International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 07 | July - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Review on Integration of Solar and Wind into Power Systems Using MATLAB

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Abstract - Renewable energy is a viable option for generating power in modern society. Conventional energy generation is negatively impacting the environment. Humans' environmental and ecological lives. Renewable energy is abundant throughout the cosmos. Renewable energy sources are clean, environmentally friendly, efficient, and reliable. Solar and wind energy are becoming important in today's globe. This project presents latest advancements in power electronics for integrating wind and solar power producers. This article discusses current and future developments in solar and wind energy systems, with a focus on dependability and technical maturity. The Power Electronics interface is crucial for the proper integration of wind and solar energy systems, as well as their impact on power generation, especially when renewable energy sources account for a significant portion of the overall system capacity. However, there are challenges with grid integration of renewable energy sources. Given predicted developments, it's important to research potential solutions.

Key Words: Matlab, Free Energy, Solar, Wind, MSEB, Renewable Energy, Simulation

1. INTRODUCTION

Renewable energy resources will become a viable option for future energy demands. India's diverse size allows for the integration of renewable energy sources from multiple states into the national system, balancing their varied output. The Indian government aims to develop 25000 MW of grid-interactive solar and 28500 MW of wind power by 2030. Wind and solar energy are the primary renewable energy sources for power generation and have had rapid growth over the past two decades. Renewable energy sources, such as wind and solar, now account for a significant amount of grid power.

The future of electric systems is influenced by government policy, customer efficiency needs, and the introduction of new technology. Environmental concerns have led to global government policies promoting energy efficiency, conservation, and renewable sources of electricity. The following factors are driving the adoption of new renewable energy and storage technologies, as well as energy efficiency and conservation measures.

Figure-1: The Smart Grid and Renewable Energy Resources

Consumers are more empowered to make energy-related decisions that impact their daily lives. Additionally, they are increasing their energy requirements. Consumer participation will lead to increased use of electric vehicles, remote control of home appliances, ownership of distributed renewable energy sources, and management of electricity storage to match supply and demand. New technologies, like SCADA system sensors, secure 2-way communications, integrated data management, and intelligent controllers, have created opportunities that were not possible even a decade ago.

2. Literature Review

The literature review is divided into two sections: modeling and performance evaluation of RPG integration into existing power systems with AC/DC transmission/distribution networks. Topics covered include load classification, price calculations, real and reactive power flows, voltage/frequency regulation, power inverters, protection schemes, and use of the internet of things. Integrating renewable energy into power system planning involves balancing the renewable power generation (RPG) portfolio with load fluctuations to provide dependability and enhance renewable capacity through appropriate generation, transmission, and distribution planning processes. Renewable power generation should follow daily and seasonal trends based on net load. To save costs, the power system load curves should be linked to the RPG portfolio, which should be dispatched daily based on the fuel mix and expected load levels.

RPG enables regular load-following and frequency control through efficient market design, precise renewable resource forecasts, and resource data collection and extraction. The transmission planning model examines the infrastructure used to distribute electricity from generators to loads and performs time domain simulations for various operating scenarios. Finally, distribution planning takes into account weather conditions that impact loads in various topologies, voltage levels, and equipment. Automated screening methods and peak load calculations will be essential for RPG installs in existing distribution systems.

To address feeder voltage control, fault current, and protection desensitization, use on-load tap-changers in the substation and self-commutated inverters as needed.

Small-scale renewable energy generation at unity power factor incurs significant costs for utilities to provide reactive power. Large renewable power plants are recommended for efficient real and reactive power flow, controlled voltage management, and improved power factor. Renewable power penetration in a power system varies depending on factors such as load type, weather, feeder capacity, network parameters, system design, and connection type (three or single phase). Researchers have examined the influence of RPG on the electric power grid, a complex process. First, create an accurate model of the power system, including renewable energy technologies, load patterns, and demand response. The process includes evaluating power quality and dependability, recommending corrective remedies, and conducting experimental research cases.

