International Journal of Scientific Research & Engineering Trends
Volume 10, Issue 5, Sept-Oct-2024, ISSN (Online): 2395-566X

A Performances Evaluation and Modelling of Solar and Wind Hybrid Power Generation Source

Dharmendra Malviya, Neha Singh
Department of Electrical Engineering
School of Engineering and Technology, Ujjain (M.P.)

Abstract- The recent upsurge in the demand of PV and wind systems is due to the fact that they produce electric power without hampering the environment by directly converting the solar radiation into electric power. However the solar radiation, wind never remains constant. It keeps on varying throughout the day. The need of the hour is to deliver a constant voltage to the grid irrespective of the variation in temperatures, wind pressure and solar isolation. We have designed a circuit such that it delivers constant and stepped up dc voltage to the load. We have studied the open loop characteristics of the PV array and wind system with variation in temperature and irradiation levels. Then we coupled the PV array and wind system with the boost converter in such a way that with variation in load, the varying input current and voltage to the converter follows the open circuit characteristic of the PV array and wind system closely. At various isolation levels, the load is varied and the corresponding variation in the input voltage and current to the boost converter is noted. It is noted that the changing input voltage and current follows the open circuit characteristics of the PV array and wind system closely.

Index Terms- Electricity, hybrid, solar, power, wind, perturbation and observation (P&O) algorithm.

I. INTRODUCTION

The Conventional sources of energy are rapidly depleting. Moreover the cost of energy is rising and therefore photovoltaic system is a promising alternative. They are abundant, pollution free, distributed throughout the earth and recyclable. The hindrance factor is it's high installation cost and low conversion efficiency. Therefore our aim is to increase the efficiency and power output of the system. It is also required that constant voltage be supplied to the load irrespective of the variation in solar irradiance and temperature. PV arrays consist of parallel and series combination of PV array and wind system that are used to generate electrical power depending upon the atmospheric conditions (e.g solar irradiation and temperature). So it is necessary to couple the PV array and wind system with a boost converter. Moreover our system is designed in such a way that with variation in load, the change in input voltage and power fed into the converter follows the open circuit characteristics of the PV array and wind system. Our system can be used to supply constant stepped up voltage to dc loads.

II. WORK SUMMARY

We have discussed about the renewable energy, solar energy, distribution of solar radiation reaching the earth's surface. The details regarding the PV cell have been discussed in chapter 3. The PV array and wind system has been designed in MATLAB environment. The open-circuit characteristic of the PV cell has been studied in depth. The boost converter design, the coupling of the PV array and wind system with the converter has been described. The deals with the simulation results and discussions part. The P-V, I-V, P-I curves have been obtained at varying irradiation levels and temperatures. The generation of the PWM signal has been shown. We get constant voltage across the load resistance of the boost converter. Output load of the boost converter is varied and the variation in the input voltage and current fed into the boost converter is noted. The various values of the voltage and current have been plotted in the open loop curves of the PV array and wind system. The voltage and current values lie on the curves and thereby prove that our coupling of the boost converter with the PV array and wind system is proper.

Wind energy is the energy which is extracted from wind. For extraction we use wind mill. Ii is renewable energy sources. The wind energy needs less cost for generation of electricity. Maintenance cost is also less for wind energy system. Wind energy is present almost 24 hours of the day. It has less emission. Initial cost is also less of the system. Generation of electricity from wind is depend upon the speed of wind flowing.

III. RENEWABLE ENERGY

Renewable energy sources also called non-conventional type of energy are the sources which are continuously replenished by natural processes. Such as, solar energy, bio-energy - bio-fuels grown sustainably, wind energy and hydropower etc., are some of the examples of renewable energy sources. A renewable energy system convert the energy found in sunlight, falling-water, wind, sea-waves, geothermal heat, or biomass into a form, which we can use in the form of heat or electricity. The majority of the renewable energy comes either directly or indirectly from sun and wind and can never be fatigued, and therefore they are called renewable [1].

However, the majority of the world's energy sources came from conventional sources-fossil fuels such as coal, natural gases and oil. These fuels are often term non-renewable energy sources. Though, the available amount of these fuels are extremely large, but due to decrease in level of fossil fuel and oil level day by day after a few years it will end. Hence renewable energy source demand increases as it is environmental friendly and pollution free which reduces the greenhouse effect [1].

