Renewable Energy Integration in Smart Grid

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ABSTRACT: Environmental concerns and the rising cost of fossil fuels have prompted a significant increase in the use of renewable energy sources. The amount of electricity produced has an impact on the integration of renewable energy with utility infrastructure. Large-scale power generation is connected to transmission networks, while small-scale distributed power generation is connected to distribution networks. The direct integration of both kinds of technologies creates certain challenges. As a result, wind energy has attracted significant investment from throughout the globe. However, it is difficult to acquire excellent quality electricity owing to the unpredictability of wind speed, because wind speed changes affect the voltage or active energy density of the electric machine attached to the wind turbine. Solar perforation alters the voltage stability or frequency responsiveness of the system, as well as the utility grid's generation or distribution systems. The potential of power storage technology to improve the integration of renewable into the smart grid is examined in this paper, as well as the concerns, challenges, and usage of renewable sources (RES) Grid Integration. In this paper, author talks about renewable energy integration in smart grid. Renewables are expected to account for about 95percent of the growth in worldwide power capacity by 2026, and solar PV accounting for more than half of it. Between 2021 and 2026, the quantity of renewable capacity installed is predicted to be 50% more than between 2015 and 2020.

KEYWORDS: Grid Integration, Renewable Energy, Renewable energy sources, Smart Grid.

1. INTRODUCTION

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While renewable energy sources such as wind energy have enormous potential to significantly reduce emissions or another impact to the environment associated with electricity generation, incorporating these techniques into the electric power grid remains a technological or institutional challenge. Big-scale increase in energy consumption necessitates grid upgrading, including a great deal of energy to transport or integrate electricity produced from large, variable renewable energy sources, as well as low-voltage distributing to integrate small-scale, distributed renewable energy (Vakulchuk et al., 2020). The phrase "smart grid" encompasses a wide range of specific technologies, such as enhanced meters, energy storage, sensors, or others, that are critical for the integration of much more renewable or low-carbon electricity into the electric power system. The creation of new standards, management techniques, and technologies to improve dependability, assure affordability, or control the temporal but also geographical variability of renewable power production is also included in the smart grid (Güney, 2019).

Smart grids have the potential to provide a more dependable or secure energy sector, a more robust economy, a healthier environment, or an empowered populace involved in energy system management, among other social advantages. The potential advantages (and hazards) of the smart grid are valued differently in various circumstances and among different important players (Aboagye et al., 2021). Even though the vital ties between a "smarter" grid and renewables are among the most popular arguments for smart grid, the various promises of smart grid result in a difficult policy discourse that goes beyond the smart grid and renewable energy. The emergence of linked technological and social systems integrating government or commercial stakeholders just at federal, regional, or state levels is required to develop a smarter grid (Levenda et al., 2021).

1.1. The Importance of a Smart Grid:

The majority of the world's power is supplied via a system that was created roughly 50 years ago. These are inefficient and incapable of responding effectively to today's serious global concerns. Within the next 20 years, an estimated $13 trillion in power infrastructure investment would be needed. As a result, there is a pressing need and opportunity to transition to a low-carbon, efficient, or clean

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energy system. In this transformation, smart grids would be a critical facilitator (Burke & Stephens, 2018). The smart grid is a wide community of transmission systems, equipment, controllers, and new technologies that work together to react quickly to the electrical demand of the twenty-first century. It enables an end-to-end intelligent two-way distribution system from source to sink that is both efficient and dependable. In this manner, the system ensures efficiency and long-term viability in addressing rising energy needs while also ensuring dependability and high quality. Smart Grids also allow for real-time power system measurement and reporting. Smart Grids' main goals are to encourage active customer participation, accommodate sustainable energy generation or storage options, enable innovative products that will improve the economy, optimize strength utilization but also work effectively, address disruptions through automated prevention, containment, but also restoration, or operate resiliently against all hazards (Khan & Dwivedi, 2018).

Existing systems were built to distribute power to customers and charge them monthly. The electricity demand has been increasing, making it harder for current systems to keep up. Smart Grids offer two-way transmission, allowing consumers and utilities to share power and information. Smart Grids include innovative new technologies, smart meters, or data monitoring and control capabilities. It also connects renewable energy sources like wind and solar to power systems. Furthermore, users may control their power consumption by using Smart meters placed in their houses to monitor their usage (Kumar & Jain, 2021). Smart instruments that modify their run schedules to minimize power consumption on the grid at key periods and cut energy costs may be built. Peak demand necessitates the operation of extra, and sometimes less efficient, power plants to fulfill the increased demand. With the help of its consumers, smart grids will allow utilities to regulate and reduce power use (Jun et al., 2021). Electricity usage may be managed in real-time by operators. The present distribution system is inefficient, and any disruption caused by poor weather or storms, or by rapid changes in electrical consumption, might result in power outages. Smart Grids transmission intelligence mitigates energy swings or outages by automatically detecting and rerouting faults, as well as restoring power supply (Gola & Gupta, 2021).

