Simulation of a Solar-Wind Hybrid Energy System Connected to A Battery and Compensation of Faulty Grids

RISHABH MISHRA[1], BHOOPENDRA SINGH[2]

[1] *Department of Electrical Engineering, UIT-RGPV, Airport Road, Gandhi Nagar, Bhopal*

[2] *Associate professor, Department of Electrical Engineering, UIT-RGPV, Airport Road, Gandhi Nagar, Bhopal*

Abstract— Renewable energy sources such as solar, wind, biomass, hydropower, geothermal and marine sources have emerged as clean energy options. However, although the use of PV cells and wind turbines to generate electricity has increased significantly in recent years, solar and wind energy are inferior to fossil fuels. This article describes a solar-wind hybrid power system that uses renewable energy from the sun and wind to generate electricity. This system is mainly controlled by a microcontroller, which optimizes resource utilization and improves efficiency compared to discrete generation systems. It also increases reliability and reduces dependency on a single source. This hybrid solar-wind power generation system is suitable for both industrial and domestic energy sources.

Indexed Terms— Solar energy, Wind energy, Renewable energy, PV cell, Hybrid power system

I. INTRODUCTION

With distributed generation and renewable energy sources becoming the fastest growing segment of the energy industry, it is important to understand their technical issues and environmental impacts. However, the large number of small-scale Microgrid components with unique characteristics poses a significant challenge for Microgrid modeling and planning. The power plant in the microgrid is complexly connected to the load, and small-scale generators are usually located at the user site to meet the demand for reliable and high-quality power.

Renewable energy sources such as solar and wind power have low emissions and low operating costs, making them an attractive alternative to dwindling and expensive conventional energy sources. However, the stochastic nature of solar and wind sources is a major drawback, as solar energy is only available on clear days and wind speeds are highly variable. Hybrid power generation combining solar and wind energy systems is the best option for reliable electricity supply. Hybrid systems improve reliability, reduce energy storage requirements, and overcome redundancy issues, but increase system complexity.
Optimal sizing of each component is required to make the hybrid system technically and economically viable and effective. Renewable sources such as solar and intermittent wind are inherently less reliable. However, in many regions, when solar and wind energy sources are combined to produce electricity, they complement each other through diurnal and seasonal variations. This combination of renewable energy sources can make the system more reliable and, depending on regional conditions, can reduce system costs. However, due to the physical nature of nonlinear components, power system measurement procedures and practical control strategies become more complicated.

The global warming crisis, the depletion of conventional energy sources and the continuous increase in oil prices have given impetus to the development and use of renewable energy sources. Renewable energy sources are clean energy sources that can meet energy needs without causing environmental pollution. Wind and solar energy sources have great potential to reduce dependence on conventional energy sources. The integration of renewable energy sources into the energy grid is widely recognized as an important part of the transition to a sustainable energy future.

In summary, distributed generation and renewable energy sources are critical components of the energy industry's transition to a sustainable future. However, technical issues and their environmental impact need to be studied and understood. The optimal size of each component of the hybrid system, together with the correct control management strategy, is essential to make the system technically and economically viable and efficient. Combining solar and wind energy sources can make the system more reliable and reduce the overall cost, but it also increases the complexity of the system. The development and use of renewable energy sources will play an important role in mitigating the global warming crisis, reducing conventional energy sources and rising oil prices.

II. PV-WIND HYBRID SYSTEM

The process of raising and optimizing a hybrid-wind-photovoltaic energy system is complex, as it requires the sizing of renewable energy sources and storage components to match the given load profile and the availability of solar radiation and wind speed. These hybrid systems are often unique in design, and dynamic testing can be time-consuming and expensive. Even with adequate time and budget for testing, it is difficult to anticipate all possible scenarios in the life of a hybrid system, and the difference between actual performance and predicted results can lead to uncertainty. Reliable software design and simulation tools are needed to evaluate the performance of hybrid energy systems at specific locations and to compare the performance of different hybrid energy systems. These tools can provide high-level computer comparisons between actual and simulated predicted performance, allowing users to better understand hybrid system performance and make informed investment decisions.

III. RESEARCH OBJECTIVE

The purpose of this thesis is to study and determine the optimal design for hybrid charge control and models of renewable energy sources such as PV-arrays, wind generator inverters and energy storage banks (battery banks). The energy requirements of remote countries, especially developing countries, where access to the main grid is not possible due to geographic and economic constraints.

