitable solution.**

Index Terms— **Electrical energy system, Energy Management, Smart grid, Smart grid Metering.**

I. Introduction

According to the Electric Power Research Institute (EPRI), "a smart grid system is one that integrates digital services into every phase of power generation, distribution, and consumption in order to reduce costs and boost efficiency while minimizing environmental impact." Smart grid technology improves the energy system's dependability, pliability, confidentiality, and efficiency essential factors in the continuing upgrading of the power distribution network. The characteristics of grid redevelopment are:

- Ultimatum response, Importunate request for resources, and energy-efficiency supplies are all being developed and incorporated.
- Smart meters, grid services and status communication systems, and transmission automation using intelligent technologies that are real-time, automated, collaborative technologies that optimise the physical operation of appliances and consumer gadgets.
- The utilisation of intelligent gadgets and costumer electronics (U.S Department of Energy, 2018).

A smart grid is a technology that authorize the customers and power generation companies to communicate in two directions. The intelligent meter, i.e., the smart meter put on the customer end, is a must-have for Smart Grid. Although "Smart Metering" can flourish without the Smart Grid connection, the Smart Grid is reliant on it. The following are the core Smart Grid drivers: Combined Multiple-Energy, income Safeguard, Operational Efficiency Consumer gratification, Energy productivity.

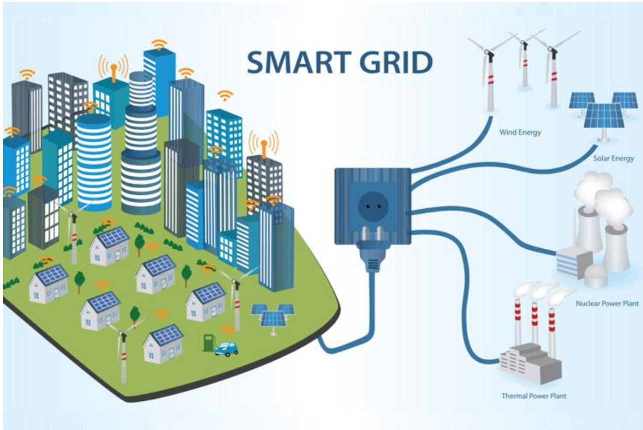

Fig. 1. Concept of a Smart Grid (IEEE, 2019)

A Smart Grid system is an electrical network that can intelligently form the actions of all users connected to generation units, consumers, and those who do both – in order to provide a cost-effective, long-lasting, and secure supply of power. The term "smart grid" refers to a future-generation power transmission network that uses information technology and other sophisticated technology to function sensibly. In terms of new technology, the electricity business has lagged behind the telecom industry. However, if we look at the current state of the telecom business, it was not as sophisticated as it is now, say 8-10 years ago. Mobile phones were only used for receiving and outgoing calls as a form of wireless communication. However, in the last 5-8 years, this business has seen a spectacular transformation, and today offers hundreds of services to its end clients through the use of cutting-edge IT and other creative technology. Now it's the turn of the power industry, as smart grid, which is transforming electric power networks and is nearly as powerful as the Internet, is getting a lot of interest from a variety of companies (Lamba, 2011). Total worldwide energy consumption will rise by 28% from 575 quadrillion British Thermal Units (BTUs) in 2015 to 736 quadrillion BTUs in 2040, according to the International Energy Outlook 2017. As a consequence, increased global electricity consumption is predicted to provide new opportunities for the global solar panel recycling market throughout the forecast period. Because of the growing focus on climate change and the long-term sustainability of fossil fuels, demand for renewable energy has surged in the global power generation mix. The amount of renewable energy sources (including hydropower)

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in the global power generation mix grew by 26% in 2018 compared to 2000 (Surender Rangaraju, 2021).

The installation of smart meters is typically related to the deployment of smart grids. They were employed to relay customer information back to the grid in the 1970s and 1980s. However, even with the most recent advancements, the most important and critical necessity is still being considered: energy transmitting and delivery through the electric power grid's dependability and efficiency However, according to the most recent study, grids and network systems should not only be used for transmission and distribution, but also for generating clean and sustainable energy in order to minimize greenhouse gas emissions and carbon emission (OsamaMajeed Butt, 2021).

