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Grid Integrated Renewable Energy Resources (Res) - Challenges And Management Strategies: A Review

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Abstract
Due to the world's fast socio-economic expansion, environmental concerns, and the rising expense of fossil fuels, renewable energy resources (RES) are increasingly integrated into distribution networks.
The use of renewable energy sources (RES) offers several enticing characteristics; yet, there are some doubts about RES since there is a lack of monitoring and management of these grid-connected RES systems, which might contribute to the instability of the electric grid.
There are several obstacles to overcome when integrating solar PV and wind energy systems directly into the grid. Due to the influence of wind energy on voltage and active power production, it is challenging to maintain acceptable power quality. A variation in wind speed is responsible for this. The integration of solar PV, on the other hand, affects the voltage profile and frequency of the power system.
This article reviews the difficulties, threats, and ramifications associated with grid integrated solar and wind power.
Keywords: *Renewable Energy Resources (RES), Wind Energy, Solar PV, Grid, Integration, Distributed Generation (DG).*

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I. Introduction

Electric energy consumption increases, placing pressure on utilities to improve production. Nonetheless, utility companies are becoming more anxious about fulfilling growing energy demand. Fuel usage rises to fulfil the rising demand for electric energy as demand rises. (Alsayegh et al., 2010).

However, growing pollution levels, worries about rising temperatures, limited fossil energy resources, and rising prices have underscored the need of shifting to alternative energy sources as a long term energy choice. Because fossil fuels are finite resources, the use policy of fossil fuel resources must be carefully regulated. Despite the fact that economic expansion and tax incentives have hastened the expansion of the renewable sector, green sources must be explored in order to fulfil the aim of decreasing reliance on fossil fuels. (Arun et al., 2015).

Distributed generation (DG)is a phrase that refers to renewable energy sources (RES) that are incorporated into distribution systems. Renewable distributed generation (DG) will play a big part in the world's energy generation in the future. Currently, energy systems worldwide are experiencing substantial transformations as society transitions to the substantial utilization of cleaner and more sustainable sources (Hernández, 2021).

The benefits of increased penetration of renewable power distributed generation would improve supply security by reducing energy imports and establishing a varied energy portfolio. Because it supplies loads in islanded operations, the DG improves system dependability (Bayod-Rújula, 2009).

RES enhances system consistency somewhat, however, the substantial penetration of renewable energy into the grid offers a challenge; overzealous installation of DG units might have had an impact on power system stability and power quality.. Renewable energy sources usually used to generate electricity includes wind, photovoltaic, wave, marine, thermal, and bioenergy sources, among other sources (Abdmouleh et al., 2017) (Sandhu & Thakur, 2014).

II. Literature Review

Wind Energy Conversion System.

Wind power is the most promising renewable energy source in its capacity to generate electricity while emitting no greenhouse emissions (GHGs). WIND power generation is gaining popularity worldwide because it is cheaply accessible and can meet global energy needs. It is currently a vital element of the grid in many countries that have made significant investments in the sector. One of the fastest-growing and most cost-effective renewable energy (RE) sources accessible today. Wind power output grows on an annual basis worldwide, increasing its penetration into the power grid and contributing to the overall energy supply (Alsayegh et al., 2010).

However, there are several limitations to wind energy's power integration to the grid. Wind speed estimates have a high degree of uncertainty, volatility, and predictability, which reduces the system's security (Ahmed Sharique Anees, 2011).

Voltage stability

Voltage stability is described as a system's capacity to sustain voltage within a certain range for a specified time period and to recover to a steady-state voltage level after perturbations. Methodologies for static power flow analysis, including PV and QV curves are often used when analyzing voltage stability. The investigation of dynamic voltage stability, on the other hand, is essential for accurately identifying a system voltage profile (Al kez et al., 2020).

A common fear is that large-scale wind energy integration may result in sags/dips in voltage, noise, surges/spikes, and power outages. While the fluctuation of wind speed over time is one factor, other factors such as grid connection difficulties and huge malfunctioning motors are also to blame (Borges, 2012).