IV. SCOPE OF RESEARCH

Mains grid electricity is not yet available in most developed areas, but there is great potential for solar and wind systems. Due to the scarcity of fossil fuel reserves and the negative environmental impact of conventional power generation systems, renewable energy sources are becoming more attractive. Wind-solar hybrid power is currently the fastest growing energy source in the world, growing at 25-35% annually over the past decade. The advantages of using renewable energy sources to generate electricity in remote areas include the high cost of fuel transportation, climate change issues, and global warming. Hybrid energy systems consist of renewable energy, PV and solar systems, energy storage systems and electric cooling systems. Charge controllers designed for hybrid power systems can provide high-quality electricity 24 hours a day. Compared to standalone systems, hybrid energy systems offer better efficiency, schedule flexibility, and environmental benefits. In addition, it can be expanded in the future to meet the growing demand.

V. EXISTING SYSTEM

Meeting future energy requirements is a pressing issue, and the hybrid renewable system is an important research area that addresses this. Many research methods have been explored in the past, and some are ongoing. This research draws upon and builds upon some of the existing research to further improve the hybrid system. Reviewing the literature has been a critical part of this thesis, which aims to contribute to future technology. The methods examined in the literature review provided a strong foundation for this research, and additional work has been done to enhance the efficiency of the hybrid system and improve upon previous work.

VI. EFFECTS OF HARMONICS

Power converters produce harmonic currents when they enter the feeder, which can cause various problems. These harmonic currents can be trapped by power factor correction capacitors, resulting in voltages above resonance. This destroys the supply voltage and causes problems in computers, telephone lines, motors, power supplies and even transformer faults due to current losses. As a result, the material wears out faster and there is more loss due to excessive porosity. Current fluctuations affect production equipment and cause unexpected losses in productivity and high product costs. Harmonic problems can be reduced by installing loads or conditioning systems that reduce line interference. In the first approach, the equipment is less sensitive to voltage disturbances, so its operation can only be considered by voltage deviation and is not practical for most applications.

VII. PROPOSED METHODOLOGY

In today's world, many environmental problems arise due to the negative impact of greenhouse gas emissions on the environment. Non-renewable energy sources such as power plants are a significant contributor to greenhouse gas emissions and cause disease among people living nearby. Furthermore, this energy source is not sustainable as it will eventually run out. To solve this problem, large wind turbines use mechanical systems such as gears or gears to increase the speed of the generator. In addition, the inverter adjusts the output voltage above the grid value, so that the wind power can be coupled to the grid bus and the leading phase to the bus phase. Combining wind power with solar energy increases the reliability of individual power systems in the renewable energy system. However, wind power systems face problems related to output voltage fluctuations and power supply quality fluctuations. The AC output voltage from the wind turbine is usually rectified by combining it with the output voltage of the solar cell to charge the battery and supply power to the load. By using renewable energy sources such as wind and solar energy instead of non-renewable sources, it is possible to create a more sustainable and environmentally friendly VI. energy system. Combining these energy sources can also lead to increased reliability of the power system.

VIII. SOLAR CONTROLLER

A PV array is non-linear and produces peak power at certain operating points. The perturbation and control method measures voltage and current to determine the current operating area. Based on this, the reference voltage is increased or decreased to ensure that the system operates near the MPP. This method is easy to implement because it only involves adjusting the reference voltage. However, it may not be able to follow sudden environmental changes.

IX. WIND POWER GENERATION

Wind power is derived from the Sun, just like any other energy source on Earth. As the Earth revolves around the sun, it receives light and heat that causes temperature differences in different areas, causing air movement or wind. Wind turbines have been used for thousands of years for mechanical power applications such as grain threshing and water pumping. Today, there are more than a million wind turbines around the world that generate electricity and pump water. Wind power has the potential to produce large amounts of electricity without the problem of pollution from conventional forms of electricity generation. Hybrid systems that combine different energy sources such as wind and solar have a significant impact on electricity generation. Solar-wind hybrid applications are designed for year-round energy use without downtime. Photovoltaic solar panels and small wind turbines depend on the weather and climate and are not sufficient on their own. Renewable energy production requires a combination of wind and solar energy in one system. The control unit in the hybrid system determines which source is used to charge the battery based on the state of incoming energy. Wind turbines convert kinetic energy into mechanical energy, which is then converted into electricity using DC, AC, speed converters, vanes, and other components.

X. SIMULATION RESULT

Several components are required to extract power from solar panels and wind turbines. First, it is necessary to monitor the current and voltage of the solar panel to determine the output power, and this can be achieved by using a high current monitor and resistor divider in the output voltage of the solar panel. The next step is to control the output power of the solar panel, which can be done by adjusting the output current of the panel. Finally, a software algorithm is needed to determine how to adjust the current. After the comparator is enabled, the output of the comparator will be high when the positive input is greater than the negative input.