3. Methodology

Energy is crucial for human progress and contributes to global wealth. The system Promotes economic progress, human well-being, and nation-wide quality of life. Limited conventional energy sources pose significant environmental and safety risks, both locally and globally. The world's energy supplies will be drained within a few years. In today's energy-demanding world, renewable energy sources provide a cleaner, non-polluting, and environmentally beneficial solution that is free for all. Renewable energy comes from natural sources like sunlight, wind, rain, waves, geothermal heat, and tides. Natural power sources are carbon-free, pollution-free, and capable of replacing coal and fossil fuels, safeguarding resources for future generations.

India relies heavily on both traditional and unconventional energy sources to address its energy issue. The country must fulfill expanding needs in a reasonable and dependable manner to create and provide them. India has access to several energy sources, including renewable and non-renewable. India's primary power generating source is thermal energy, accounting for around 68% of total installed capacity as of 2020. Renewable energy is the second largest contributor to overall generation capacity, with hydro coming in third.

Hybrid energy systems link solar and wind energy to the grid and use control techniques to provide optimal electricity. Hybrid power generation units are connected to the grid, allowing the grid to act as a backup source during shutdowns in renewable energy production such as solar or wind. Excess renewable energy is stored in the grid system and used to satisfy load demands as needed. Hybrid power generation is ideal for the future as it addresses seasonal changes in solar and wind energy and improves output performance to meet demand.

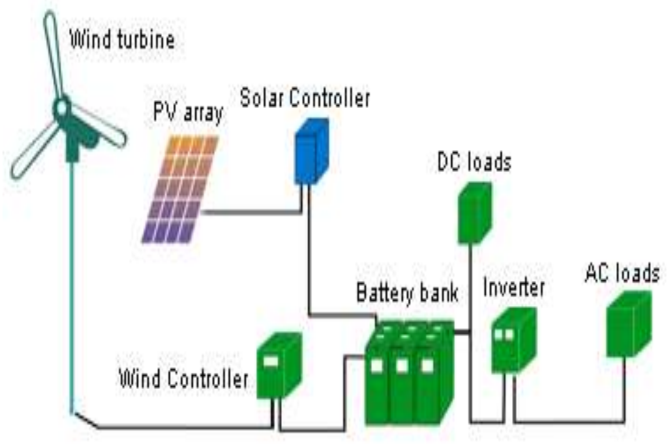

Fig. 2: Schematic Dig of Hybrid Solar-Wind Energy

Figure 2 illustrates a hybrid power generating system that combines solar and wind energy sources. The suggested system combines two energy resources using regulating approaches before powering the grid or load. The MPPT technology converts solar energy into a controlled DC output, which is then fed into an inverter to generate an AC output. Wind turbines provide mechanical energy, which is then transformed to electricity by a generator and sent to the system's inverter. Both outputs are mixed and sent to the AC grid generator. A hybrid system is beneficial for continuous power generation due to seasonal fluctuations in solar and wind energy.

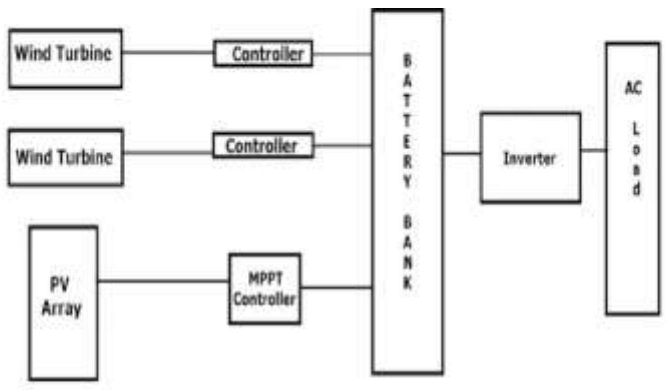

Fig 3: Block Diagram of Hybrid Energy System

Figure 3 depicts a hybrid energy system that combines solar and wind electricity. The graphic illustrates the hybrid system's energy production. The proposed system captures and converts solar energy to generate power, using a tracking technique to maximize energy resource utilization. The tracking method employed is the perturb and observe (P&O) scenario. The solar DC output is amplified by a boost converter before being sent into the inverter for processing. An inverter turns DC electricity into AC electrical energy. A three phase inverter converts input to AC and supplies it to the grid, meeting energy demands for applications. Wind turbines capture spinning wind speed and convert it to mechanical energy. Wind energy is converted into electricity using a generator. The generator utilized is a permanent magnet synchronous generator. The generated power is distributed to the grid to meet demand.