IV. SOLAR ENERGY

Solar energy is a non-conventional type of energy. Solar energy has been harnessed by humans since ancient times using a variety of technologies. Solar radiation, along with secondary solar-powered resources such as wave and wind power, hydroelectricity and biomass, account for most of the available non-conventional type of energy on earth. Only a small fraction of the available solar energy is used [2].

Solar powered electrical generation relies on photovoltaic system and heat engines. Solar energy's uses are limited only by human creativity. To harvest the solar energy, the most common way is to use photo voltaic panels which will receive photon energy from sun and convert to electrical energy. Solar technologies are broadly classified as either passive solar or active solar depending on the way they detain, convert and distribute solar energy.

V. WIND POWER

Wind power is the use of air flow through wind turbines to provide the mechanical power to turn electric generators. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land.[3] The net effects on the environment are far less problematic than those of nonrenewable power sources.

Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants.[4][5][6] Offshore wind is steadier and stronger than on land and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.[7]

Wind power gives variable power, which is very consistent from year to year but has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid and a lowered ability to supplant conventional production can occur.[8][9] Power-management techniques such as having excess capacity, geographically distributed turbines, dispatchable sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, energy storage, or reducing demand when wind production is low, can in many cases overcome these problems.[10][11] Weather forecasting permits the electric-power network to be readied for the predictable variations in production that occur.[12][13][14]

In 2017, global wind power capacity expanded 10% to 539 GW.[15]. Yearly wind energy production grew 17% reaching 4.4% of worldwide electric power usage,[16] and providing 11.6% of the electricity in the European Union.[17] Denmark is the country with the highest penetration of wind power, with 43.4% of its consumed electricity from wind in 2017.[18][19] At least 83 other countries around the world are using wind power to supply their electric power grids.[20]

VI. LITERATURE REVIEW

Review of Past Research

D.B.Nelson, Unit sizing and cost analysis of stand-alone hybrid wind/PV/fuel cell power generation systems: An economic evaluation of a hybrid wind/photovoltaic/fuel cell (FC) generation system for a typical home in the Pacific Northwest is performed. In this configuration the combination of a FC stack, an electrolyser, and hydrogen storage tanks is used as the energy storage system. This system is compared to a traditional hybrid energy system with battery storage. A computer program has been developed to size system components in order to match the load of the site in the most cost effective way. A cost of electricity, an overall system cost, and a break-even distance analysis are also calculated for each configuration. The study was performed using a graphical user interface programmed in MATLAB.

AlirezaMaheri, Multiobjective optimisation of hybrid wind-PV-battery-fuel cell-electrolyser-diesel systems: An integrated configuration-size formulation approach: A generic integrated configuration-size optimization formulation for design of hybrid renewable energy systems (HRES) is presented in this paper. This formulation allows identifying the optimum configuration for a given site and the optimum size of each component in that configuration by solving only one optimization problem. Single and multi objective case studies are defined for both on-grid and standalone systems using wind turbine, PV panel, battery bank, fuel cell, electrolyser and diesel generator as potential components. To solve the optimization problems a genetic algorithm (GA) and a non dominated sorting GA (NSGA-II) are developed, in which the reproduction operators are designed carefully for robust exploration and exploitation at both size and configuration levels. Eight single and multi objective case studies for a variety of renewable resources, objectives and constraints are conducted. The results show the versatility of the problem formulation in defining different HRES design problems and the robustness of the developed GA and NSGA-II in search within the design space at both configuration and size levels and finding the optimum size and configuration simultaneously.

BoualamBenlahbib, Experimental investigation of power management and control of a PV/wind/fuel cell/battery hybrid energy system microgrid: This paper presents an experimental study of a standalone hybrid microgrid system. The latter is dedicated to remote area applications. The system is a compound that utilizes renewable sources that are Wind Generator (WG), Solar Array (SA), Fuel Cell (FC) and Energy Storage System (ESS) using a battery. The power electronic converters play a very important role in the system; they optimize the control and energy management techniques of the various sources. For wind and solar subsystem, the speed and Single Input Fuzzy Logic (SIFL) controllers are used respectively to harvest the maximum power point tracking (MPPT). To maintain a balance of energy in the hybrid system, an energy management strategy based on the battery state of charge (SOC) has been developed and implemented experimentally. The AC output voltage regulation was achieved using a Proportional Integral (PI) controller to supply a resistive load with constant amplitude and frequency. According to the obtained performances, it was concluded that the proposed system is very promising for potential applications in hybrid renewable energy management systems.