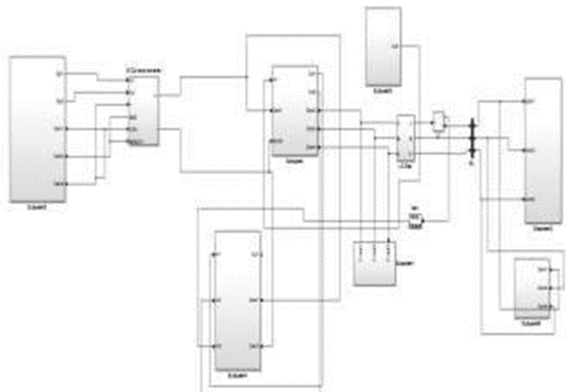

Fig 6.1 System modelling.

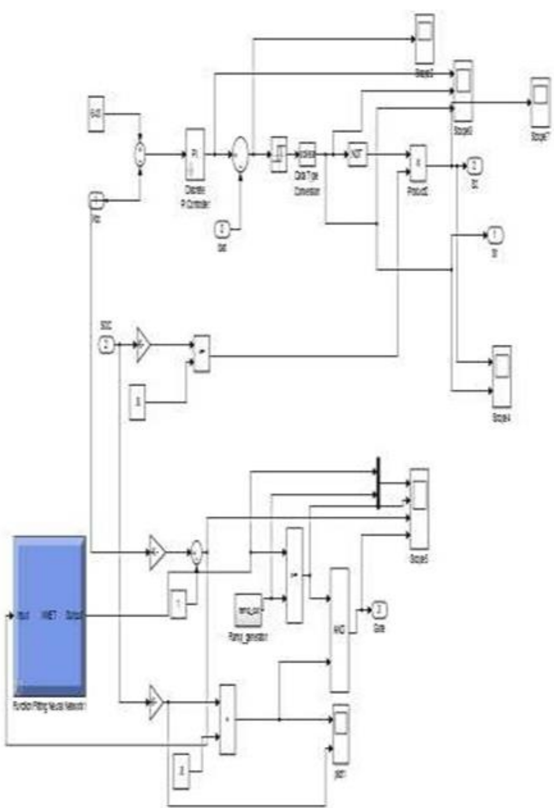

Fig 6.2 ANN Controller.

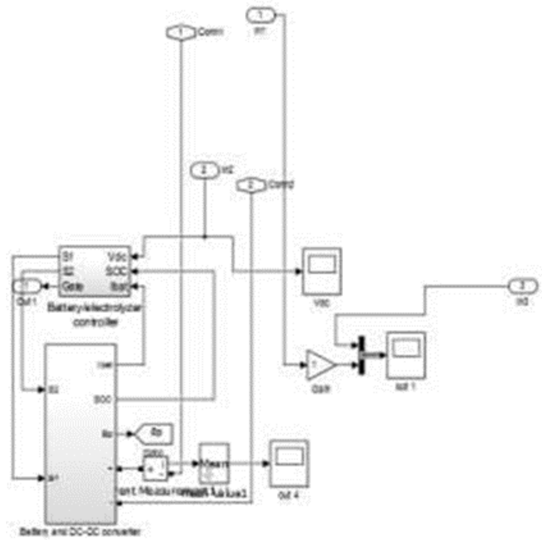

Fig 6.3 Battery subsystem.

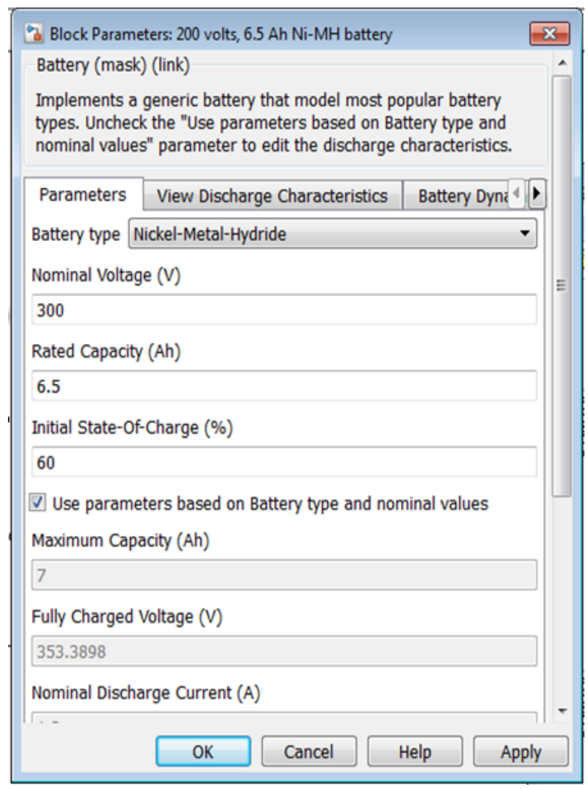

Fig 6.4 Input parameters in battery.