To integrate wind and solar energy into the grid, consider making the following adjustments gradually:
a) Improve cooperation in balancing areas.
b) Use sub hourly scheduling for generation and transmission expansion to accommodate RPG.
c) Coordinate and dispatch generation over larger regions.
d) Use appropriate wind and solar forecasts in unit commitment and grid operations to provide down reserves.
e) Increase RPG flexibility and commit additional operating reserves.
To assess PV impact, first create an accurate model of the distribution circuit that includes the PV system. Then, add all other components such as LTC transformers, voltage regulators, capacitors, breakers, recloses, fuses, sectionalizes, switches, and control parameters, including time delays and dead bands, along with their characteristics and locations. This model should consider customer load and PV generation models, as well as priority setting for smart PV inverter activities such as low/high voltage ride through, volt-watt/volt-VAR control, and time-varying representation.
Power flow assessments are used to evaluate the influence of PV equipment on the distribution system,

including voltage, thermal loads, and loss of PV generation with or without feeder activities.
PV inverter features, such as power factor operation, reactive power compensation, and dynamic voltage management, effect mitigation strategies for high penetration PV.
Key drivers of renewable energy transition include public awareness of climate change, cost reductions, technology advancements, new markets, and energy security. Barriers to investment include changing rules, expensive supply chains, a lack of digital skills, limited infrastructure, and a transition away from the oil, gas, and coal sectors.
Drivers and impediments affecting the change from a power grid perspective:
The primary drivers are renewable integration, system expansion to accommodate load growth, digitalization for resource management, data and information trade among stakeholders, and energy security. Barriers to HVDC development include inadequate utility business models, concern of stranded investments, insufficient coordination among stakeholders, insufficient interoperability of HVDC systems, high investment costs, and a skilled workforce.

The following points should be addressed while transitioning to renewable energy:
a) Enhance power system development and operations,
b) Optimize hybrid generation,
c) Improve cyber security governance, practices, and capabilities,
d) Leverage digital technology,
e) Diversify company portfolio across segments and locations,
f) Maintain financial discipline and flexibility for growth, maintenance, and re-investment, and
g) Build an agile and digitally proficient staff for sustainability.

Smart grid systems are divided into three layers: physical power, control, and application. A smart grid requires ongoing two-way communication and dynamic behavior.

PV panels on rooftops enable sophisticated building systems to generate, store, and consume their own energy.
Active buildings connect to the smart grid, potentially saving energy and improving dependability and transparency. This study presents the dynamic simulation model for a solar photovoltaic/wind turbine hybrid generating system.
The system includes a photovoltaic array, a dc/dc converter with an isolated transformer, a wind turbine, an asynchronous induction generator, and an ac/dc thyristor controlled double-bridge rectifier. The current reference control (Iref) is generated by the P&O algorithm.

4. CONCLUSIONS

Smart grid technology uses two-way communication to manage appliance usage, building on analogue technology.
With widespread Internet connection, implementing the smart grid has become more feasible. Smart grid devices send information fast, allowing users, operators, and automated devices to respond to changes in smart grid condition systems.
To achieve global leadership in renewable energy, India should set a target of 550 GW by 2030, build evidence for reforms, and adopt a market-based approach to innovation. This article examines how high RE penetration affects system design and integration techniques. To improve the system performance of renewable energy (RE), standards, legislation, incentives, smart inverters, and control approaches should be carefully considered, comparable to regular generators. Policy and regulatory frameworks are necessary for cost-effective investments and operations of dedicated renewable energy infrastructure. This may be achieved through peer-to-peer collaborations between governments, system operators, and private sector participation.

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