Shiref A.Abdalla, Performance enhancement and power management strategy of an autonomous hybrid fuel cell/wind power system based on adaptive neuro fuzzy inference system: In this paper, a hybrid wind/fuel cell generation system which can be used for loads in remote areas as a micro grid application is considered. This micro grid mainly includes fuel cell (FC), wind generator as electrical power suppliers, resistive-inductive impedance as static load, induction motor (IM) as a dynamic load, DC/AC converter and water electrolizer for supplying hydrogen gas. The Fuel cell is used to compensate the decrease in the power generated by wind, which leads to an increase in the system efficiency. Furthermore, an adaptive control model and achievement refinements of a micro-grid using Adaptive Neuro Fuzzy Inference System (ANFIS) controller has been utilized to regulate the load voltage and frequency. This suggested microgrid system is achieved so that the wind generation unit supplies the loads, while any additional energy needed by the loads will be offset by the fuel cell generator unit. Thus, the main objective of this work is to apply an adaptive control method for improving the proposed electrical micro grid performance. In addition, the performance of the considered system is compared with the proposed ANFIS control when applying the traditional fuzzy control. The outcomes also demonstrated a better reaction and durability to the chosen control model. The MATLAB/SIMULINK programming software tools have been used for carrying out case studies towards the evaluation and validation of the methodology developed in this work with applications. The proposed solution achieved improvement in transient performance. However, the settling time is decreased to 21% in the case of using the suggested ANFIS controller comparing with conventional fuzzy control.

Syed RaahatAra, Two-level planning approach to analyze techno-economic feasibility of hybrid offshore wind-solar pv power plants: In this paper, a two-level planning framework has been proposed to assess the techno-economic feasibility of hybrid offshore wind-solar PV power plants. In the first level, the optimal layout design of hybrid offshore wind-solar PV plants is determined to maximize the generation considering wake effect and shadow loss for wind turbines (WTs) and solar PV panels, respectively. Particle Swarm Optimization (PSO) is used to determine the optimal layout of hybrid power plants. In the second level, economic analysis has been conducted to determine the feasibility of the hybrid offshore power plants for any particular site. In this context, two scenarios have been investigated. In scenario-1, the optimal share of wind and solar generation for an offshore hybrid plant of given capacity is determined from a techno-economic point of view. On the other hand, in scenario-2, the optimal share of solar PV panels utilizing the existing electrical infrastructure of offshore wind plants has been determined. Both cases are compared on the basis of the Levelized cost of energy (LCOE), and the best alternative has been highlighted for a site in this study. Yearly data of wind speed and solar irradiation of a site near the coast of Gujarat in India has been considered to investigate the proposed approach.

ZhanleiWang, Hydrogen fuel and electricity generation from a new hybrid energy system based on wind and solar energies and alkaline fuel cell: Excessive consumption of fossil fuels has led to depletion of reserves and environmental crises. Therefore, turning to clean energy sources is essential. However, these energy sources are intermittent in nature and have problems meeting long-term energy demand. The option suggested by the researchers is to use hybrid energy systems. The aim of this paper is provide the conceptual configuration of a novel energy cycle based on clean energy resources. The novel energy cycle is composed of a wind turbine, solar photovoltaic field (PV), an alkaline fuel cell (AFC), a Stirling engine and an electrolyzer. Solar PV and wind turbine convert solar light energy and wind kinetic energy into electricity, respectively. Then, the generated electricity is fed to water electrolyzer. The electrolyzer decomposes water into oxygen and hydrogen gases by receiving electrical power. So the fuel cell inlets are provided. Next, the AFC converts the chemical energy contained in hydrogen into electricity during electrochemical reactions with by-product (heat). The purpose of the introduced cycle is to generate electricity and hydrogen fuel. The relationships defined for the components of the proposed cycle are novel and is examined for the first time. Results showed that the output of the introduced cycle is 10.5 kW of electricity and its electrical efficiency is 56.9%. In addition, the electrolyzer uses 9.9 kW of electricity to produce 221.3 grams per hour of hydrogen fuel. The share of the Stirling engine in the output power of the cycle is 9.85% (1033.7 W) which is obtained from the dissipated heat of the fuel cell. In addition, wind turbine is capable of generating an average of 4.1 kW of electricity. However, 238.6 kW of cycle exergy is destroyed. Two different scenarios are presented for solar field design.