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II. THE SMART ELECTRIC ENERGY SYSTEM

The future Modernized Grid system is a goal that will need financial justification at every stage prior to execution, as well as testing and verification prior to widespread adoption.
However, it is not necessary or practicable to execute all features at the same time in order to qualify as a Smart Grid; alternatively, each new feature might be developed independently. Each one will require cost justification and a reasonable return on investment. After the advances have been tested, though. If fully implemented, the Smart Grid will have the following characteristics:
To combat global climate change, authorize the use of renewable energy resources. Authorize more user engagement in order to improve energy conservation. To ensure system security, authorize the use of cyber-secure communications systems. Authorize more efficient use of current assets in order to ensure long-term viability. Authorize the use of improved energy flow to decrease energy losses and expenses. (Gharavi & Ghafurian, 2011).

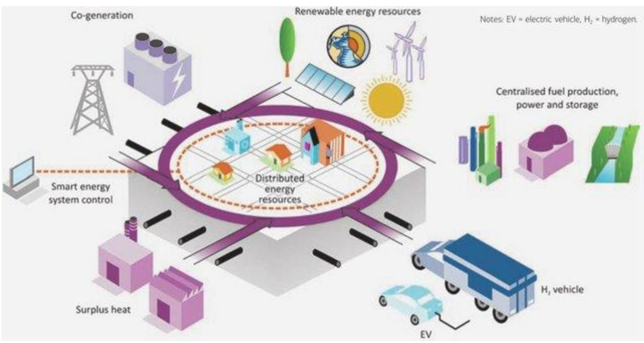

Fig. 2. The future's smart and incorporated energy network (Raillon, 2018)

It's important to note that the Smart Grid, as defined above, doesn't really enhance the conventional electric system; instead, it establishes a framework infrastructure to maximize the use of existing assets while also allowing for the addition of new features. Centralized power will continue to play an important role in the Smart Grid, but massive scale wind and solar energy will become key components of the generating mix where cost is reasonable.

III. COMPARSION WITH CONVENTIONAL ELECTRICAL SYSTEM

A network of energy producers and consumers is connected by transmission and distribution networks in an electrical system. A classic power system model is depicted in comparison with the smart grid which includes producing stations, transmission lines, and distribution lines serving various loads. Aside from that, there are control centers that assist with power system operations and control. During numerous forms of system problems, the power system protection unit safeguards the electric power (PankajGupta, 2021).

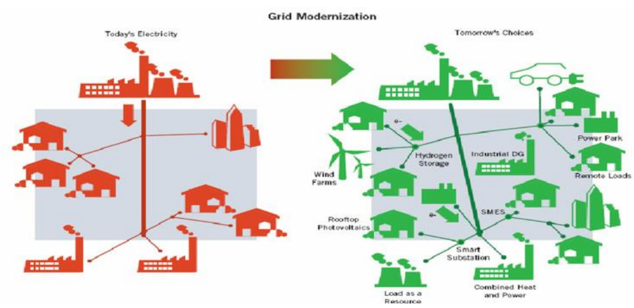

Fig. 3. Smart Grid - A Tomorrow's choice

The traditional power system is compared with the smart grid as a future energy management source to satisfy the power demand and its characteristics are featured below with the comparison in figure 4. The transmission system is being heavily used to balance the system's capacity due to the rising rise of demand. Demand is not distributed equally across the country (Surender Rangaraju, 2021).