The major challenge for power networks with a significant proportion of wind energy is the capability to ride through a voltage drop after fault incidents.The reactive power output of certain dispersed wind power generators may be regulated in reaction to voltage changes at the point of common link (PCC). Particular control systems detect voltage fluctuations and manage reactive power injection appropriately. Induction type wind turbines, on the other hand, have a higher reactive power consumption during fault occurrences because their speed increases. A reactive power compensator (capacitor) is needed to maintain the PCC voltage decrease during a fault (Al kez et al., 2020).

Frequency Stability

Key criteria for determining grid security and balance between generation and consumption are fluctuations in the frequency of the grid and its stability. Unexpected faults may cause it to divert from its normal course of action on a large scale. To keep the system's frequency response constant, the operational synchronous generators use frequency control loops to manage output power (Al kez et al., 2020).

The addition of wind-generated electricity to the electrical grid significantly reduces overall system inertia, and the impact is significant for smaller isolated systems. Because distributed wind turbines have lower inertia, the frequency behaviour of the system alters as wind penetration rises. The equivalent moment of inertia of the system decreases. When the system's frequency varies. The frequency shift in time is not responsive in a doubly-fed induction wind turbine. Because the doubly-fed induction wind turbine is no longer participating in system frequency modulation, the total moment of inertia of the system falls, making a single frequency shift more difficult. (Zhu, 2019).

Harmonics

Wind turbine output, like that of other conventional generators, must fulfil acceptable power quality criteria (minimal harmonics emissions being one of these requirements). When wind turbines are erected, harmonics will be injected into the system. While starting (soft starting), the WEG draws a lot of harmonic currents, and these current harmonics will be reflected in the voltage harmonics at the WEG terminals due to the low fault levels. In addition, non-linear loads may be added to the system and generate voltage harmonics. Overheating of transformers and generators is caused by voltage harmonics. In addition, they cause shunt capacitors to overheat and fail, resulting in a loss of power. Cables, fuses, and bus bars are all affected by harmonics in addition to the fundamental current (Sugirtha & Latha, 2011).

Solar Energy

The sun provides a lot of energy to the world. Humans use moreover 15 TW. Customers are drawn to solar energy because of its low cost, environmental friendliness, and simplicity of installation. Solar energy's disadvantages include high installation costs, low producing capacity, and power fluctuation due to the intermittent nature of sunshine. Solar penetration modifies the voltage profile and frequency responsiveness of the system. The power factor of an inverter determines the output power of a PV system. It does not contribute to system failures or transients since it lacks LVRT (Low Voltage Ride Through) capabilities. Because there is no inertia, extra components are required to keep the photovoltaic system frequency (Sandhu & Thakur, 2014).

Distributed photovoltaic (PV) systems may improve the voltage profile and reduce system losses when penetration is low. Nevertheless, with significant penetration – when PV production exceeds the local energy need It produces reverse power flow-it may also bring overvoltage difficulties. Overvoltage difficulties generally develop at peak PV production when there is minimal or no load in the LV network. Aziz and Ketjoy (2017) noted that as photovoltaic (PV) penetration exceeds 20%, voltage spikes occur in medium voltage (MV) networks owing to the transmission system's inability to adapt to PV power impact brought by clouds movement. Undervoltage, to an extent of voltage breakdown, may also occur when peak photovoltaic production rapidly drops owing to clouds passage or other factors (Gandhi et al., 2020).

Based on the fact that the output production of grid connected Solar PV declines with the waning light of day. Their inability to communicate effectively has resulted in this the grid may use your resources when demand rises after sunset (when demand for electricity is greatest). In order to accommodate this rise in demand, electric utilities increase their output from traditional power units. The duck was established by the California Independent System Operator (CAISO) to demonstrate how grid integrated solar pv impacts the electric grid's performance (Sangswang et al., 2008).

Current harmonics are mostly created by existing electrical loads in strong networks, and solar DG does not seem to play a significant role in harmonic reductionEven existing harmonic emissions seem to be regulated by inverter control and grid strength; in weak grids, they appear to grow in relation to the number of connected inverters, but appear to stay constant in robust grids (Laukamp et al., 2008).