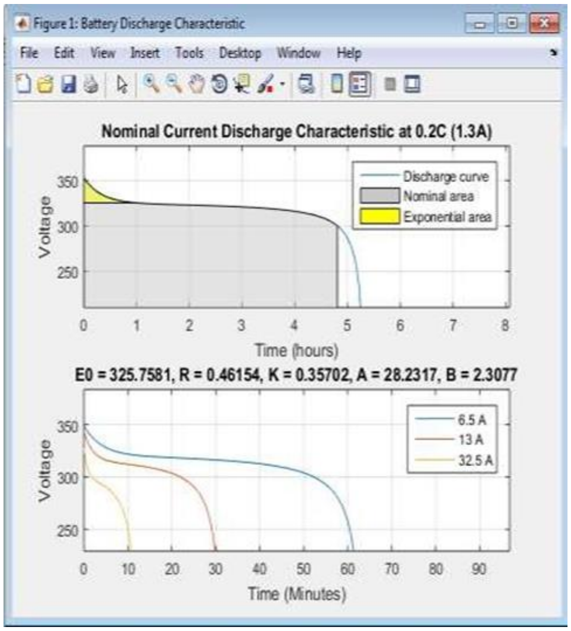

Fig 6.5 Charging and discharging Time.

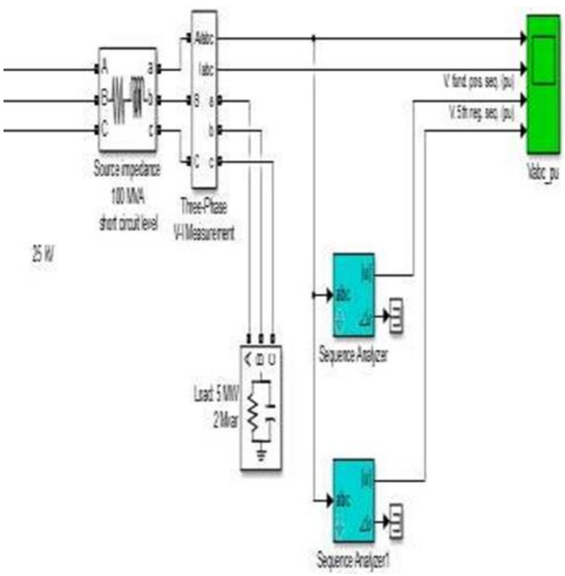

Fig 6.6 Load System.

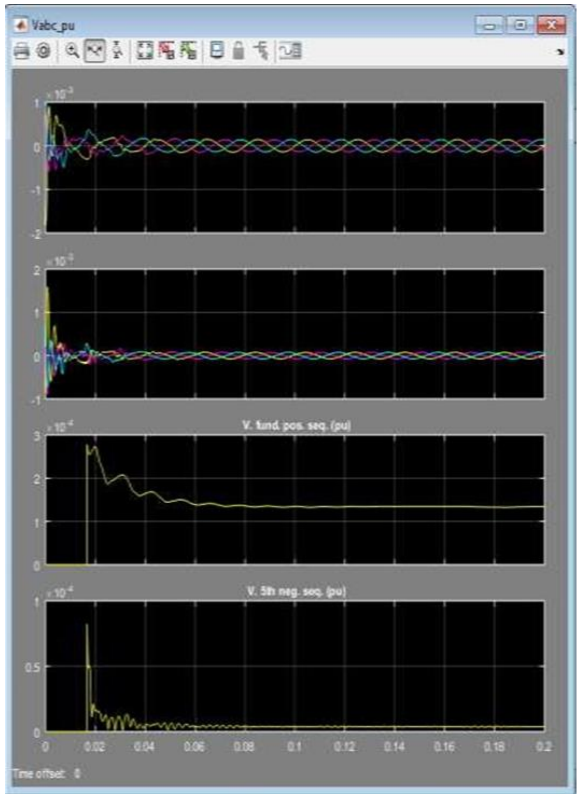

Fig 6.7 Load across Stability Index.