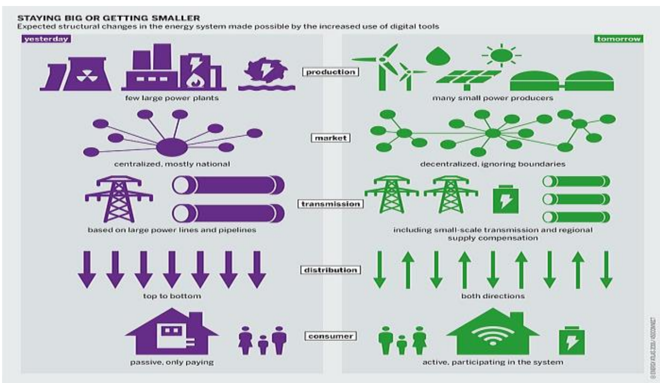

Fig. 4. Smart grid and conventional power system (Wikipedia, 2016)

The facility is rigid, making it hard to inject electricity from alternative sources at any point along the grid or to properly and sustainably manage additional services demanded by electrical users. Consumer understanding of electrical energy consumption is restricted to a monthly bill that arrives at the end of the month after the fact. Real-time monitoring and control are mostly restricted to generating and transmission, with just a few utilities extending it to the distribution system, allowing consumers to participate passively. From the source to the customers, energy flows in a single path. These are some of the real time facts on the traditional power system.

IV. IMPLEMENTATION OF ENERGY MANAGEMENT IN SMART GRID

The Energy Management System (EMS) began as a control center in 1960 and was renamed the Energy Control Centre (ECC) in 1970. When advanced computerized SCADA appeared in 1990, it was renamed Supervisory Control and Data Acquisition (SCADA-EMS), and it eventually evolved into a real-time system known as EMS, which encompasses various control techniques such as Demand Side Management (DSM), Load Control (LC), and Distribution Management System (DMS).

Energy management can be used by electricity suppliers (such as electric utilities, power plant operators, and manufacturing units) to efficiently control their generation units. For example, to satisfy a specified power demand from customers, the electric utility can use energy management to turn on some generators with the lowest operating costs, While the producers with the greatest running costs are left to meet the extra load demand during specified peak hours. In this approach, the electric utility hopes to lower the cost of operating its producing units.
The system operator (such as transmission and distribution systems) can utilize energy management to regulate power flow to decrease energy losses on the network and increase the penetration level of renewable energy sources (such as PV and wind farms) in a cost-effective way. End-users include households, residential and commercial structures, and industries. (Alzaareer, 2019).

Technical, economic, techno-economic, environmental, and social-economic goals are all part of an EMS. The majority of EMS research efforts are geared toward achieving economic goals. These goals include things like total cost of operational energy, royalties, and distributors profit maximization, among others. If economic goals are set, technical constraints must be considered as well, because if none of these technical constraints are taken into account, the EMS could produce an optimal result in terms of economic performance at the risk of causing a power outage, a power failure, or damage to distribution network appliances. Energy quality, transformer deterioration, and equipment performance are the technical foci of the EMS, and tackling them leads to higher system performance, increased life expectancy, improved power quality, and decreased maintenance and unavailability (Meryem Meliani, 2021).

The use of energy management in transmission system central optimization is still a viable option. The centralized structure of an EMS may be defined as a central controller with a high-performance processing system and secure, dedicated network connectivity for energy management. This controller, which may either be an aggregator or a utility, collects all information from each node, such as the load/energy consumer's consumption pattern, the DER's energy production, and so on, in order to conduct optimization algorithms aimed at attaining their objectives (Yan, 2015).

Contributions in this field focus on how solar and wind energy may help with large-scale deployment, as well as the possibility of demand-responsive flexible loads (DR). A novel optimum planning technique that considers DR is offered, for example, for energy systems that include large-scale wind generation (Verma, 2018).

V. CONTROL STRATEGIES ON SMART GRID

When it comes to integrating renewable energy sources with the grid and energy storage systems, control mechanisms are crucial (ESS). As a result, several control strategies are examined, with a focus on intelligent control and optimization approaches in renewable energy systems incorporating hybrid energy storage systems (HESS).

The classical control strategy of the first level is local or primary control, which is based on local measurements and has a quick response time while also requiring no connection. Because they rely on local measurements, islanding detection, output control, and power sharing controls are incorporated. The secondary control levels are essentially Energy Management Systems (EMS), whilst the tertiary control level is based on the host grid and deals with communication and coordination across numerous microgrids in line with the needs and requirements of the main grid. Cache control for ESS and adaptive droop control for battery long-term and real-time operations is employed, and it is more effective and dependable than existing droop controllers. In order to deliver active and reactive power to the grid, vector control of power is described, which requires decoupling control of the reactive and active current components. Fuzzy logic, artificial neural networks, and genetic algorithms are employed in intelligent control. (Rabbani, 2020).