M.M.Samy, Optimal economic study of hybrid PV-wind-fuel cell system integrated to unreliable electric utility using hybrid search optimization technique: This study addresses the problem of power outages in distant districts by taking advantage of the available renewable energy resources in the surrounding environment. This was done by proposing connecting the utility to a hybrid system constituting from photovoltaic (PV), wind turbine (WT), and fuel cell (FC) systems where this hybrid system is considered as a backup system that works when the grid is unavailable. This hybrid system proposed is used for feeding the load to a tourist resort in Hurghada, Egypt.

The design of the introduced system has taken into consideration the cost of purchasing electric energy and the profit from selling it to the utility network. Component scaling was implemented to improve the net present cost of the proposed system using two grouped meta-heuristic techniques, which are the Hybrid Firefly and Harmony Search optimization technique (HFA/HS) and compared to the particle swarm optimization (PSO) technique.

AmmarAlkhalidi, Cantilever Wind Turbines Installation to harvest accelerated wind in dams (Hybrid floating PV – Wind System): Lack of fossil fuel creates a need to search for unique innovations to produce renewable energy within the country. Large inland water bodies, Dams as an example, provides an opportunity to utilize both solar and wind energy for this purpose. The flat, large water surface of dams with high solar radiation in the MENA region makes it a favorable location for a floating PV system. The high temperature in the MENA region causes a high evaporation rate from inland water bodies. Thus, floating PV panels serve dual purposes, power generation and reduction in water evaporation. On the dry side of the water Dam, there is a significant amount of space available to build a wind farm, especially with this area being between two mountains, which creates a wind tunnel effect that increases the wind speed and unifies wind direction. This paper presents a case study to install the wind turbines horizontally hanging over the dry side of dam to determine the ability to utilize dam space to build a hybrid PV wind system in the MENA region. Wadi Al Mujib dam located in Jordan was chosen as a location for this study. Cantilever wind turbines hanging horizontally facing the dry side of the Dam combined with floating PV was found capable of producing up to three GWh per year.

AnisaEmrani, Optimal sizing and deployment of gravity energy storage system in hybrid PV-Wind power plant: The world today is continuously tending toward clean energy technologies. Renewable energy sources are receiving more and more attention. Furthermore, there is an increasing interest in the development of energy storage systems which meet some specific design requirements such as structural rigidity, cost effectiveness, life-cycle impact, and increased energy capacity. Gravity energy storage (GES) is one of those innovative storage technologies that is still under development. Hence, this study proposes a new methodology which aims to optimally design and deploy a large-scale GES system in a hybrid PV-Wind plant to make it more competitive technically and economically. The objective of this study is to minimize GES construction cost restricted by handling mechanical load applied on the system's structure. The sizing methodology is based on genetic optimization algorithm which aims to determine the optimum dimensions of GES components. A case study has been used to verify the effectiveness of the proposed model.

VII. MOTIVATION OF PROJECT WORK

The Hybrid grid concept acts as a solution to the conundrum of integrating large amounts of Hybrid generation without disrupting the operation of the utility network. With intelligent coordination of loads and Hybrid-generation, the distribution network subsystem (or 'Hybrid grid') would be less troublesome to the utility network, than conventional Hybrid generation. The net Hybrid grid could even provide ancillary services such as local voltage control. In case of disturbances on the main network, Hybrid grids could potentially disconnect and continue to operate separately. This operation improves power quality to the customer. From the grid's perception, the benefit of a Hybrid grid is that it can be considered as a controlled entity within the power system that can be functioned as a single aggregated load. Customers can get benefits from a Hybrid grid because it is designed and operated to meet their local needs for heat and power as well as provide uninterruptible power, enhance local reliability, reduce feeder losses, and support local voltages/correct voltage sag. In addition to generating technologies, Hybrid grid also includes storage, load control and heat recovery equipment. The ability of the Hybrid grid to operate when connected to the grid as well as smooth transition to and from the island mode is another important function [10].