1.2. Smart Grid Features In General:

The following are some of the characteristics of a smart grid:

- Engage users or markets in conversation.
- Scalable and adaptable to a variety of scenarios
- Designed for maximum resource and equipment use.
- To avoid crises, be proactive rather than reactive.
- Advanced automation and self-healing grids.
- Integrated, with monitoring, control, and protection all rolled into one.
- Network equipment with plug-and-play capabilities
- Information and communication technology (ICT) solutions.
- Trustworthy and safe
- Budget-friendly.
- Provides information or monitoring in real-time

Traditional grids have centralized power production, unidirectional power flow, and poor market integration just at the distribution system. Smart grids include centralized power production that is mostly derived from renewable energy sources. Spreader but also active resources are integrated into the electricity market and power generation (Yadav et al., 2021). The power city is an electrical network that intelligently connects producers or consumers to effectively distribute power that is adequately competent, accessible, safe, affordable, dependable, efficient, and sustainable across its coverage area. One of the two main goals for improving electricity generation interactions both for utilities and end-users tends to drive smart grid developments (N. Jain & Awasthi, 2019).

1.3. Smart Grid Technology:

Renewable energy technologies (RESs) cannot completely replace the current electric energy grid. New technologies aren't yet advanced enough to supply the world's complete energy needs. As a result, renewable energy sources must be integrated into current grids to revolutionize the system. Two concentric circles represent a smart grid. The outside circle denotes energy movement, whereas the inner circle denotes data flow across communication networks. Different ways

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have been applied to regulate the energy flow in networks that include dispersed power sources (R. K. Jain et al., 2012). The energy hub, which manages several energy carriers, is an intriguing concept. Energy converters at each hub convert one element of the transfer of energy into a different kind of energy. With the advancement of the smart grid system, meters will be able to manage household appliances, allowing customers to utilize more creative tactics to save money on power during times of high prices. As a result, peak load shift will be possible, or the system are more cost-effective and environmentally benign (Gupta et al., 2021).

1.4. Smart Grid Characters:

The following are the main qualities of a smart grid that help it achieve the electrical power sector's goals:

- Safe and Reliable:

Rather than a significant power outage, large electrical failures, malfunctions, natural catastrophes, harsh weather, as well as man-made damage, the energy is now on the power distribution capacity for the user.

- Efficient and Economical:

By policy innovation, management, but also energy efficiency, as well an orderly competitive market, the electric grid will be able to increase the economic advantages. Power networks are provided to allow for logical resource allocation, efficiently deal with the electrical market, decrease power loss, or promote energy efficiency (Singh & Khan, 2012).

- Clean and Green:

Smart Grid may lessen the possible influence on the environment by using large-scale renewable energy sources, such as carbon emissions reduction and more green energy.

- Optimization:

The most cost-effective price for the electrical energy supplied to society. Smart grid to improve resource use while lowering investment, operating, and

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maintenance expenses. Power quality is up to industry requirements as well as customer expectations.

- Interactive:

The services are enhanced by interactivity and real-time responses to the energy market or consumers. There are mature wholesale price operations in place, as well as a well-integrated country and well-integrated coordinators.

- Self-healing:

The new electrical grid includes self-healing capabilities. It's a method for improving service quality, increasing dependability, and lowering expenses. It instantly detects and corrects supply-demand imbalances, as well as identifying and corrects errors.

- Integrated:

On such a grid, a uniform platform or model is used. It can achieve high-quality power grid assimilation and information exchange, as well as standard, prescriptive, and refined business owners that integrate the infrastructure, procedures, devices, information, and market structure, allowing power to be generated, dispersed but used effectively or cost-effectively (Meza et al., 2021).

1.5. The Current Grid Has Problems:

An electrical grid is a network that connects suppliers and customers to distribute electricity. The electrical grid has progressed from a small, isolated network that served a single geographic region to a larger, more extended network that served numerous places. The electric power grid is a complicated system that transports energy produced at power plants through transmission lines to substations, and then via distribution lines to a variety of users around the country. Local grids were connected to establish more resilient and broader networks to create this system. While this strategy worked in the past, increased growth has caused the grid to become overcrowded in high-demand areas (Van et al., 2020). The system often encounters disruptions in electric service as a consequence of this surge in demand. Several of these outages are caused by issues at the distribution level, which may be addressed via distributed energy storage techniques. The inadequacies of present grid networks are highlighted by service outages, emphasizing the urgent need to update the electric grid so that it can adapt to rising energy demand and shifting generating sources. While constructing new power plants, transmission, or distribution lines is costly or complex, energy storage may improve the capacity factor of present system operations (Garg et al., 2012).