VI. CHALLENGES IN SMART GRID

Future intelligent grid technologies are enabled by two-way communication technologies, control systems, and computational capabilities. Advanced sensors known as Phasor Measurement Units (PMUs) that enable operators to assess system reliability, advanced digital meters that give consumers better information and instantaneous report outages, relays that effortlessly sense and recover from substation faults, automated feeder switches that re-route power around problems, and batteries that store excess energy and make it available to the grid later to meet customer demands are among the advanced technologies (Office of Electricity, n.d.).

Smart Grid field project measurements, cost and benefit analysis face some significant hurdles. The following are some of the Drawbacks:
Collecting the right data at the right time and place, determining societal benefits, extrapolating findings from a few circuits to a broader control area, Interpreting Smart Grid responses to electrical disturbances, Recognizing regional variances for electric service providers and consumers. Providing a level playing field for comparing baseline and Smart Grid performance. (Bossart & Bean, 2011)

Heterogeneous wired and wireless networks and devices from diverse domains make up the smart-grid metering and control system. Each smart grid subsystem presently adheres to its own set of rules and regulations, as well as having its own set of security needs. The combination of rigorous security requirements, limited computational resources, time-critical message delivery and answers, and the utilization of heterogeneous networks with numerous authentication and protection systems presents unique problems to the smart grid. Although business and academics have made significant efforts to solve a variety of security vulnerabilities in the smart grid, there are still numerous obstacles to overcome before smart grids can be extensively implemented.

Due to the prospect of inferring customer's behavior and habits from comprehensive energy usage statistics, smart-grid communications have prompted severe concerns about user privacy, potentially users might be exposed to illegal behavior and personal data leaks. Advanced privacy-preserving security techniques must be developed and implemented into smart-grid networks so that utility firms may conduct routine business activities such as customer invoicing only based on aggregated power usage data. Individual consumers should have access to real-time power use statistics (Xinxin Fan, 2013).

VII. MERITS OF SMART GRID

Intelligent grids may be able to meet increased consumer demand without the need for infrastructure improvements. It cuts down on long-term outages and the expense of subsequent restoration. Emissions can be greatly reduced. As a result, smart grid helps to keep the environment green. It significantly reduces oil use and shortages. As a result, the grid provides individuals with security by ensuring that electricity is available at all times. It eliminates technical glitches due to automatic operation based on fluctuating load conditions. Demand-Response lessens the burden on smart grid assets during peak periods, lowering the chances of default. It lowers the amount of power lost at transmission, distribution etc. It saves money on power, meter reading, T&M operations, and maintenance, among other things (RF Wireless World, 2012).

VIII. DEMERITS OF SMART GRID

The upfront expenditures of a smart grid are astronomically high and time-consuming, raising personnel costs yet, this new market for smart grids has the potential to lead to a whole new market for power, resulting in the creation of many employments (Artemia, n.d.).
In a smart grid system, network congestion or performance are major problems during an emergency. In unusual scenarios such as a windstorm, severe rain, or lightning, cellular network operators do not guarantee service. There should be a continuous communication network accessible. Replacement of analogue meters by more advanced electronic meters has resulted in a high cost; Smart grid technologies have no regulatory standards, and smart grid technologies have no regulatory norms. Official technological documentation is lacking (ForumAutomation, 2018).

IX.CONCLUSION

The smart grid system has many benefits and drawbacks beyond the such stumbling block let us consider the positive phase of it. It is creating the necessity for the solution for the future power demand as it provides electricity and information together. The smart grid provides the future energy management system which is integrated with all the power sources and collects the data of the whole power consumed which calculates the unused electrical power of some regions and such power can be collected with help of microgrids and ESS and utilized for Electric vehicles. With the help of smart grid many industrial sectors may be benefited as they require power as an emergency. Even though, the tough situation arrives smart grid are designed to provide the optimized stability and efficiency.