III. Grid-Connected RES's Expected Difficulties.

Issues and Challenges in integration of wind and solar PV to main grid

Because of their intermittent nature, wind turbines with photovoltaic solar panels systems are challenging to connect to the electricity grid. Intermittency and unpredictability in the generation of electric power from wind and solar systems are caused by several factors, including partial uncertainty, geographical reliance, and uncontrolled volatility. As a consequence of the above, utilities and grid operators are confronted with various issues when integrating wind and Solar PV power sources. The high penetration of PV generation is a topic of worry owing to the great fluctuation of the solar power source. Utilities firms are often concerned with the utility grid's efficiency, dependability, and safety(Kumar, 2020).

Grid integrated small RES may not impair power quality or disturb system dependability; but, as the injected energy of grid intergrated RES grows, it may affect system security, voltage control, stability, and system performance. Voltage surge, voltage flashing, and voltage harmonics may all be used to measure a decrease in power quality. Long-term outages imply a decline in dependability. (Alsayegh et al., 2010).

As a consequence, the following technical and non-technical aspects need to be considered in the integrating of Photovoltaic and wind energy systems into the power grid.

Technical Hurdles

A plethora of technical issues are discussed, including poor electricity supply (due to harmonics and frequency fluctuation), protection issues (such as voltage and power fluctuations), stability issues (such as current and voltage fluctuations), safety (such as weak grids), reliability (such as grid congestion), and expense (such as efficiency of grid interface).

Non-Technical Hurdles

The following non-technical challenges faced Due to the fact that most wind and solar energy sources are located in remote areas, there is a dearth of skilled technical personnel, transmission lines with limited capacity to connect large-scale power generation, a lack of competitiveness for wind and solar energy source technologies that discourages the construction of new power solar plants, and, finally, the non-dispatchability of wind and solar energy source technologies.

IV. Discussion And Interpretation Of The Various Solution In RE Utilization

Green energy sources such as photovoltaic, wind, and many others have accelerated the transition to more sustainable energy sources. The growing use of solar and wind power and distributed generators necessitates the development of new techniques for the operation and administration of the electrical grid in order to maintain, if not enhance, power-supply dependability and quality. In light of the above, various potential remedies have indeed been presented by scholars. Having in mind the above-mentioned, some of the most important RES solutions are:

The central solution for quality difficulties is a static synchronous compensator. Integrating an effective static synchronous compensator enhances voltage management and minimizes reactive power usage on the power grid. Static synchronous compensators increase power factor while decreasing overall harmonic distortion. Integrated energy storage decreases active power demand, improves voltage control, and boosts the transformer utilization factor of the renewable energy distribution network. It is feasible to combine these benefits by using a static synchronous compensator and an energy storage facility. Static synchronous compensators and energy storage systems enhance voltage management, power distribution, and transformer utilization while decreasing total harmonic distortion. Thus, by including a static synchronous compensator and energy storage, the power quality of the renewable distribution network is enhanced (Lehtola & Zahedi, 2020).

The production of power in distributed generation and the integration of renewable energy into the grid depend significantly on power-electronic technology, which is progressively being used as these systems become more integrated with the electrical grid. Because of two factors, there has been a tremendous advancement in power electronics in recent years. The first are ultrafast semiconductor switches that can switch swiftly while also managing high voltages. The second component is modern computer controllers, which are capable of executing complicated control algorithms in real-time. As a result of these properties, cost-effective and grid-friendly converters have emerged.

By dispersing the RES across a broader geographic region in tiny units, rather than one big unit concentrated in one place, the intermittent power production from the RES may be managed. Local phenomena like passing clouds, for example, may reduce the output power of a ten-megawatt solar PV system by seventy percent in five to ten minutes, indicating the need for the widespread installation of tiny solar PV systems. Because local problems may only impact tiny units of power and not the overall output power, fluctuations in total output power can be kept to a minimum (Ahmed Sharique Anees, 2011).

V. Conclusion

DG penetration into the grid has increased dramatically due to power generation and distribution systems improvements. This study discusses specific challenges about RES grid integration and potential solutions. According to various scholars, the most viable solutions to technical power quality issues include the use of an effective static synchronous compensator and high-quality power electronics and ongoing research to improve power electronics quality and defects. Finally, the use of small RES units dispersed geographically to overcome climate variability.

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