Infrastructure growth might be aided by advanced storage, which could be a trustworthy and cost-effective alternative. The move to renewable energy sources like wind and solar is perhaps the most important development driving the demand for grid-scale energy storage. While coal has historically been the most common fuel for power production, a focus on cleaner energy but a reduction in dependence on fossil fuels or other non-renewable resources has shifted the focus to renewable sources (Vakulchuk et al., 2020).

1.6. Technical Advantages:

The following must be considered technical advantages of EES:

- Bulk energy time-shifting allows for load leveling or peak shaving while also allowing for power price arbitrage. Electric cars, for example, are one sort of EES that may give these power management advantages, resulting in smart grid or renewable energy integration.
- EES ensures more main aim is to improve energy usage and contribution, while also encouraging the use of dispersed electricity generation choices in networks.
- With full charge (down) or complete discharge, efficient storage may supply two times the capacity for regulatory applications.
- Storage output may be quickly altered, providing grid ramping assistance or a black-start.
- Energy storage may be utilized to improve the dependability of grid services.
- Energy storage may save utilities or independent system operator’s money by deferring transmission or distribution upgrades.

1.7. Economic Advantages:

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The following should be considered economic advantages of EES:

- Energy storage may help clients save money on their power bills.
- Off-peak power is often less expensive than peak electricity, which favors the electricity seller.
- It helps to stabilize the price of energy on the market, allowing the power sector to operate more freely.
- Speculation and the instability that fossil fuels entail.
- It will help many nations build their economies and provide job opportunities.
- It will enable more efficient usage of renewable or off-generating capacity, resulting in increased investments in these systems.
- Reduces any need for generation & distribution capacity increases, reducing the amount of money spent on unneeded upgrades.

1.8. Grid Integration Issues In Renewable Energy Sources Systems:

1.8.1. Renewable Power System:

Wind energy production is expanding day by day to enhance rural electrification and generate employment possibilities in technology due to the great supply of wind renewable sources. However, there are several limitations to incorporating strong wind energy into the system. Wind velocity forecasting has a high level of unpredictability, volatility, or predictability, which compromises system security or income. Maintaining the voltage profile is a problem (Güney, 2019). The majority of wind turbines are connected to SCIG, which cannot sustain reactive power in the grid. Due to the increasing integration of wind energy resources and the poor fault ride-through (FRT) capabilities of wind generators, there is more stress just on the breaker, transmission line, and bus bar when a fault occurs. Renewable power penetration is restricted by the system's ATC (existing transmission capacity), which poses stability issues and the possibility of blackouts. Due to the lower inertia of scattered wind turbines, the system's frequencies behavior varies with air pungent. Finally, wind energy is inefficient and produces poor-quality electricity (Aboagye et al., 2021).

1.8.2. Solar Energy System:

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In the world, there is a vast quantity of solar energy. People use almost 15 terawatts of renewable radiation. Solar power appeals to customers because of its cheap cost, environmental friendliness, ease of installation or lack of reactive power use by solar panels. However, solar generating is constrained by high solar panel installation costs, limited generation capacity, solar irradiance unpredictability, or power fluctuation owing to sunlight's intermittency (Burke & Stephens, 2018). The voltage profile and frequency responsiveness of the system is also affected by solar pungent. The power output features of a Photovoltaic system are determined by the inverter, which is drawn using the unity power factor. Due to the lack of inertia in solar systems, additional devices are required to sustain frequency oscillation (Levenda et al., 2021).

2. DISCUSSION

Economic growth, energy security, greater access to energy, or mitigating environmental issues due to global warming are all reasons for India to deploy renewable resources. India has become one of the most promising opportunities for renewable energy due to strong government regulations and an improving economy. The Indian government has devised several frameworks and regulations to encourage foreign investment in the country's renewable energy sector. Power systems may be a viable option for lowering fluctuations or intermittent issues. In addition, to lessen power fluctuations, energy storage or the use of a dump loads in PV systems may have been used. Grid integration issues might be alleviated by bringing fresh manufacturing and storage elements into the balance of activities.

3. CONCLUSION

In recent years, the penetration rate of DG into the grid has expanded significantly in the power generating and distribution network. End-user appliances are paying greater attention to the power quality. This case examines the reasons for poor power quality from a technical standpoint. Issues with renewable-energy-based distribution generating systems (wind energy, solar energy). Wind penetration lowers voltage, whereas sun perforation raises it. Power systems are potential choices for reducing variations or intermittent difficulties. In addition, energy storage or the usage of a dump load in PV systems might be employed to reduce power fluctuations. By introducing novel materials and storage components into the balance of processes, the problems regarding grid integration might be reduced. This study examines the potential of energy storage technology to promote renewable energy integration into the smart grid, as well as the issues, problems, and applications of renewable energy sources (RES) Grid Integration. The author of this study discusses renewable power integration in smart grids. By 2026, renewables are predicted to account for almost all of the expansion in global electricity capacity, with solar Photovoltaic accounting for even more than half of that. The amount of renewable capacity built between 2021 as well as 2026 is expected to be 50% higher than between 2015 through 2020.

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