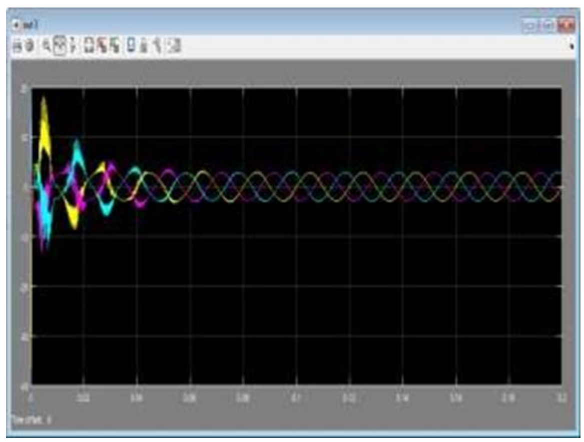

Fig 6.8 Harmonics Variation voltage.

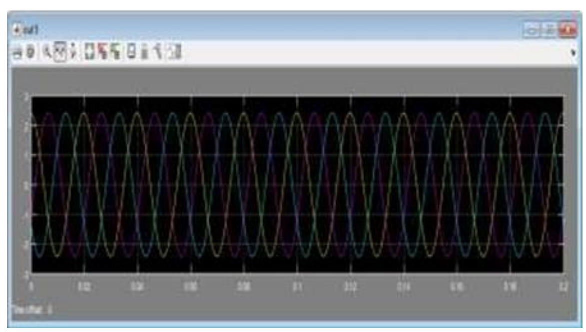

Fig 6.9 Harmonics Variation current.

CONCLUSION

Solar-wind hybrid energy systems have become popular as a reliable source of electricity for small-scale applications. To increase the efficiency of solar photovoltaic energy production, wind energy is combined to create a hybrid energy system. This approach was adopted to reduce air pollution caused by conventional power generation systems. By installing SWHES in every household, the load on the conventional power generation system is reduced. In addition, the battery storage system ensures an uninterrupted power supply even when production is off. SWHES is widely used in various areas of electric power application and provides power to places inaccessible to conventional power sources. Compared to other energy generating systems, SWHES is more reliable and efficient, has less impact on the environment, and requires no maintenance.

REFERENCES

[1] Ceran B. The concept of use of PV/WT/FC hybrid power generation system for smoothing the energy profile of the consumer. Energy 2019;167:853–65.

[2] Devrim Y, Bilir L. Performance investigation of a wind turbine–solar photovoltaic panels–fuel cell hybrid system installed at İncek region – Ankara, Turkey. Energy Convers Manage 2016;126:759–66.

[3] Budak Y, Devrim Y. Comparative study of PV/PEM fuel cell hybrid energy system based on methanol and water electrolysis. Energy Convers Manage 2019;(179):46–57.

[4] Li YF, Zio E. A multi-state model for the reliability assessment of a distributed generation system via universal generating function. Reliab Eng Syst Saf 2012;(106):28–36.

[5] Spinato F, Tavner PJ, van Bussel GJW, Koutoulakos

[6] E. Reliability of wind turbine subassemblies. IET Renew Power Gener 2009;3:387–401.

[7] Guo H, Watson S, Tavner P, Xiang J. Reliability analysis for wind turbines with incomplete failure data collected from after the date of initial installation. Reliab Eng Syst Saf 2009;94:1057–63.

[8] Scheu MN, Kolios A, Fischer T, Brennan F. Influence of statistical uncertainty of component reliability estimations on offshore wind farm availability. Reliab Eng Syst Saf 2017;168:28–39.

[9] Barros JJC, Coira ML, López, de la Cruz MP, del Caño Gochi A. Probabilistic life-cycle cost analysis for renewable and non-renewable power plants. Energy 2016;(112):774–87.

[10] Faza A. A probabilistic model for estimating the effects of photovoltaic sources on the power systems reliability. Reliab Eng Syst Saf 2018;(171):67–77.

[11] Hasan KN, Preece R, Milanović JV. Existing approaches and trends in uncertainty modelling and probabilistic stability analysis of power systems with renewable generation. Renew Sustain Energy Rev 2019;(101):168–80.

[12] Kan C, Devrim Y, Eryilmaz S. On the theoretical distribution of the wind farm power when there is a correlation between wind speed and wind turbine availability. Reliab Eng Syst Saf 2020;(203):107115.

[13] Adedipe T, Shafiee M, Zio E. Bayesian network modelling for the wind energy industry: An overview. Reliab Eng Syst Saf 2020;(202). Article 107053.

[14] Acuña LG, Padilla RV, Mercado AS. Measuring reliability of hybrid photovoltaicwind energy systems: A new indicator. Renew Energy 2017;(106):68–77.

[15] Kamal Anoune K, Bouya M, Astito A, Abdellah AB. Sizing methods and optimization techniques for PV- wind based hybrid renewable energy system: A review. Renew Sustain Energy Rev 2018;93:652–73.