VIII. CONCLUSION

The world is witnessing a change-over from its present centralized generation to a future with greater share of distributed generation. Hybrid energy systems are inter-connected with wind power, photovoltaic power, fuel cell and micro-turbine generator to generate power to local load and connecting to grid/micro-grids that decrease the dependence on fossil fuels. The hybrid system is a better option for construction of modern electrical grids that includes economic, environmental and social benefits. An overview of different distributed generation technologies has been presented. This paper puts forward a comprehensive review of optimal sizing, energy management, operating and control strategies and integration of different renewable energy sources to constitute a hybrid system. The feasibility of the different controllers such as microcontroller, proportional integral controller, hysteresis controller and fuzzy controller are presented. The controller is a closed loop feedback mechanism used for power regulation which achieves zero steady state error and the output signal generated from the controller produces desired output response

REFERENCES

1. D.B.Nelson, Unit sizing and cost analysis of stand-alone hybrid wind/PV/fuel cell power generation systems, Renewable Energy, Volume 31, Issue 10, August 2006, Pages 1641-1656.
2. AlirezaMaheri, Multiobjective optimization of hybrid wind-PV-battery-fuel cell-electrolyser-diesel systems: An integrated configuration-size formulation approach, Energy Available online 8 December 2021, 122825.
3. Boualam Benlahbib, Experimental investigation of power management and control of a PV/wind/fuel cell/battery hybrid energy system microgrid, International Journal of Hydrogen Energy, Volume 45, Issue 53, 30 October 2020, Pages 29110-29122.
4. Shiref A.Abdalla, Performance enhancement and power management strategy of an autonomous hybrid fuel cell/wind power system based on adaptive neuro fuzzy inference system, Ain Shams Engineering Journal, Available online 13 December 2021, 101655.
5. Syed Raahat Ara, Two-level planning approach to analyze techno-economic feasibility of hybrid offshore wind-solar pv power plants, Sustainable Energy Technologies and Assessments.
6. Zhanlei Wang, Hydrogen fuel and electricity generation from a new hybrid energy system based on wind and solar energies and alkaline fuel cell, Energy Reports, Volume 7, November 2021, Pages 2594-2604.
7. M.M.Samy, Optimal economic study of hybrid PV-wind-fuel cell system integrated to unreliable electric utility using hybrid search optimization technique, International Journal of Hydrogen Energy, Volume 46, Issue 20, 19 March 2021, Pages 11217-11231.
8. AmmarAlkhalidi, Cantilever Wind Turbines Installation to harvest accelerated wind in dams (Hybrid floating PV – Wind System), Renewable Energy Focus, Available online 2 December 2021.
9. AnisaEmrani, Optimal sizing and deployment of gravity energy storage system in hybrid PV-Wind power plant, Renewable Energy, Volume 183, January 2022, Pages 12-27.
10. MahdiFasihi, Global potential of green ammonia based on hybrid PV-wind power plants, Applied Energy, Volume 294, 15 July 2021, 116170.
11. Benyoh Emmanuel KighaNsafon, Optimization and sustainability analysis of PV/wind/diesel hybrid energy system for decentralized energy generation, Energy Strategy Reviews, Volume 32, November 2020, 100570.
12. Ahmed F.Bendary, Battery Charge Management for Hybrid PV/Wind/Fuel Cell with Storage Battery, Energy Procedia, Volume 162, April 2019, Pages 107-116.
13. PikasoPal, Viability analysis of direct current (DC) standalone hybrid photovoltaic (PV)/ hydrogen fuel cell (HFC) energy system: A techno-economic approach, Materials Today: Proceedings, Volume 39, Part 4, 2021, Pages 1807-1812.
14. HadiTaghavifar, Techno-economic viability of on grid micro-hybrid PV/wind/Gen system for an educational building in Iran, Renewable and Sustainable Energy Reviews, Volume 143, June 2021, 110877.
15. CerenCeylan, Design and simulation of the PV/PEM fuel cell based hybrid energy system using MATLAB/Simulink for greenhouse application, International Journal of Hydrogen Energy, Volume 46, Issue 42, 18 June 2021, Pages 22092-22106.