REFERENCES

[1] U.S Department of Energy, 2018. *Smart Grid System Report 2018.* [Online] Available at: https://www.energy.gov/sites/prod/files/2019/02/f59/Smart%20Grid%20System%20Report%20November%202018_1.pdf
[2] Lamba, G. S., 2011. *Smart Grid and its Development Prospects In the Asia-Pacific Region.* [Online] Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.302.7592&rep=rep1&type=pdf
[3] OsamaMajeed Butt, M. B., 2021. Recent advancement in smart grid technology: Future prospects in the electrical power network. *Ain Shams Engineering Journal.*
[4] Raillon, L., 2018. *Experimental Identification of Physical Thermal Models for Demand Response and Performance Evaluation.* s.l.:s.n.
[5] Gharavi, H. & Ghafurian, R., 2011. Smart Grid: The Electric Energy System of the Future. *Proceedings of the IEEE.*
[6] IEEE, 2019. *The Smart Grid and Renewable Energy.* [Online] Available at: https://innovationatwork.ieee.org/smart-grid-transforming-renewable-energy/
[7] PankajGupta, R., 2021. Chapter 1 - An introduction to the smart grid-I. *Elsevier.*
[8] Wikipedia, 2016. *Smart grid.* [Online] Available at: https://en.wikipedia.org/wiki/Smart_grid
[9] Yan, X. Z. L. W. Y. e. a., 2015. Secure smart grid communications and information integration based on digital watermarking in wireless sensor networks.. *Enterp Inform Syst.*
[10] Verma, P. S. D. S., 2018. A review of uncertainty handling techniques in smart grid. *Internatiuonal Journal on Uncertainty Fuzziness Knowledge Based System.*
[11] Meryem Meliani, A. E. B. I. E. A. A. M. D. M. M., 2021. Energy management in the smart grid: State-of-the-art and future trends. *International Journal of Engineering Business Management .*
[12] Surender Rangaraju, O. I. A. G. P. L. V. S. B., 2021. Review on Energy Storage Systems (ESS) - A Study on Effectiveness of ESS Solution in Vietnam's Solar Energy Storage. *International Journal of Research Publication and Reviews.*
[13] Surender Rangaraju, O. I. A. G. P. L. V. S. B., 2021. Solar Panels Life After Death – An Overview on Solar Panel Recycling Methods and Imminent Business Opportunities. *International Journal of Multidisciplinary Research and Publications.*

[14] Rabbani, M. A., 2020. *Optimizing and Measuring Smart Grid Operation and Control Chaper8: Smart Grids and Hybrid Energy Storage Systems: Optimization Techniques Applied in Control Strategies for Hybrid Energy Storage Systems.* s.l.:IGI GLOBAL USA.

[15] Office of Electricity, n.d. *Grid Modernization and the Smart Grid.* [Online] Available at: https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid

[16] Alzaareer, C. Z. E.-B. a. K., 2019. *Energy Management in Smart Grid.* [Online] Available at: https://smartgrid.ieee.org/newsletters/august-2019/energy-management-in-smart-grid

[17] Xinxin Fan, G. G., 2013. Security Challenges in Smart-Grid Metering and Control Systems. *Technology Innovation Management Review.*

[18] Bossart, S. J. & Bean, J. E., 2011. Metrics and benefits analysis and challenges for Smart Grid field projects. *IEEE 2011 EnergyTech.*

[19] Artemia, n.d. *THE PROS AND CONS OF SMART GRID TECHNOLOGY.* [Online] Available at: https://artemia.com/blog_post/the-pros-and-cons-of-smart-grid-technology/

[20] ForumAutomation, 2018. *Smart Grid - Benefits of using smart grid, Disadvantages.* [Online] Available at: https://forumautomation.com/t/smart-grid-benefits-of-using-smart-grid-disadvantages/4422

[21] RF Wireless World, 2012. *Advantages of Smart Grid | Disadvantages of Smart Grid.* [Online] Available at: https://www.rfwireless-world.com/Terminology/Advantages-and-Disadvantages-of-Smart-Grid.html